ANALYSIS OF SOCIAL IMPACTS OF MINES AND PATHWAYS TO RESPONSIBLE MINING

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Short summary

This report comprehensively analyzes both the positive and negative social impact of the extractive industry. It highlights opportunities for sustainable development, emphasizing positive impacts on community growth, infrastructure construction, business opportunities, national economy expansion, employment, and education. While certain impacts, such as migration, and resettlement, have both positive and negative aspects, environmental impacts are predominantly negative. Identified risks to the environment and society encompass gender inequality, child labour, corruption, poverty, mining in the protected, conserved area and territory of Indigenous People, illegal mining practice, environmental risks like water depletion and contamination, health and safety risks including tailings dam failure. Irresponsible mining practices, neglect of ecological, social and governance (ESG) principles, regulatory non-compliance and inadequate enforcement contribute to these risks. Nevertheless, implementing effective environment management and establishing a robust governance structure can help to avoid or mitigate these risks, enabling mining company to gain social acceptance for their operations. The report resents case studies demonstrating three different scenarios of social acceptance (or non-acceptance) of the mining operations: (1) Jadar deposit in Serbia, (2) Talvivaara deposit in Finland, and (3) Per Geijer deposit in Sweden.

It is crucial to acknowledge that the sustainable management is a shared responsibility that requires a collective effort from diverse sectors and stakeholders. Clearly defining the roles of stakeholders and outlining how they can contribute to responsible mining is essential. The report proposes a way of knowledge transfer to each identified group (citizens, students, researchers, companies, and policy makers), along with recommended actions for them to consider and implement.

Extended summary

There is increasing pressure on the natural resources due to growing global population, industrialization, and digitalization. There is a widespread awareness that this pressure must be reduced to preserve resources for future generations. Numerous initiatives, programs, and organizations, including UN agencies, non-governmental organizations, and industry groups, are working to foster the concept of sustainable development in the mining sector. This concept implies the need for a balance between economic benefits, social justice, and environmental sustainability. This motivation has prompted the industrial sector to enhance its environmental, social and governance (ESG) principles, with companies evaluating their sustainability performance using ESG as a crucial indicator. ESG commitments depend on whether companies operate responsible, contributing positively to the society and environment. If the impact are negative, various risks emerge. By adopting responsible practices, mining companies can positively influence their reputation, facilitating social acceptance for operations. Consequently, this can contribute to reducing the Europe's dependence on imported critical raw materials (CRMs), which are essential for the green and digital transition.

This report comprehensively analyzes both the positive and negative social impact of the extractive industry. It highlights opportunities for sustainable development, emphasizing positive impacts on community grow, infrastructure construction, business opportunities, national economy expansion, employment, and education. While certain impacts, such as migration, resettlement, have both positive and negative aspects, environmental impacts are predominantly negative. Identified risks to the environment and society encompass gender inequality, child labor, corruption, poverty, mining in the protected, conserved area and territory of Indigenous People, illegal mining practice, environmental risks like water depletion and contamination, health and safety risks including tailings dam failure. Irresponsible mining practices neglect of ESG principles, regulatory non-compliance and inadequate enforcement contribute to these risks.

However, with effective environment management and robust governance structure, these risks could be avoided or mitigated. Three different scenarios of social acceptance (or non-acceptance) of the mining operations are presented in this report, featuring case studies from (1) Jadar deposit in Serbia, (2) Per Geijer deposit in Sweden, and (3) Talvivaara deposit in Finland. In the first case (Jadar project), it involves the discovery of one of the largest lithium deposits in Europe, a project that has been halted by the government due to protests in the country, stemming from concerns about its significant environmental impact. The Per Geijer Rare Earth Elements deposit demonstrates that the opening and expansion of a mine are possible through dialogue between the mining company and the local population. The third case, the Talvivaara mine, represents an instance of a mine facing certain challenges, such as problem with the negative impacts on the environment and fluctuation of price of nickel and cobalt. Nevertheless, it also demonstrates the positive effects on the employment.

It is crucial to acknowledge that the sustainable management is a shared responsibility that requires a collective effort from diverse sectors and stakeholders. Defining the specific roles of stakeholders and ways in which they can contribute to responsible mining is vital. The report proposes a way of knowledge transfer to each identified group (citizens, students, researchers, companies, and policymakers), along with recommended actions to them to consider and implement (see the table below).

Table "Five major target groups for responsible mining guidelines

	Knowledge to be transmitted	Actions and means to convey the knowledge	How HERawS can help?
Citiziens	• demystifying the idea of a "dirty mine"; • that currently recycling cannot cover our need in metals; • sourcing metals from outside EU may lead to higher dependency from other countries; • which social and environmental consequences mining can have	• via a documentary, podcasts, exhibition, journal articles	• HERawS can provide a tool to understand the consequences of consumer's choice; prepare an exposition for general public
Students	• understanding the issue of critical raw materials and their impacts;	• via training courses on critical materials for the green and digital transition, podcasts, conferences	• HERawS can provide training courses and a reliable source of information to gain and improve knowledge
Researchers	• highlight the raw material challenges considering sustainable development; challenges that the companies may face on different levels.	• research and transfer knowledge to the academia, society, and industry via articles, scientists' mobility, conferences	• HERawS an interactive platform and training programs for the target group to raise awareness about raw material issue
Companies	• develop Innovative solutions that support the green transition; • respect human rights and avoid conflicts in their mineral sourcing practice; • incorporate relevant SDGs into their business.	• improve knowledge and demonstrate a high level of environmental and social commitment via interactive platform and training course	• HERawS can deliver an interactive platform and training course on the impacts of raw materials in developing innovative devices. • use OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas; • document Mapping Mining to the Sustainable Development Goal: An Atlas
Policy makers	• provide essential support to the mining sector in achieving a higher level of sustainability; • consider the power imbalance between the Indigenous people / local community and the mining company; reinforce the principle of free, prior and informed consent.	• establishing laws, regulations, policies and strong environmental standards; implementing environmental standards, conducting environmental impact assessments, and providing permits etc.; • Promoting dialogue via conferences, organized trainings. Regular exchange with representatives of the groups impacted by mining activities.	• HERawS can offer training sessions with policy makers.

Introduction

In 2014, R. Broad published a viewpoint in which he highlighted that the words “Responsible mining” and “Sustainability” were frequently used as fuzz- or buzzwords, which is, unfortunately, still often the case now, ten years later. Whereas “sustainable mining” may sound to some people as a contradictory phrase, as some are convinced that “mining, by its definition, cannot be sustainable”, “responsible mining” sounds more achievable. What these two phrases generally mean overlaps – it is a wise approach to resource use, with a high focus on reducing the impact on the surrounding environment and society and enhanced awareness of its effects in the long run (e.g., care for future generations). In the case of responsible mining, however, the focus is principally on the social and ethical components. In the above-mentioned viewpoint, R. Broad addresses the principal question for defining responsible mining: ‘‘responsible’’ **for whom** and **by whom**?”. The primary responsibility is held **by** the company initiating the mining project and directly profiting from the exploration **before** the local communities, Indigenous peoples, and workers – social groups affected by the mining and processing activity.

Now, what does this responsibility include? Moving on to concrete components that can make mining more responsible, one can identify three main categories: social, environmental, and governmental. The ESG (environment, social and governance) combines these three themes into an overarching framework that can help a mining or metals company navigate and successfully balance between benefits for the planet and people on the one hand and its obligation on the other. Thus, the challenge for the mining industry is to respect these ESG objectives while ensuring the profitability of the operation, at less in the occidental market. What are some of the examples that each of the categories encompasses?

• Environmental: biodiversity, ecosystem services, water management, mining and metallurgical waste and tailings, air quality, noise, energy, climate change (carbon footprint, greenhouse gases), hazardous substances, mine and metallurgical plant closures.

• Social: human rights, land use, resettlement, vulnerable people, gender equality, labor practices, worker and community health and safety, security, artisanal miners, mine closure/post-use.

• Governance: legal compliance, ethics, anti-corruption, transparency.

Neglecting these responsibilities may lead to severe consequences. A good risk manager will tell you that the best way to deal with a disaster is to prevent it from happening – and she will be right. Initially, as many as possible potential risks have to be identified. Then, one needs to find ways to prevent them from occurring or minimize the probability of a tragic outcome if an accident takes place (containing and minimizing the negative impact). For that, the existing guidelines are cited below.

Before listing the risks that may occur on various levels, let us address the elephant in the room: the first thing that comes to mind is “no mine – no problem”. This logic, commonly used by those opposing mining activities altogether, isn’t technically false, but the price for such an approach is high. With insufficient recycling to fulfill our needs in metals, no mining essentially means losing our comfort. At the same time, the “not in my backyard” mentality is incompatible with the idea of the EU’s independence (see table 1). Moreover, unlike a regular plant, one cannot simply move a rare earth elements deposit to a more convenient place. These messages need to be communicated to the general public to allow for an informed decision. In this report, we will consider three case studies demonstrating three different scenarios of social acceptance (or non-acceptance) of the mining operations: (1) Jadar deposit in Serbia, (2) Talvivaara deposit in Finland, and (3) Per Geijer deposit in Sweden.

Table 1 – EU's Import reliance for some critical materials (European Commission, 2023)

Critical material	Stage	% reliance on import	Critical material	Stage	% reliance on import
Aluminium/ bauxite	Extraction	89	Manganese	Extraction	96
Antimony	Extraction	100	Natural Graphite	Extraction	99
Arsenic	Processing	39	Nickel	Processing	75
Baryte	Extraction	74	Niobium	Extraction	100
Bismuth	Processing	71	Phosphate rock	Extraction	82
Cobalt	Extraction	81	Phosphorus	Processing	100
Coking coal	Extraction	66	Scandium	Processing	100
Copper	Extraction	48	Silicon metal	Processing	60
Feldspar	Extraction	54	Strontium	Extraction	0
Fluorspar	Extraction	60	Tantalum	Extraction	99
Gallium	Processing	98	Titanium metal	Processing	100
Germanium	Processing	42	Tungsten	Processing	80
Hafnium	Processing	0	Platinum Group Metals	Processing	100
Lithium	Processing	100	Heavy Rare Earth Elements	Processing	100
Magnesium	Processing	100	Light Rare Earth Elements	Processing	100

Social impacts

Social impact of extractive industry includes concerns of directly or indirectly affected people related to any specific aspect of human existence (lifestyle, culture, political system, environment, health, well-being, and rights) (Vanclay, 2003). There are numerous positive and negative impacts that depend mostly on the company's responsibility and legislation enacted by the government but can also be influenced by the engagement of local community, NGOs, and other stakeholders.

Social impacts could be related to a different set of indicators used to access and promote sustainability in various context (UN Sustainable Development Goals-SDG, Global Reporting Initiative-GRI, the EU policy, database used in Social Life Cycle Assessment -SLCA) (Mancini & Sala, 2018). Social impacts considered in this report include community development and business opportunities, impact on the economy, income and security, employment, education, migration, resettlement, impact on the environment, human health, and human rights.

SDGs could not be achieved without the evaluation of impacts of mining operations on society and the environment. The social impact of the mining project could be estimated within the Social Impact Assessment (SIA), Environmental Impact Assessment (EIA), or as a part of Strategic Environmental Assessment (SEA). These assessments are essential in preparing and implementing any project, including mining with the aim to identify and analyze potential impacts, and propose mitigation and control measures to reduce negative consequences.

1) **Community development and business opportunities**

The mining industry can significantly impact community development both locally and nationally. Such attempts typically arise primarily from corporate social responsibility (CSR) agreements between mining companies and state governments (Widana, 2021) and are also aligned with the 2030 Agenda - Transforming Our World: The 2030 Agenda for Sustainable Development**.**

Community development by mining companies is most often reflected in the construction of new infrastructure and the provision of certain services that significantly improve the local community. Transport, water, and energy supply as well as the availability of communication technologies represent infrastructure that is necessary for regional or national development (Rey-Martí et al. 2023). These infrastructure elements represent basic services for the functioning of a modern community, the functioning of the health and education system, as well as the productivity of agriculture and the economy (Sonneson et al., 2016).

The mining industry is most active in rural areas (OECD, 2019) where roads, railways, ports, sewage, electricity, and telecommunication infrastructure are inaccessible to a large part of the population (Sonneson et al., 2016; Rey-Martí et al 2023). Although very often mining companies invest in infrastructure for their needs (construction of roads, ports, introduction of the Internet, gas, and energy supply), the local community is allowed to use this infrastructure, which improves the standard of living, especially in rural communities (Widana, 2021; Mononen et al., 2022). Besides that, through mining profits, the government and local authorities encourage community development through the construction of new health care institutions as well as educational institutions that are of great importance, especially in rural, underdeveloped areas (Nguyen et al., 2018).

In this way, the local population benefits from improved transportation and mobility (to their agricultural holdings, to larger centers, etc.), enhanced education and healthcare, compared to similar communities within mining activity.

The mining activity in the local community creates opportunities for the establishment of independent local businesses. This includes opening of various types of small shops, markets, gas stations, private transport, etc. (Fleming et al., 2014). The mining industry is also characterized by the multiplier effect of job creation, i.e., the need to start industrial branches that process raw ore obtained from the mine (European Commission, 2021).

Example: Gold Fields Limited's Contribution to Tarkwa's Development

Since the establishment of the Tarkwa mine in 2004 in Ghana, Gold Fields Limited of Ghana has invested $96.38 million in the local community. The company focused on areas such as education, health, water supply, sanitation services as well as transport and recreation infrastructure. These actions greatly improved life quality of the local population, but also relieved the pressure on the state budget. Health projects initiated by GFL have noticeably improved the well-being of communities, contributing to the reduction of infant mortality, and supporting the health-related sustainable development goals. Similarly, the educational infrastructure, which included modern classrooms, libraries, and information technology centers, had a positive impact on increasing literacy by strengthening communities socially and economically.

The improvement of water supply and sanitary infrastructure led to the prevention of diseases, improvement of the quality of the environment and the achievement of the goals of the Millennium Development Agenda. In addition to the above, the company's contribution to the local community included infrastructure projects related to electricity and road infrastructure (Mensah et al., 2014).

Potential Risks:

- Land expropriation
- People displacement
- Disruption of social cohesion
- Environmental risks

Opportunities:

- Employment and good living wages (SDG 1, SDG 8)
- Investment in water, energy supply an infrastructure development (SDG6, SDG 7, SDG 9)
- Investment in education and healthcare (SDG4, SDG 3)
- Invest in clean and energy efficient technology (SDG 11, SDG 17)
- Enhance economic diversity within the local economy (SDG 8)

2) Impact on economy, income, and security

Mining often provides a stimulus to the local economy, increasing both population income and business opportunities. The operations aim to extract valuable resources, and the revenue generated from the sale of these resources constitutes a significant part of the income for mining companies and, in some cases, for the governments of the countries where mining occurs. In many countries, mining is of key importance to the national economy. The mining industry promotes foreign investments, makes a large contribution to the increase of the national GDP, creates opportunities for investments as well as well-paid jobs (OECD, 2019). For instance, mining sector in Chile, which is one of the world leading producer of metals and minerals including molybdenum, silver, gold, and copper, contributed nearly 15% to the country’s GDP in 2021 and generated 200 thousand direct jobs.

Incomes generated from the mining industry can be categorized as individual, including those that are earned by the mining company, as well as the income earned by the state (Mancini & Sala 2018; Widana, 2021).

Individual income refers to the earnings of workers engaged in the mining industry, encompassing salaries and wages. Additionally, it includes the income generated by the local community through the provision of diverse services to both the company and the individuals employed in the mining sector. In many developing countries, where the mining industry is active, the income earned by mine workers is the only household income and accounts for 90% of the household budget (Mancini & Sala 2018).

Mining companies make a profit by selling raw or processed mineral materials that they exploit by selling the generated energy or other products of the mining industry such as natural gas. The state also earns from the mining industry - on account of the sale of raw materials or raw material products if the companies are state-owned or on account of mining rents, where these revenues are significant and make up a large part of the GDP. Based on the data for the year 2021, income from the rent of natural resources (oil, gas, coal, mineral ores, and forestry) amounts to 6.83% of GDP on average. Ranging from 61.03 in Libya to 0.01 in Switzerland (2021a).

On the other hand, the issue of income inequality arises in mining communities (Sincovich et al., 2018; Widana, 2021). While individuals employed in the mining industry typically earn significantly higher incomes then those people engaged in other activities, this can, in some communities, lead to an increase in poverty.

Example: Mining's contribution to national economies worldwide

The mining industry has played a significant role in influencing the gross domestic product of various countries over the past years. Based on a study (Ericsson & Löf, 2019) in which the impact of the mining industry on national economies was analyzed in the period between 1996 and 2016, it was concluded that this branch of the economy contributed a lot to economic development. In 1996, the value of mining activity amounted to 300 billion dollars, which is equivalent to 0.6% of the total world GDP. By 2011, this figure had reached a peak of 1800 billion dollars, or 1.9% of global GDP. Although in 2016 this industry experienced a decline to 1.2% of global GDP, it's still representing one of the most important branches of the world economy.

Based on the Mining Contribution Index that was used as an indicator, countries such as Burkina Faso, Mali, Liberia and Sierra Leone recorded a significant increase in GDP through mining activity in those countries (Ericsson & Löf, 2019).

Potential Risks:

- Bribery and corruption
- Income inequality
- Poverty
- Social tensions

Opportunities:

- Pay taxes and royalties, increase income, and reduce poverty (SDG 1)
- Provides opportunities for employment and economic growth (SDG 8),
- Use revenue to invest in sustainable cities (SDG 11)

3) Employment

The establishment of a new mine brings various advantages, with the prominent benefits being the creation of job and the potential for employment. In countries with a significant mining sector, the direct contribution of mining to formal employment ranges from 1-4%; however, it provides higher wages compared to similar positions in the country, as observed by Ericsson and Löf (2017).

Opening a mine in a particular region results in the emergence of several employment opportunities highlighted by (Kaitlin et al., 2016) which can be categorized into three main types: direct employment (individuals employed by the company that owns and operates the mine), indirect employment – encompasses individuals employed in companies that supply goods or provide services to the mining company, and induced employment – involved establishment a small businesses (shops, hotels) intended for people employed in the mining industry.

Regarding the potential employment in the mining industry, it is essential to distinguish three phases in the life cycle of a mine that require the largest number of workers should be distinguished: exploration, construction, and operation (Foo & Salim 2022).

Employment within the mining sector is not only an economic imperative but also a crucial element of social well-being, offering individuals opportunities for sustenance, autonomy, and personal growth. It is widely acknowledged that employment in the mining industry plays a pivotal role in enhancing the overall quality of life and alleviating poverty, particularly in rural areas (Yang & Ho, 2019). Moreover, the creation of jobs in mining can have a cascading effect, leading to additional employment opportunities in various sectors (Moritz et al., 2017).

The local communities in mining area may experience negative consequences of employment for the mining are situation when mining companies choose to hire local people due to several reasons: possible conflicts that arise because of the opening of mines (pollution, detonation), engagement of local population in some branch of agriculture, and their obligations in the field while they occasionally leave the mine. For these reasons, mining companies tend to employ workers from other places, who live in mining complexes and have control over them (Yang & Ho, 2019). Also, one of the reasons for not employing the local population is the frequent incidents that companies "cover up", i.e., it is easier to solve with workers who are not from the local community.

Example: Mining-driven employment opportunities, Africa

Jobs in the mining sector in Africa are showing an increasing trend due to the influence of many international and local companies investing in this branch of the industry. For example, in South Africa the mining industry directly and indirectly created over 450,000 jobs, while the copper sector in Zambia employs around 90,000 people. Also, countries with rich resources such as the DRC, Ghana and Tanzania follow the same trend. The increased global demand for minerals and the great potential of the African continent are responsible for this trend.

Salary ranges for positions vary depending on the position in the sector. Therefore, salaries for workers in the production sector of mining range from 40 to 55 thousand dollars per year, while the salaries of responsible personnel are slightly higher. In general, the salaries of employees in the mining sector are many times higher compared to other activities present in local communities.

The impact of new jobs goes beyond employment, the presence of mining companies can have a positive effect on the economic development of the local community through the improvement of infrastructure, education, and healthcare.

Potential Risks:

- Gender inequality
- Violence against women
- Child labor
- Income inequality
- Migrations

Opportunities:

- Stimulate income growth, poverty reduction (SDG 1) and economic development (SDG 8)
- Offering equal opportunities for women (SDG 5)
- Employ marginalized population (SDG 10)
- Eliminate child labor (SDG 8)

4) Education

The mining industry has the potential to positively impact the development and enhancement of education in the local communities where mineral raw materials are exploited (Siankulu, 2022). According to some authors, education is recognized as a basic factor in the overall development of the community (Bilal, 2017) and recognized as one of the goals of the 2030 Agenda for sustainable development (Sonesson et al., 2016). The role of the mining sector in this context extends beyond economic benefits and includes corporate social responsibility initiatives with a special emphasis on improving education.

The mining industry most often improves education through investments in infrastructure (construction of schools, libraries, etc.), scholarships, training of teaching staff, as well as through programs to improve the skills of the local population employed in the mines (Siankulu, 2022).

Through scholarships and similar initiatives, mining companies help shape the future workforce, where there are generally employment practices in mining companies after obtaining certain qualifications. On the other hand, by organizing different types of educational training and workshops for already employed workers in mines, companies get a workforce that will perform their work in the mine better (Widana, 2021).

Overall, the mining industry can make a significant contribution to education and, therefore, to the socio-economic development of local communities.

Example: Investment in education in Zambia

Based on research (Siankulu, 2022), a large impact on the improvement of the education system was recorded through investments by a mining company that mines copper in the Lumwana mine. The greatest benefits are represented by scholarship programs, investment in infrastructure, and support for professors who teach in schools and other educational institutions.

Mining company Barrick Lumwana Mining actively contributes to the improvement of education in Zambia. During 2019, the company gave about 100,000 dollars for sponsorships in schools in Zambia. Within this program, 183 individual scholarships were awarded to the best students in this area.

Considering the small number of high schools in this area, one of the incentives for education contributed by this company are various programs that finance the departure of students to high schools throughout the country, providing money that covers the costs of education (student boarding schools, pocket money, meals, uniforms, etc.).

The company states that the improvement of education in rural areas in Zambia is a win-win situation for them, in which the company, by investing in education through various sponsorship and scholarship programs, creates a quality workforce, who will be provided with jobs.

Possible risks:

- Inequalities
- Insufficient awareness of environmental issues
- Ecological risks

Opportunities:

- Invest in training and educational program for workforce and local community (SDG 4)

5) Migrations

As one of the vital economic branches, mining activities largely shape economic flows, and therefore significantly influence the social dynamics through labor force migration. Economic factors play a crucial role in driving migration within the mining industry (Owen & Kemp, 2017). Migration is most often present in rural areas of underdeveloped countries where mining activity is the primary industry that provides employment opportunities and secure earnings. Also, in addition to employment in the mining industry, the opening of mines implies the development of other economic branches (construction of supporting infrastructure - roads, electrical network), which indicates the possibility of the need for a larger number of workers and therefore a larger volume of migration (Coderre–Prolux et al., 2016).

Migration as a social component of mining significantly shapes the social structure of mining communities. The arrival of migrants in existing communities greatly affects the community's cultural identity and gender dynamics.

Also, an increased population under the influence of newcomers can lead to increased pressures on land (intensive agriculture), water and other resources as well as pressures on infrastructure, hygiene, and waste disposal (Environmental Law Alliance Worldwide 2010, Sincovich et al., 2018). In some cases, due to the increase in the population, there are great pressures on healthcare, which results in a lack of complete healthcare services and placing certain social groups in a subordinate position compared to others (Sinovich et al., 2018).

The influx of migrants often leads to an increase in the need for goods and services, which leads to the need to increase production and consumption. This leads to an increase in the price of certain goods and services (prices of basic food, prices of apartments, etc.) and has the consequence that people who are not employed in the mining industry, especially the local population, have a problem affording certain things due to lower incomes compared to employees in the mining industry (Yang et al., 2019, Sincovich et al., 2018). All this very often leads to conflict between the local population and migrants (Owen et al., 2017). In addition to social conflicts, migration can lead to the spread and transmission of infectious diseases. According to (McCulloch & Miller, 2023) migration due to employment in the mining sector led to the spread of HIV/AIDS - in South Africa during the 1980s there was a spread of HIV/AIDS, because of it, 13,000 newly arrived workers were rejected for work at the mine, to eventually stop possible spreading of the disease.

Example: Porgera, Papua New Guinea, center of immigration

The establishment of opening of gold mines in Papua New Guinea in 1989 led to large population migrations in search of employment opportunities. Prior to the opening of mines by the Porgera Joint Venture/Barrick in the area, gold was mined in small artisanal mines or by gold panning from the river. The Indigenous population of the Ipili tribe lived around today's mine. They were widely distributed in this area, and their main activity was agricultural production and artisanal gold mining. The establishment of the mine resulted in the displacement of the local communities of Ipili. With the development of the mine, Porgera became a center of immigration, especially from the Southern Highlands and Enga provinces. Not long after the mine was established, there was a sudden increase in the population from about 3000 people living in the valleys around the mine before the project to about 22000 people. The patterns of immigration in this case were varied, immigrants settled in existing villages near the mines like in the town of Porgera. Due to arrival of many people, the population density increased dramatically. This resulted in great pressure on water resources and the sanitation network, and very unhygienic and inhuman living conditions were recorded in this area, potentially threatening the health of all residents in the vicinity of the Porgera mine (World Bank, 2009).

Possible Risks:
(in-migration)

- Conflicts
- Trigger local inflation
- Loss of cultural identity
- Increased pressure on local resources
- The possibility of the emergence and spread of diseases
- Increase in crime
- Gender imbalance

Opportunities:

- Employment of migrants can reduce inequalities

6) Resettlement

Resettlement can lead to the physical displacement of people and communities when they must leave their home and change residence, and economic displacement by affecting their source of income and livelihoods. There are voluntary or informed voluntary resettlements – when people give consent and receive fair compensation, and involuntary resettlement- which refers to force displacement without free and informed consent. Involuntary resettlement should be avoided, but if it became necessary, ensuring fair compensation and offering opportunities to improve livelihoods of the affected people is essential.

Industrial sector, conflicts (state of war), natural disasters and long-term environmental changes could be reason for the forced displacement of the population. According to a report by the Rew et al (2000) the mining industry ranks as a fourth most significant factor contributing to the involuntary population displacement. The main reason for population displacement in mining is the expropriation of land for future mine development and its associated infrastructure (Owen et al., 2020b). Unlike other industries, displacement in the mining industry can occur at any stage of the mine life cycle, which is most affected by the volatility of the ore market (Owen & Kemp 2015; Owen et al., 2021). Analysis of a study with 262 cases showed that displacement most often occurs in the operations phase (57%) and then in the phase of mine construction (about 30%) (Owen et al., 2021).

The resettlement could be permanent when individuals or community must leave their homes and land without possibility of return, or temporary when they can go back to their origin locations after some period. The reason for the temporary displacement could be short-term land access due to the drilling activities of rerouting of access roads (https://socialway.angloamerican.com).

Mining caused displacement is a global issue affecting not only poor, underdeveloped countries, but also extended its impact to develop countries such as USA, and Europe (Germany, Poland, Serbia) (Terminski, 2012). In some cases, it represents a visible and pressing social concern posing a threat to human rights and freedom, as observed in countries like India, Mali, and Ghana (ibid). The consequences of people displacement may include inadequate compensation, limit community involvement in resource profit distribution, cultural disruption, violation of human rights (particularly indigenous and tribal people), loss of land and lack of quality areas for agricultural production, unemployment, loss of residence, marginalization, spread of disease and increased mortality, lack of food and problems with the supply of drinking water (Terminski, 2012; Wilson, 2019; Yang & Ho 2019).

Grievances received by mining companies mostly pertain to concerns about resettlement and land compensation concern. For instance, in 2022 the Barrik company received 422 grievances, with 202 of them related to resettlement and land compensation.

Examples: Mining induced displacement and resettlement worldwide

Mining in India lead to the displacement of about 1.5 million people between 1960 and 2000 (Fernandes & Walters, 2006). While according to Downing (2002) mining-related displacement in India affected more than 2.5 million people between 1950 and 1990.

More than 15,000 people, mostly Indigenous, have been displaced because of the development of the Grasberg copper and gold mine situated in the Papua province of Indonesia (New Guinea) (Hyndman, 1994). Many of the displaced inhabitants have fled to the lowlands, where malaria and other diseases have killed several hundred of them (Roberts, 1996).

In Germany, lignite mining operations transformed over 1,770 square kilometers (680 square miles) of the German countryside, disrupting land and water environments, forcing people to relocate, and increasing greenhouse gas emissions. Entire villages have been relocated to make way for these operations, causing disruption and loss of traditional homes. According to estimates, more than 300 communities have already been destroyed, and well over 100,000 people displaced by German lignite mining (Michel, 2008).

Population resettlement is generally carried out by the mining company in cooperation with local or regional authorities and consultants. According to Downing (2002), the following are distinguished: a) population displacement with expropriation of land and goods, without compensation; b) resettlement with compensation (money or construction of new assets); and c) rehabilitation, apart from resettlement and compensation, includes restoration of the social system of the displaced population. The costs of resettlement, especially rehabilitation, are high, but mining companies must accept them based on adopted international conventions on human rights and other binding declarations.

Managing displacement and resettlement: For all projects that involve involuntary resettlement, a Resettlement Action Plan (RAP) is required. This action plan must be prepared during the project preparation with the consultation with the affected communities with the aim to avoid or minimize negative social impacts caused by resettlement (IFC, 2002). In addition, mining companies can implement Livelihood Restoration Plan (LRP), Land Access Procedure (LAP) and Remedial Plans.

Possible Risks:

- Land Acquisition
- Unemployment
- Poverty
- Marginalization
- Spread of disease and increased mortality
- Human right violation
- Water supply disruption
- No access to school and education

Opportunities:

- Enable fair compensation and livelihood for the displaced population (SDG1, SDG 3, SDG 4, SDG 6, SDG8, SDG 15, SDG 16)

7) Impact on the environment

Mining, especially large-scale operations, results in deforestation and removal of vegetation and topsoil, movement of massive amount of rock, diversion of watercourses, use of chemicals to extract minerals, all of which can create various impact on air, soil, and water resources, affecting human health and well-being. The magnitude of these impacts depends on the legislation in each country, as well as the company's responsibility and adherence to standards and laws, investments in clean technologies, and transparency regarding monitoring results.

Major environmental impacts:

- Water accessibility and quality
- Waste generation
- Soil erosion
- Soil quality
- Air quality
- Vegetation and Biodiversity
- Climate-change

a. **Impact on the water resources**

Three major water consuming sector globally are municipalities, industries, and agriculture, while in Europe their respective water withdrawals (fresh water taken from ground or surface) are estimated at 26%, 45%, and 35% (UN, 2023). In the industrial sector, mining stands out as a large local water consumer, potentially influencing both the quantity and quality of water resources.

Water is resource significant for mining operations such as mineral extraction and processing, dust suppression, cooling of mechanization, mine closure and supporting the needs of workers. In the initial stages, during the development of a mine, activities such as vegetation removal, deforestation, and the construction of access roads may lead to soil erosion, increase sedimentation in watercourses, reduction of water infiltration and increase in surface runoff. These changes in hydrological regime can lead to undesirable effects such as floods, droughts, affecting the quality and availability of water.

Mineral processing is the stage with the highest water consumption (Moraga et al., 2023). Various factors affect the consumption and the embodied water (total water require to produce product or service) of a metal or mineral output such as mine type (open or underground), climate conditions, ore mineralogy and chemistry, initial moisture content of the ore, techniques used for metal extraction etc. (Mudd, 2008).

Consumption of water for ore extraction and processing, as well as for pump drainage in underground mine to reduce the risk of floods, can lead to the reduction of groundwater level which can have adverse effects. The consequences could be reduction of water available for the vegetation and loss of biodiversity, reduction of river flow and amount of water required for the agriculture, households.

In addition to the question of water availability, there arises the issue of its quality, influenced by various contaminating substances used in the extraction and processing of ore.

b. **Impact on the air**

Air pollution caused by mines is present in all phases of the life cycle of the mine and is most pronounced in the phases of construction, operation, and processing of raw materials (Environmental Law Alliance Worldwide 2010). The emission of potentially toxic particles (Cd, As, Pb, Cr, Cu, Ni, Zn) of various origins from mining complexes into the atmosphere occurs because of detonation of explosives, the operation of machinery in the mine, the transport of ore and tailings, the processing of raw materials and through wind, i.e., aeolian erosion (Batur & Babii, 2022). Very often, the impact of mines on air pollution continues even after the closure of the mine if remediation was not done or it was unsuccessful (Venkateswarlu et al., 2016; Monaci et al., 2023).

Particles of dust and harmful substances, after entering the atmosphere, undergo physical-chemical transformation processes before reaching the recipient. By means of the wind, the particles from the mine can be transported to a significant distance in relation to the place of origin, and due to atmospheric precipitation, they reach the soil (Environmental Law Alliance Worldwide, 2010; Su et al., 2022). Through agricultural production through the food chain,

these harmful substances enter the human body and represent a serious threat to human health (Shaheen et al., 2020).
A great danger to the human health of both miners and the communities living in the immediate vicinity of the mine is represented by PM2.5 and PM10 particles, which lead to the development of chronic lung diseases (Batur & Babii, 2022).

Example: Air pollution in Appalachian Coal Basin, USA

A significant amount of coal is produced within mines in the Appalachian Mountain range in America. In the 1990s these mines produced about 30% and in 2013 about 13% of the total amount of coal in the USA. Coal is mined both surface and underground. Several studies have found devastating rates of cancer diagnoses, with the number of cases doubling in areas where surface coal is mined. About 60,000 cases in this subject are directly related to the mining industry. In addition to cancer, respiratory diseases are also present in this area. This region experiences increased rates of cardiovascular diseases, with death rates increased in areas with open coal mines. In addition, in this region and especially in West Virginia and Kentucky, life expectancy is shorter than in the surrounding states. Dust particles released in the coal mining process have been directly linked to increased tumor growth, cardiovascular disease, and reduced life expectancy, pointing to a link between air pollution from the mining industry and human health.

c. Impact on the soil and land

Land degradation is an inevitable consequence of the mining industry, particularly in the case of open pit mines. In the context of mining, there is physical and chemical degradation of the soil resulting in the significant soil losses (Dragović & Vulević, 2021).

Physical degradation is reflected in the removal of the surface layer of the soil to get to the mineral raw materials that are found deeper in the lithosphere. This process leads to permanent soil loss as well as the destruction of plant and animal habitats. In addition, due to use of mechanization and detonations in the mine, there are significant vibrations that can be transmitted to the surrounding area of the mine. Vibrations can affect the collapse of the soil structure and the deterioration of the physical and water characteristics of arable land (Wang et al., 2021). Erosion processes also affect soil degradation in mines, especially in the case of open pits, which leads to a change in the deposition regime in the surrounding watercourses and their potential pollution, due to the transport of potentially toxic elements together with the soil (Environmental Law Alliance Worldwide, 2010).

Chemical soil degradation occurs during raw ore processing. Depending on the type of ore and the processing, various chemicals are used, which reach the soil through wastewater or washing from the air due to atmospheric precipitation (Mulenga, 2022). Transported particles of potentially toxic elements, salts or radioactive elements can reach the soil and can pose a serious risk to human health, if food is grown on such land (Shaheen et al., 2020; Mulenga, 2022).

The main consequences of land degradation are the impossibility of using the land for agriculture, which, in addition to mining, is one of the main activities in the communities in the mine area. The inability to produce food or reduced yields due to soil pollution can lead to the problem of food shortages for the local population and ultimately poverty. In addition, the use of contaminated land for food production can lead to health problems.

At the end of mine life cycle, the mine closure should be realized to ensure progressive rehabilitation (recontouring and revegetation) of mine site in alignment with the closure plan. This plan is required by the most regulatory agency before granting mining permits. Among other objectives, it aims to ensure human health and to guarantee the preservation of environmental resources (preventing any physical and chemical deterioration).

d. **Impact on climate-change**

Climate change generates many risks to the people and environment due to temperature increase, deterioration of air and water quality, sea level raise, changes in rainfall amount and patterns, and increase frequency and intensity of extreme weather events such as droughts and floods etc.

Mining contributes to the climate change through greenhouse gas (GHG) emission. This is occurring using fossil fuels to generate energy for mining operations, release of fugitive methane or carbon dioxide during coal mining, burning of coal, and removal of vegetation which is consider as significant carbon pool (Responsible Mining Foundation, 2019). To prepare and adapt to climate changes mining sector is requested to reduce energy and water consumption and environmental footprint (ibid.).

To meet the limit of global warming to 1.5°C by 2050, the mining industry must reduce direct CO_2 emission to zero. The diesel engine powered haul trucks are one the biggest source of emission. There are around 28,000 large haul trucks which consume approximately 900,000 liters of diesel per year and emit 68 million tons of CO2 (Muralidharan et al., 2019). Applying battery electric vehicle technology, replacing diesel with hydrogen, reforestation of degraded lands are possible strategies to meet emission target. Company investing in the rehabilitation of degraded lands promoting nature-based solutions (supporting carbon neutral world) demonstrate their commitment to sustainable business practice and social responsibility.

e. **Environmental responsible mining**

Mining operations must be conducted in a manner that balances resource extraction with environmental conservation, social responsibility, and long-term sustainability. A tool to achieve sustainability is Environmental Impact Assessment, that is required for the building and developing projects in EU. It provides procedure for environmental protection and require identification of all adverse effects and measures to avoid, prevent, reduce, or compensate possible impacts on the environment, and thus human health and well-being.

In accordance with that, “plan, do, check, act” is management approach adopted by many mining companies for environmental protection. It’s based on the identification and assessment of potential environmental impacts and risks, their prevention and mitigation, environmental monitoring and evaluation, and reporting.

Environmental risks:

- Water scarcity
- Water contamination
- Changes in hydrology
- Air pollution
- Dust
- Soil pollution
- Soil erosion
- Deforestation
- Habitat destruction
- Biodiversity loss
- Cultural heritage loss
- Global warming

Opportunities:

- Preserve land for agriculture production and other purpose (SDG 2, SDG11, DG12)
- Support biodiversity conservation project (SDG 13-SDG16)
- Realize mine-closure rehabilitation (SDG11-SDG 16)
- Reduce emissions (SDG3, SDG 6, SDG 11-SDG16)
- Reduce waste production (SDG3, SDG6, SDG11-SDG16)
- Reduce water consumption, recycle water (SDG 3, SDG 6, SDG11-SDG15
- Monitor and report environmental impacts (SDG17)

8) Impact on health and safety

Based on the definition of the World Health Organization, health is defined as "a state of complete physical, mental and social well-being and not merely the absence of disease or weakness" (WHO, 2020). A study (OECD, 2019) showed that communities in mining areas and their vicinity are in a significantly worse health condition.

The main problems related to human health in mining areas are water, air and soil pollution originating from the mining industry (Environmental Law Alliance Worldwide, 2010; Sahoo & Rout, 2023). Surface and underground water are often the only sources of water supply in underdeveloped communities where mines are established. As a result of mining activity, physical and chemical pollution of water occurs, mainly by products and by-products of the mining industry, such as heavy metals, various types of acids, etc. (Nguyen et al. 2018). In addition, incidents that may occur in mines such as breaching of dikes where tailings are stored or incidents in ore processing plants can seriously threaten water resources (Leuenberger et al., 2021). Using polluted water for drinking, in the household and in agriculture can lead to serious health problems. Mining areas are also characterized by air pollution. In addition to dust, the air is mostly polluted by high concentrations of toxic gases such as CO_2, CO, SO_2, NO and NO_2. Constant exposure to polluted air very often leads to various acute and chronic respiratory diseases, not only mine workers but also people living near the mine (Sahoo & Rout, 2023).

The land located in the immediate vicinity of the mine is mainly used for agricultural purposes. Pollution mainly by heavy metals and acidic oxides reaches the soil through wind or rain. The use of crops grown on such land in the diet leads to the introduction of harmful elements into the human body directly or indirectly, through the food chain, which leads to a violation of human health (Sahoo & Rout, 2023).

In addition to the above, noise generated by mechanization, detonation and incidents that occur in mines negatively affect the mental and physical health of both mine employees and people living near the mine (OECD, 2019).

Example: Health Impact of Kabwe Lead Mine

One example of the extremely negative impact of mines on human health is the Kabwe lead mine in Zambia. Although the mine with accompanying facilities for ore processing was closed in 1994, today over 300,000 people live in the contaminated area. According to data from the World Health Organization, there are no tolerant concentrations of lead in human blood. More than 95% of children in the area around the mine were tested positive for the presence of lead in their bodies, in concentrations higher than 10 µg/dL, which represents a high risk for their health. In the course of 2021, research funded by the World Bank was conducted in which children's health was tested. Data shows that about 2,500 children in Kabwe have blood lead concentrations greater than 45 µg/dL.

The toxic effects of lead on the central nervous system cause various types of diseases such as anemia, convulsions, brain damage and, in the last case, death, and have especially negative effects on children, impairing the development of the brain and nervous system. Experts emphasize the need for Zambia to fulfill its responsibilities, calling for decisive steps to protect the right to live with dignity, the right to health and the right to a clean environment, to ensure a dignified future for the country's children.

Mining contributes to health and safety through numerous initiatives related to health programs for employees, investments in health infrastructure, various educational programs in the local communities.

Positive example: Investment to tackle HIV and malaria in Sub-Saharan Africa

The Barrik company recognized the importance of tackling HIV and malaria identified as global development priorities through target 3.3 of SDG 3 (ending the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases as well as combatting hepatitis, water-borne illnesses, and other communicable diseases) within the communities surrounding the sites where they operate. In 2022, the company invested $1.67 million. Their teams run campaigns to fumigate homes, identify and treat sources of stagnant water, which is often a source of malaria-carrying mosquitoes. They invest in education and provide equipment and capacity to local health clinics for the treatment of diseases.

Possible risks:	Opportunities:
• Risk of fatality, injury, and illness	• Invest in workforce and community health programmes (SDG 3) • Monitor and report on possible health and safety risks (SDG 17)

9) Human rights

While mining stands an essential industry contributing to economic development, it frequently becomes associated with serious human right issues. Violations emerged through various phases of mine's life cycle, predominantly affecting workforce, population of the surrounding communities and Indigenous population. The rights of Indigenous people are according to the United Nations Human Rights Council, FPIC manifests related to be consulted, the right to participate and right to their land, territories, and resources.

Respecting human rights of workers employed in mining sector and the community who might be affected by mining activities lies in the core of the sustainability approach. The legal framework for defining and protecting human rights includes a series of laws and conventions whose foundations were laid in 1948 in the Universal Declaration of Human Rights, followed by two more conventions from 1966 - the International Convention on Economic, Social and Cultural Rights and the International Convention on Civil and Political Rights, which consider human rights through five basic categories: civil, cultural, economic, political and social rights (Handelsman et al., 2003). Also, it is important not to neglect the conventions on labor rights issued by the International Labor Organization, which refer to the rights of the Indigenous population and local tribes and which are related to development projects, especially mining (Spohr, 2016).

According to Amnesty International mining companies should ensure Right to no discrimination, Right to life and liberty, Ban on slavery, Ban on torture, Right on security of person, Right to privacy, right to property, right to freedom of religion, right to freedom of opinion, right to freedom of association, right to protection of labor standards, ban on interference with course of government and noninterference in legitimate internal affairs or inter-governmental relations of host country, ban on bribery.

Mining companies can affect the rights of the labor force they employ and the rights of the inner and wider community in both positive and negative terms. Labor rights are influenced by the offered working conditions, the safety of the working environment, health care, wages, (non)discriminatory treatment in employment, respect for the workforce. Also, rights may be affected in the case of slavery and servitude.

The impact on local communities may refer to the way land is appropriated for mining purposes (considering human consent and fair compensation), which can affect people's rights to land, territory, and culture, which can particularly affect Indigenous people. The responsibility of mining companies towards the environment can affect people's environment clean and healthy environment and access to resources (clean water, land for agricultural production, forests, etc.), and thus human health. If mining activities take place in conflict-affected areas, they can contribute to the financing of armed conflicts, which affect people's right to freedom and life.

Potential human right issue is recognized by the mining companies applying sustainability approach in their business. For any new mining project, evaluation of human rights is integrating into the Social Impact Assessments, which is updated for each operation sites.

Example: Violation of Indigenous people's rights

According to Hutakara Yanomami Association illegal mining in the Rondônia state is impacting the well-being of Indigenous communities. The association documented the death of nine children due to illnesses.

In 2022, Constitutional Court ruled in favour of the A'I Cofán Indigenous community of Sinogoe, confirming that the state had violated the community's rights to prior consultation, nature, water, healthy environment, culture, territory. This violation occurred by granting 20 mining concessions without their consent and processing 32 others that affected their land.

In 2020, during the ore mining by the Rio Tinto company in the Juukan Gorge area, Western Australia, sacred sites of Indigenous people were destroyed, including 60,000-year-old rock shelter.

Possible risks:

- Inequality
- Conflicts
- Grievance
- Sexual and gender base violence
- Slavery
- Health issues

Opportunities:

- Advocate open and inclusive dialog with government and civil society (SDG17)
- Manage their operation to provide health environment (SDG 3)
- Monitor and report human health and safety (SDG 3)
- Respect Indigenous people rights (SDG 16)
- Enable public participation and community involvement

Example: Human rights commitments

Newmont is committed to implementing the United Nations Guiding Principles on Business and Human Right. According to the Newmont publication 'Respecting Human Rights: Our approach' (2022) eight silent human rights risks are identified (table 2).

Table 2 – Salient human rights risks

	Human right issue	Example of stakeholder's concern	Example of action undertaken to address concern
1.	Right to life	Population influx due to new project developments increasing potential diseases and putting pressure on healthcare facilities, potentially leading to fatalities	Provision of social infrastructure and services (education, health, water, and sanitation); Population influx action plans
2.	Right to water and sanitation	Actual or perceived impact on water supply systems from mining activities	Community outreach activities and participatory monitoring
3.	Right to an adequate standard of living	Structural damage related to blasting complaints	Joint Company-Community-District Assembly committees for engagement and resolution planning
4.	Right to enjoy just and favorable conditions of work	Insufficient local employment opportunities	Encouraging business partners to recruit local people through criteria in tenders, promotion of alternative livelihood opportunities, training programs for employable skills
5.	Right to not be subject to discrimination in employment or occupation	Company's systems and processes are a barrier for inclusive employment	Employment pathways specific to local Indigenous people and the availability of scholarships through tertiary institutions; Listening exercises at Canadian sites with First Nation employees and contractors
6.	Right to health	Concerns about cyanide's impact on health	Third-party compliance with the International Cyanide Management Code, cyanide management plans, and public posting of all audit documents; Multi-company identification and verification of critical controls to prevent catastrophic spills; Wellbeing Framework
7.	Right to not be subject to slavery or forced labor	Government concerns around modern slavery issues in global supply chains (e.g., Australia)	Supplier Risk Management program; Public reporting on efforts in Modern Slavery Statement
8	Right to self-determination	Lack of coordinated and collaborative engagement with Indigenous groups on land management programs	Collaboration with land councils and academia on scoping studies and projects (e.g., on rehabilitation and closure and analysis of market opportunities for Indigenous people's programs)

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- Enable public participation and community involvement

Risks in the mining industry

The likelihood of experiencing adverse effects with potential negative consequences is defined as risk. In the mining industry, any adverse effects on health, communities, the environment, and the economy are regarded as risks, requiring the implementation of measures to maximize benefits and avoid, reduce, or mitigate negative impacts. Described are some of the risks arising from various social, economic, and environmental impacts of the mining industry on affected groups, which, of course, cannot be limited solely to those mentioned.

1) Gender inequality

In mining companies and communities where the mining industry is active, women are often disadvantaged compared to men (Campero et al., 2019; RMF, 2020). Women in mining communities are at increased risk of social and economic marginalization, sexual or gender-based violence and domestic violence as well as exclusion from community engagement (IRMA, 2022).

Some of the main indicators of gender inequality in the mining industry and communities are unequal employment opportunities, working conditions, large differences in compensation levels for performing similar jobs, inadequate compensation for land expropriation and general decision making.

According to data from the World Economic Forum (WEF, 2021), in 2019, 12.1% of the total number of employees were women in the mining industry, with a tendency to increase this number. Despite this, women who work in mining are often discriminated against based on gender, receiving lower wages, more difficult promotion in the hierarchy, or no promotion at all.

Examples:

Opening of mines in India were followed with a large displacement of population. Women who were primarily responsible for childcare and agricultural production due to displacement are facing a lack of land to cultivate and thus a lack of food for the household. In the absence of other employment options, they are forced to work in small private mines.

Although in the 20th century women made up 30 to 40% of the workforce in large mines, today they make up less than 12%. Large mines, especially coal, today depend more and more on technology and do not leave room for the inclusion of women, very often due to a lack of education, technical skills to operate machines and cultural prejudices.

Unlike large mines, the small-scale mining sector agrees to employ women, but mostly with short-term contracts and under conditions of high exploitation. In such mines, women's earnings are several times lower than men's, safety standards do not exist, and paid leave is not allowed even during and after pregnancy, mostly without adequate work equipment as well as with a lack of toilets and similar facilities. Also, women are exposed to physical and sexual exploitation by mine owners, entrepreneurs, and miners.

To contribute to gender equality (SDG 5), mining companies should avoid discriminating against women in procurement and professional development processes, refrain from neglecting gender-based violence, prevent the marginalization of women in decision-making processes. They should provide and maximize equal opportunities for women, actively recruit more women, ensure equal pay for both women and men, promote more women to prominent leadership roles, and adopt inclusive practices wherever possible.

2) Child labor

Child labor is a global social problem. The International Labor Organization defines child labor as any work that separates children from childhood and deprives them of their potential and dignity, in addition to harming their physical and mental health and social well-being (ILO - IPEC 2013). Based on data from the International Labor Organization (ILO, 2019), more than a million children are involved in working in mines and quarries in the world.

Child labor is more common in small, artisanal mines where the work is mostly done manually, without mechanization (O'Driscoll, 2017; ILO 2019; Metta et al., 2023). Workers in small, artisanal mines represent one of the most marginalized groups of workers (Gaffar & Kämpfer, 2023). The general informality and illegality of this mining sector in many cases leaves artisanal mine workers exposed to the harshest working conditions (World Bank 2020). In such cases, the most prominent problems are human and children's rights, including the worst forms of child labor.

Depending on the type of mine, children are subjected to a variety of hard physical jobs that carry high risks such as: manually digging tunnels underground using explosives and various types of primitive drills, carrying and breaking ore and tailings, handling heavy metals such as lead and mercury in ore separation processes, etc. (O'Driscoll, 2017; ILO, 2019). In addition to hard physical labor in mining, children are subjected to providing various services such as cooking and cleaning for superiors in the mines and selling goods, during which children suffer various forms of physical and verbal abuse (ILO, 2019).

Involvement of children in mine work can be voluntary or forced. The main reason for involving children in mine work is poverty caused by various social and economic factors, whereby children in some cases willingly agree to this type of work, while in some cases parents insist on employing children (Metta et al., 2023). In addition, the International Labor Organization (ILO, 2019) states that children are forced to work in mines because of debt slavery or human trafficking.

The consequences of child labor in artisanal and small-scale gold mining (ASGM) in some countries (Ghana, Burkina Faso, and Niger) is low education level due to children absent from school. According to report on children-mine gold, 35% of children employed at ASGM in Ghana, do not enroll at school at all, and additionally 32% do not attend regularly (Schipper et al., 2015).

Example: Child labor in Tanzania, Africa

Tanzania is the fourth largest gold producer in Africa. Based on ILO data (ILO, 2016), more than 30,000 children between the ages of 5 and 17 are involved in work in small artisanal mines, both girls and boys. On average, they work between 20 and 28 hours a week and are exposed to harsh working conditions that pose serious threats to their health (O'Driscoll, 2017). In small, artisanal gold mines in Tanzania, children perform a variety of work tasks: digging pits that range from a few to as much as 70 m deep, mostly with primitive tools such as shovels and hammers; work in underground tunnels in which they dig for ore, where they descend into the pits in primitive ways (using a rope or holding on to the sides of the pits); conveying and manual transport of ore, with sacks weighing up to 60 kg, as well as grinding ore into powder. Another very dangerous work process carried out by children is the separation of gold from tailings using mercury, where the process is carried out without any protection, with bare hands.

Elimination of child labor is supported by The International Program on the Elimination of Child Labor (EPIC) run in 1992 by the International Labor Organization. Mining companies should guarantee the absence of child labor in their operations or supply chain, as it contradicts the principles of fair labor and the dignity of children, aligning with SDG 8 (target 8.7).

Frequent monitoring and inspections can contribute to the reduction of child and forced labor, along with the implementation of laws and regulations designed to address these issues. Education and awareness-raising, as well as programs supporting education, health, and basic needs, are crucial elements.

3) Bribery and corruption

The mining industry has the potential to improve living standards, stimulate local and national economic development, generate tax revenues, and increase foreign investment, especially in rural underdeveloped areas. On the other hand, this sector is very vulnerable to corruption. According to the OECD report, one out of five bribery cases occur in the extractive industry (mining, quarries, oil and gas extraction and mining support services) (OECD, 2014).

Potential places where corruption occurs are, for example, when mining companies enter joint ventures, when companies work with subcontractors, when the government grants or changes mining licenses, when the government initiates routine mine inspections, when minerals are exported, and when collecting taxes (RMF, 2021). Based on the submitted reports, it was determined that companies or their representatives offer bribes to responsible persons in the government, but the opposite cases have also been reported (OECD, 2021).

Corruption has a wide range of negative effects: depriving the state of tax revenue, preventing economic prosperity, undermining the rule of law, and enabling crime. In addition to economic consequences, corruption in the mining industry also has social and environmental consequences, namely the violation of human rights and non-implementation of obligations related to environmental protection.

Examples:

Based on the audit, it was found that between 2010 and 2020, more than $400 million disappeared from a state-owned mining company in the Democratic Republic of Congo, which is involved in several of the world's largest cobalt and copper mining projects. The missing money is believed to have been embezzled. Also, in the same country, copper and cobalt contracts concluded between 2010 and 2012 through an agent, now punished for corruption (based on the US Magnitsky Act) led to the loss of 1.36 billion dollars from the state treasury. Large companies such as Tesla, General Motors, Samsung, LG and others are supplied with cobalt from companies involved in these businesses (Natural Resource Governance Institute, 2022).

In 2020, mining company Rio Tinto began negotiations with the UK Serious Fraud Office (SFO) seeking an agreement to avoid prosecution on bribery charges. In 2017, the SFO launched an investigation into suspected corruption related to the way Rio Tinto secured the rights to the Simandou iron ore mine in Guinea. Rio Tinto paid $10.5 million to a consultant who allegedly helped facilitate an iron ore mine deal with Guinea's then-president. Later, Rio Tinto fired the director responsible for the mentioned project as well as the head of legal affairs stating that they did not maintain the standards expected of them and which are defined by the company's global code of conduct (RMF, 2021).

Reducing bribery and corruption in the mining sector is possible through compliance with regulations, transparency in the licensing, permitting, and approval processes, inclusive and participatory decision making between government, mining and local community, NGOs, and other stakeholders. In addition, conducting regular training for employees on anti-corruption policies, and risk assessment could be effective bribery and corruption mitigation measures.

4) Poverty

The impact of the mining industry on poverty in the local community varies depending on several factors and can be positive or negative (Tsaurai, 2021). Mining can contribute to poverty reduction in several different ways, mostly directly, through generating income at the local and national level, providing employment opportunities for local people and providing opportunities for the development of other small businesses. Indirectly, the mining industry contributes to the reduction of poverty through investments in the local community, enabling better social services and stimulating the development of local infrastructure (Weber-Fahr et al., 2001).

On the other hand, the mining industry in some cases contributes to increasing poverty in local communities through income inequality (Ankra et al., 2017). The establishment of mines very often leads to the displacement of the local population, which in some cases can lead to an increase in poverty in the communities affected by the displacement. Changing one's place of living brings with it challenges of finding a new source of income (Terminski, 2012). Another factor that can contribute to the increase in poverty is the reduction in the volume of work and the closure of mines, whereby a large part of the community employed in the mine remains without a basic source of income (Ntema et al., 2017; Widana, 2021). Another thing that supports the claim that the mining industry does not have a positive impact on poverty reduction is research (Widana, 2021) that shows that the level of poverty is significantly higher in countries where the mining industry makes a significant share of GDP (DRC, Guinea-Bissau and Burundi) than in countries with lower incomes from the extraction of mineral resources (Chile, Angola, Algeria, Kyrgyzstan and Kazakhstan), where it is stated that the reason for this is the responsibility of the government that does not invest money in improving the standard of living, but also corruption, which is very common in mining industry.

Example:

Based on research (Nguyen et al., 2018) that compared mining (Phuoc Duc and Tam Lanh) and non-mining (Phuoc Nang and Tam An) communities in two different provinces in Vietnam. Based on statistical data at the local and provincial level, income data in communities where the mining industry is active were compared with communities where there is no mining activity.

Based on the data presented, in the period from 2010 to 2014, poverty in Phouc Nang (without the mining industry) was higher than in Phouc Duc (with a mine), and in 2014 this difference reached 12%. On the other hand, for the period from 2010 to 2013, the poverty rate was higher in Tam Lanh (with a mine) compared to Tam An (without a mining industry) and in 2014 the situation was reversed (poverty was higher in a place without mining activity). Also, for this observed period, there is a trend of poverty reduction.

Residents in both mining sites stated during the interviews that the mining industry contributed a lot to poverty reduction, stating that "the wages in the mines are regular and stable and very important for their families" and that "the income of the people who work in the mines is the main driver of poverty reduction" (Nguyen et al., 2018).

5) **Risks due to the mining withing the protected area, conserved area, and territory of Indigenous People**

Until 2020, the World Database on Protected Areas (WDPA) documented 260,000 protected areas spanning 250 countries globally (UNEP-WCMC and IUCN, 2020). These areas are significant for biodiversity conservation, serving as habitats for numerous species of animals and plants. Protected areas provide various ecosystem services (climate regulation, erosion control, provision of clean water, etc.), preserve traditional practices and cultural heritage, among other benefits.

The conflict between two sectors of mining and conservation emerges from the competition for resources and space between mining activities and endeavors to preserve biodiversity in protected areas. Possible negative impacts that could be expected due to the irresponsible mining within the protected areas are land take, habitat loss, degradation, pollution, accidents due to the tailing dam failure, human immigration, pressure on Indigenous peoples lives. The rights of Indigenous people are according to the United Nations Human Rights Council, FPIC manifests related to be consulted, the right to participate and right to their land, territories, and resources. Indigenous peoples inhabit a quarter of the world's land, covering approximately 38 million km^2 across 87 countries or politically distinct areas (Garnet et al. 2018) and they contribute to the sustainable land use and thus preservation of various habitats. They hold deep cultural and spiritual value for land which is conserved and managed using their traditional practices.

Example: Controversy of Mining in the Amazon: The Case of RENCA, Brazil

Brazil has the most extensive protected area system among all countries. In 2021, based on the UNEP-WCMC and IUCN database of protected and conserved areas, Brazil had 2.6 million square kilometers of protected lands. Between 2005 and 2015, a total of 11,670 km^2 of the Amazon Forest, one of the world's largest remaining tropical forests, was lost due to mining activities (Sonter et al., 2017). According to Global Atlas of Environmental Justice the RENCA (the ‘National Reserve of Copper and Associates’) Amazon reserve is the case where four conservation units are fully protected by mining, while in three other conservation units mining is permitted under the guidance of appropriate management plan. Additionally, within two Indigenous territories, commercial mining activities are effectively restricted. In 2017, there was controversy and concern when the Brazilian government, issued a decree to open up RENCA for mining activities. This faced strong opposition from environmentalists, Indigenous communities, and various organizations concerned about the potential environmental impacts and the infringement upon Indigenous lands. There are mining companies pending for the approval on mining on the approximately 10 million hectares of Indigenous land in Brazilian Legal Amazon which are home for the 43 Indigenous isolated groups (Villén-Pérez, et al. 2022). Allowing mining on Indigenous lands within the isolated groups could results in significant ecological, health and social consequences. The interaction between Indigenous communities and mining is characterized by heightened tensions and conflicts, particularly escalating during armed confrontations (Arbeláez-Ruiz, 2022). Results of the Beattie et al. (2023) indicated that 79% of the Indigenous People’s lands had experienced armed conflict.

IUCN members recommended that mining activities should be prohibited in the strict nature reserves, wilderness areas, national parks, national monument of feature and habitat/species management areas (Dudley, 2008). The decision to ban mining in these protected categories varies among countries, depending on their national legislations.

In 2007, the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) was adopted as an effort to promote sustainable mining practices within the territories of Indigenous peoples. It is mandated that states engage in consultations with Indigenous Peoples and secure their Free Prior and Informed Consent (EPIC) from the initiating any natural resource development project that may impact them (Bose, 2023).

6) Environmental Risks

Water-related risks that could affect communities depends on the location of mining operations, legal and regulatory compliance, the mining company itself, including the technology it employs, its management practices, and commitment to social responsibility and sustainable development. The most common risks that could arise due to the water extraction and consumption by the mining companies are related to the disruption of water availability, water contamination, and health and security.

a. Risk of Disruption of water availability

Mining water consumption varies depending on the climate condition, ore mineralogy, mine management and practice and commodity being mined. The problem of water availability is a challenge for mining companies, especially in arid and semi-arid regions characterized by water deficiency. Due to the drier periods at high water demand operations and increased production demand, some companies are experiencing a rising trend in water withdrawal. The example is AngloGold Ashanti, with an estimated water withdrawal from ground and surface water bodies reaching 34,721 megaliters in 2022, reflecting a 29% increase from the levels observed in 2018.

Lower ore grade requires more water and energy for processing and generates greater quantities of waste per ton of product (Lubuzh et al., 2023; Mudd, 2008). In general, precious metals, gold, platinum, diamonds, nickel, and copper require greater water usage to separate the ore from the rock. Around 90 cubic meters of water is needed to produce one ton of copper, and around 2,000 cubic meters of water to produce one ton of lithium (Lubuzh et al., 2023).

It is essential that mining companies ensure that local population has sufficient water for their needs avoiding situation that occurred to the Tendele's open cast coal mine in Somkhele, South Africa which left the local community without water for several weeks.

b. Water contamination risk

Surface water and groundwater pollution in one of the major concerns (Kivinen et al., 2020). The potential contaminants come from Acid Mine Drainage (AMD), heavy metal (such as arsenic, lead, mercury, cadmium) contamination and leaching, chemical pollution, erosion, and sedimentation (https://www.safewater.org/). Mining can endanger the quantity of water available to communities especially in the area with unstable water resources and inadequate mine water management (IGF, 2022).

Contamination can occur due to incidents that may arise accidentally or as a result of human error, encompassing accidents in ore processing facilities, incidents in warehouses, potential dam breaches, and the release of large quantities of tailings (Environmental Law Alliance Worldwide, 2010, Mononen et al., 2022). The discharge of mine wastewater into natural watercourses was a common practice, but it can vary widely depending on the environmental regulations, and standards in place in a particular region or country. Some mining companies have historically engaged in this practice, releasing treated or untreated mine water into rivers or other natural water bodies. However, this has been a source of environmental concern due to the potential for water pollution, habitat disruption, and negative impacts on aquatic ecosystems.

As a result of mining activity, the quality of surface and underground water is often damaged in physical, chemical, and biological terms through the direct or indirect release of harmful substances (cyanides, mercury, arsenic, selenium, heavy metals, acids, etc.) into water bodies (Li et al. al., 2018). Contamination of water with these harmful elements has a direct impact on aquatic ecosystems and human health (Beck et al., 2020; Mononen et al., 2022).

Examples:

1. Baia Madre cyanide-contamination, Romania

In 2000, the Baia Mare mine in Romania experienced a dam failure, resulting in the release of 100,000 cubic meter of cyanide-contaminated water that flowed into farmlands and the river system. The polluted waters extended to Hungary and Serbia, leading to the death of significant amounts of fish in the Tisza and Danube rivers.

2. Ok Tedi copper mine tailing spill, Papua, New Guinea

Ok Tedi copper mine is situated in rain-forest region in Papua New Guinea, which released tailings waste into the Ok Tedi tributary of the Fly River, resulting in increased sedimentation, frequent flooding, and water contamination. For nearly twenty years, the mine has released approximately 30 million tons of metal-contaminated mine tailings and 40 million tons of waste rock annually into the Ok Tedi River, causing severe consequences for the 50,000 residents from 120 villages who rely on the rivers for subsistence fishing and other resources (United Nations Development Programme, United Nations Environment Programme, World bank, & World Resources Institute, 2003).

3. QMMM Ilmenite mine, Madagaskar

One instance of irresponsible wastewater management in mining is the QMM ilmenite mine in Madagascar operated by Rio Tinto. A 2019 investigation by the Andrew Lees Trust revealed that the mining activities exceeded permitted limits in the Lake Besaroy basin conservation area, potentially endangering the water body. Downstream water from the mine was found to be contaminated with elevated levels of uranium and lead, up to 350 times the permitted levels, linked to mineral extraction processes. These concentrations exceed WHO drinking water standards and pose a serious health risk to the 15 thousand people relying on the water for various purposes. The study also highlighted increased health issues reported by the local population, emphasizing the lack of company consultation and transparency. However, Rio Tinto denies responsibility for elevated concentrations of uranium and lead, claiming that they are naturally present in this area. (RMF, 2021).

Managing water-related risks. Mining companies should implement water stewardship strategies and plans to ensure responsible and socially equitable use of water. Water use can be managed planning the water usage according to seasonal variations and climate change scenarios and investing in efficient technologies that reduce the amount of water required for some operations (IGF, 2022).

The water footprint can be reduced by reducing losses (filtering tailings, minimizing wet areas), increasing the local supply of water (through shared use water infrastructure), using dry processing technologies, obtaining water from appropriate sources (treated wastewater, desalinated seawater) (IEA, 2022). The water efficiency strategies are of particular importance due to the possibility that authorities (e.g., government agency responsible water resource management) increase regulations and reduce the rate of water extraction.

Dewatering of a tailing Storage Facilities is related to the reduction of tailing slurry volume and represent possibility for mines to recover more water and reduce tailing footprint. The use of centrifuges for dewatering tailing is a technology that can achieve 90% water recovery (Klug, R and Schwarz, 2019).

Desalination of seawater is one of the ways to reduce the use of fresh water in mining and contribute to the conservation of this limited resource. The supply of water mining companies could increase through investment in the water and sanitation infrastructure (SDG 6) for the local community as a part of their corporate social responsibility initiatives.

One of the technologies that has be developed to reduce the water usage is **magnetic resonance (MR)** performing at the mine site to determine the high-grade ore portion. Real-time analysis is performed by measuring the radio impulse resonance from ore batches, and low-grade ore portions are discarded immediately and transported to the dump (Lubuzh et al. 2023). Therefore, the technology can significantly decrease water consumption by reducing mineral processing volumes.

Modern technologies such as analytics-backed **Internet of Things (IoT) sensors and artificial intelligence (AI)** can maximize wastewater reuse and reduce energy consumption in mining operations' wastewater/water treatment processes.

Water monitoring and reporting are essential obligations of mining companies to ensure compliance with environmental standards, to enhance transparency and keep community informed about potential impacts.

Examples of good practices:

1) Water supply in BHP's Escondida copper mine, Chile

Chile is one the world's largest producer of copper and lithium with reserves of 200 million metric tons of copper and 9.2 million metric tons of lithium (Lubuzh, et al. 2023). The largest reserves are in the arid regions on the north of the country. Escondida is copper mine in Atacama Desert in Norther Chile, one of the driest regions in the world. During 2022 this mine produces 1 million tons of copper. For mining operations, they practiced using groundwater, sourced from the aquifer located in the Salar de Atacama. The company shift to desalinated water supply, thanks to US$4 billion investment in desalination plants over the past 15 years as well as operational enhancements resulting in the reduction of Escondida's net water consumption per ton of processed ore (https://www.bhp.com/).

2) Cerro Verde copper mine, Peru - sustainable water initiative

Cerro Verde copper mine, located in arid region of Arequipa in Peru. It's one of the largest copper reserves in the country estimated as 4.63 billion tons of copper. When company planning the mine expansion, security access to water for ore processing was crucial. Operating in the water scarce area, Cerro Verde aimed to avoid conflicts over water resources by engaging stakeholders. Recognizing the importance of clean water access, especially for agriculture (80% of water use in Arequipa), the mine explored using the municipal wastewater. In 2011, Cerro Verde partnered with regional and municipal government and water authorities to plan, built, finance and operate a wastewater treatment plant. The $450 million plant, commissioned in 2015, treats 85% of Arequipa's municipal sewage, providing treated water for mining operations. The plant's capacity is projected to increase in the future expansions to meet the growing population of Arequipa. The collaboration addressed water scarcity concerns, utilizing the treated wastewater as a reliable supply without competing with farmers for fresh water (Jocelin, 2018).

7) Health and safety risks

Mining is an industry characterized by high risks, including a substantial frequency of accidents and disasters. These risks include accidents such as explosions, collapses in mining tunnels, injury risks, chemical risks due to poisoning by chemicals, risks of noise and vibration, risks to mental health, as well as risks of accidents due to the failure of tailings dams.

Various internal factors such as lack of safety protocols, inadequate worker training, use of outdated equipment, and improper maintenance contribute to these risks. External factors such as weather conditions or geological instability can also pose health and safety risks. Workers in the mining industry and local communities are primarily exposed to harmful influences. Additionally, certain population groups including woman, children, elderly, Indigenous peoples, and individuals with disabilities may be more vulnerable to specific risk.

Examples:

1) Flood caused failure in floatation plant Stolice, Kostajnik, Serbia

At the closed flotation plant Stolice in Kostajnik, Serbia containing approximately 1.2 million tons of mining waste, a significant incident occurred during the catastrophic floods in May 2014 (Vidojević et al., 2015). Excessive water accumulation within the tailings dam led to reduced dam stability, resulting in its failure. Over 100,000 m^3 of tailings mud flowed into the Kostajnik stream, creating the Korenita River, a seasonal tributary of the Jadar River. Downstream, a floodwater covered a 50-75-meter-wide strip on both banks, depositing sediment 5-10 cm thick. Through the examination of soil degradation, concentrations of Zn, Pb, Cd, Sb, and Hg were found to exceed the remediation values prescribed by the national legislation (Belanović Simić et al., 2018).

2) Lead poisoning in artisanal gold mining in Zamfara, Nigeria

Zamfara is state with significant deposits of gold where acute lead poisoning of child is a result of artisanal gold mining (https://www.hrw.org). In 2010, due to the unregulated mining in northern state of Zamfara, around 400 children under the age of 5 died due to the lead poisoning (Tirima et al. 2018). Exposure to lead is particularly harmful to the children due to their behavioral habits such as frequent hand-to-mouth activities and the concentration of the lead in soil samples at some sites goes to the 100,000 ppm, and exceed U.S. EPA threshold of 400 ppm (Dooyema et al. 2011). Direct exposure to the contamination was reduced after the remediation program that started in 2010, but until that period serious health consequences occurred due to the cultural/religious and diet habits of the people. The woman employed in the mining conducted the ore processing within the residents, because of the purdah which involves the sequestration of married women within residential areas. In the same contaminated area, women prepared food where a flour mill was used for both grinding flour and crushing ore.

Managing health and safety risks. To avoid and minimize health and safety risks that could arise from mine site during the whole life cycle, their proper identification, analysis, and management is necessary. Health impact assessment (HIA) are procedures and tools that enable to analyze potential impacts on the health, developing options for maximizing positive health impacts and avoid and minimizing the negative impacts. The guidelines for the HIA is provided by the ICMM (https://www.icmm.com/).

a. **Tailing dam failure and disaster risk**

The tailings dam disaster risk could be considered as environmental and health and safety risk. The mining industry generates a huge amount of waste, potentially reaching 65 billion tons annually, resulting in the production of billions of tons of mine tailings each year (Kalisz et al., 2022; Owen et al., 2020a). Common types of mining waste include waste rock, tailings, slag, and hazardous waste, necessitating specialized handling and disposal methods. Tailings, generated post-crushing and processing of ore into concentrate, are typically stored as a slurry within Tailings Storage Facilities (TSFs). Tailing dams are commonly constructed to expand the storage capacity of TSFs (Piciullo et al., 2022). According to the World Mine Tailings Failures organization (WMTF, 2020), the global count of constructed TSFs is estimated to be around 32,000. Post-2020, incidents resulted in 115 million m^3 of contaminated residues and 640 fatalities, contributing to severe environmental and human tragedies (Piciullo, et al., 2022).

Examples:

The Fundão Dam failure, state of Minas Gerais, Brazil

The Fundão Dam served as a storage facility for tailings from the iron ore mine within the Samarco Mariana Mining Complex, Brazil. In 2015, it experienced a catastrophic failure, resulting in the release of 44.4 million cubic meters of tailing. The subsequent flooding devastated the downstream villages of Bento Rodrigues and Paracatu de Baixo, claiming the lives of 19 individuals including the 14 workers at the dam site and 5 inhabitants of the Bento Rodrigues (Czajkowski et al., 2023; Sánchez et al., 2018). However, the impact extended beyond, with the tailings contaminating a stretch of 675 km along the Doce River, affecting 40 municipalities before reaching the Atlantic Ocean (Scarpelin et al., 2022). The consequences include the displacement of 220 families, the destruction of 218 buildings and the devastation of 1,496 ha of natural vegetation (Sánchez et al., 2018).

Brumadinho tailings dam disaster, state of Minas Gerais, Brazil

The Brumadinho tailings dam was a structure located within the Córrego do Feijão iron ore mine, operated by Vale S.A. in Brazil. In 2019, the dam experienced a catastrophic collapse, releasing a massive torrent of 9 million cubic meters of mine waste (equivalent to 75% of the pre-failure volume of tailings). The unleashed mudflow surged out of the dam in a span of 5 minutes, resulting in the tragic loss of at least 259 lives, with most of the victims being employees at the mine (Kobayashi et al., 2023; Robertson et al., 2019). The devastating mudflow wreaked havoc on the Córrego do Feijão district, causing damage to several rural properties, as well as destroying sections of a railway bridge and approximately 100 meters of railway track (Robertson et al., 2019).

Mining waste management is necessary due to potential for contamination of the water, air and soil and risk to human health and safety caused by catastrophic failure of waste storage facilities. Managing mine waste involve minimizing waste generation and subsequently ensuring the long-term physical and chemical stability of mine waste and management facilities (IGF, 2021). This aligns with specific SDGs, notably 6, 8, 13, 14, and 15, thereby promoting clean water, sustainability of oceans and rivers, resilience to climate impacts, and local economic prosperity (IGF, 2021). It is important to develop strong policy on mine waste management, including waste management plan that is developed within the Environmental Impact Assessment (EIA) following the set of international standards. The Global Industry Standard on Tailings Management provide framework for safe tailings facility management with requirements that cover six topic area: I. affected communities and their rights, II. knowledge base about social, environmental, and local economic context, III. engineering design, construction, operation, and monitoring of tailing facility, IV. management and governance, V. emergency response and long-term recovery and VI. public disclosure and access to information (International Council of Mining on Mining and Metals et al., 2020).

Examples of good practices: Management of Tailings storage facilities

AngloGold Ashanti is one of the mining companies that apply Global Industry Standards on Tailings Management (GISTM). This company has 34 TSFs constructed to a strict set of standards and carefully managed and monitored (https://www.anglogoldashanti.com/). It's one of the companies with the high-performance tracking and corrective actions to improve effectiveness of tailing facility management. In response to tailing management legislation changes in Brazil, after the Brumadinho TSF failure in 2019, this company make a transition toward filtered tailing deposition. Serra Grande mine is the first mine in Brazil that implement filtered tailings disposal system, and compared to the conventional TSF, doesn't have water reservoir, and thus reduce the risk of accidents and environmental incidents.

Glencore mining company has TSFs designed to the requirements of standards that support design resilient in the event of rapid extreme rainfall. The company regularly inspect their facilities and the external inspections conduct independent review. Additionally, they apply satellite monitoring as a mitigation measure to tailings risk management. In 2020, the company expand satellite monitoring to over 110 of its dams. The monitoring provides measurements of surface movements every 11 days.

According to the Barrick sustainability Report for the 2022, the company is managing 60 TSFs (18 active and 42 closed). The riverine tailings disposal system is used in the case of Porgera Joint Venture an open pit and underground gold mine in Papua New Guinea. The tailings are realised into the Porgera River instead of being disposal in a TSF, due to high risk of collapse caused by heavy rainfall and earthquakes. Before discharge into the river the tailings undergo two stages treatment process to destroy cyanide and raise pH value of the water. The company is committed to minimizing risk associate to riverine disposal.

8) Illegal mining

United Nation Office on Drugs and Crime define Illegal mining as extraction of valuable minerals and metals without appropriate land rights, exploration and mining licenses, and other permits with negative impacts on peace, security, stability, justice, environment, and economy. Health and safety risk of illegal mining are one of its most important detrimental effects.

Martins-Filho et al. (2024) found the connection between the malaria-related incidence and mortality and illegal gold mining within the Brazilian Yanomami territory which is the home for 30,000 Indigenous individuals. Their land was opened for mining from the 1980s when 45,000 miners entered the territory resulting in 20% of population succumbed to diseases within the 7 years (Risso et al., 2021).

The reason for uncontrolled illegal mining could be lack of enforcement by state authorities (Espin & Perz, 2021). These authors investigated the reasons for the low enforcement effectiveness in the case of illegal gold mining in region of Madre de Dios in the Peruvian Amazon. They considered insufficient resource that should be distributed among the state agencies at different levels (local, state, national) and lack of collaboration among enforcement agencies (such as Ministry of Environment and Ministry of Energy) as a the most important factor.

Example: Illegal mining activities within the territories of Indonesia

Indonesia is considered as resource rich-country with 3,600,00 miners engaged in artisanal and small-scaling mining (ASM) (https://artisanalmining.org/Inventory/). Around 900,000 workers are employed at artisanal small-scale gold mining (ASGM) which is considered as illegal primarily it takes place without the formal permit to operate and involves illegal substances such as mercury (Meutia et al., 2023). Discharged of mercury waste into the river such as Bone River in the Gorontalo Province lead to the water pollution, and people positioning. Gafur et al. (2018) found high concentration of As, Hg and Pb in the water from Bone River from 66 to 82,500 µg/L, 17 to 2080 µg/L, and 11 to 1670 µg/L, respectively, exceeding the WHO's guideline value (i.e., 10 µg/L, 6.0 µg/L, and 10 µg/L, respectively (World Health Organization, 2022). One of the common consequences of mining in is destruction of Indonesian forests There were also a conflict between the local community and Gorontalo Minerals Ltd on the utilization of limited forest space.

Knowledge transfer

It is crucial to acknowledge that the sustainable resource management is a shared responsibility that requires a collective effort from diverse sectors and stakeholders. Defining the specific roles of stakeholders and ways in which they can contribute to responsible mining is vital. The basic facts about responsible mining and, in general, responsible metal sourcing, should become a common knowledge to allow for an informed, rational and fair decision for all. The educational goal should be set beyond “only the social groups directly concerned”.

Below, in the table 3, we considered five categories: citizens, students, researchers, companies, and policy makers, with an aim to advice on the knowledge to be transferred to each of them. We then propose ways to achieve the knowledge transfer and how HERawS can contribute to this task. The results are summarized in the table 3 below.

Table 3 – Five major target groups for responsible mining guidelines

	Knowledge to be transmitted	Actions and means to convey the knowledge	How HERawS can help?
Citiziens	• demystifying the idea of a "dirty mine"; • that currently recycling cannot cover our need in metals; • sourcing metals from outside EU may lead to higher dependency from other countries; • which social and environmental consequences mining can have	• via a documentary, podcasts, exhibition, journal articles	• HERawS can provide a tool to understand the consequences of consumer's choice; prepare an exposition for general public
Students	• understanding the issue of critical raw materials and their impacts;	• via training courses on critical materials for the green and digital transition, podcasts, conferences	• HERawS can provide training courses and a reliable source of information to gain and improve knowledge
Researchers	• highlight the raw material challenges considering sustainable development; challenges that the companies may face on different levels	• research and transfer knowledge to the academia, society, and industry via articles, scientists' mobility, conferences	• HERawS an interactive platform and training programs for the target group to raise awareness about raw material issue
Companies	• develop Innovative solutions that support the green transition; • respect human rights and avoid conflicts in their mineral sourcing practice; • incorporate relevant SDGs into their business	• improve knowledge and demonstrate a high level of environmental and social commitment via interactive platform and training course	• HERawS can deliver an interactive platform and training course on the impacts of raw materials in developing innovative devices. • use OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas; • document Mapping Mining to the Sustainable Development Goal: An Atlas
Policy makers	• provide essential support to the mining sector in achieving a higher level of sustainability; • consider the power imbalance between the Indigenous people / local community and the mining company; reinforce the principle of free, prior and informed consent	• establishing laws, regulations, policies and strong environmental standards; implementing environmental standards, conducting environmental impact assessments, and providing permits etc. • Promoting dialogue via conferences, organized trainings. Regular exchange with representatives of the groups impacted by mining activities.	• HERawS can offer training sessions with policy makers.

Sustainable development and mining

Sustainability, a concept underlining the need for a balance between economic development, social justice, and environmental responsibility, gained prominence through its definition in the Brundtland Report 'Our Common Future' (WCED, 1987). This shaped the understanding of sustainable development as a process that meets current needs without compromising the ability of future generations to meet theirs. As a pivotal event in promoting sustainability, the UN Conference on Environment and Development in Rio de Janeiro in 1992, also known as the 'Earth Summit' laid the foundation for integrating sustainability into the global political agenda. Another significant step towards achieving sustainable development is the 2030 Agenda, adopted in 2015, which outlines 17 Sustainable Development Goals (SDGs), providing a concrete plan for achieving global balance by 2030.

Numerous initiatives, programs, and organizations, including UN agencies, non-governmental organizations, and industry groups, are working to support mining companies to incorporate relevant SDGs in their business and operations. The OECD's Mining Cities and Regions Initiative is promoting international standards that aim to improve identify main strengths and challenges and improve well-being in mining regions (https://www.oecd.org/). The initiative aims to enhance sustainability in mining through field case studies, fostering collaboration with stakeholders, and formulating policy recommendations. The Mining, Minerals, and Sustainable Development (MMSD) Project, initiated by the International Institute for Environment and Development (IIED) aimed to provide a global review of the minerals sector and its relationship with sustainable development. It involved extensive research, consultations, and the collaboration of various stakeholders, including governments, industry representatives, and non-governmental organizations. The MMSD project produced a final report in 2002, known as the 'Breaking New Ground: Mining minerals and Sustainable Development' report, which presented findings and recommendations for fostering sustainable development in the mining and minerals sector (IIED, 2002).

Many of the Sustainable Development Goals (SDGs) could not be reached without the contribution of minerals and metals (Figure 1) which are fueling the manufacturing sector and creating jobs and value added along the supply chains of material goods. At the same time, the production of mineral raw materials can generate negative environmental and social impacts, constraining the achievement of other sustainable development goals (e.g., climate action, good health, clean water) (Mancini et.al., 2018). This commitment is crucial in obtaining social license to operate (SLO) which refers to the project's social acceptance contingent on its actual performance (Hall et al. 2015; Slack, 2012).

The mining industry has the chance and capacity to make positive contributions to all 17 SDGs in various ways, including:

SDG1 – End Poverty: Eradicating extreme poverty for all people everywhere by 2030 is a pivotal goal of the 2030 Agenda for Sustainable Development. Mining plays a critical role in the fight against poverty, even though it might not be immediately associated with social development and poverty eradication. We can reduce poverty through direct employment, local sourcing, tax and royalties, infrastructure development, alternate livelihoods. Mining creates thousands of direct jobs, often in remote and underdeveloped regions. For instance, in 2020, Barrick Gold Corporation provided direct employment to 20,000 people across 13 countries (Barrick Annual Report, 2020). These jobs not only sustain families but also contribute to local economies. Mining companies procure goods and services from local suppliers, which stimulates economic activity. The scale of mining necessitates the development of significant infrastructure. Roads, schools, healthcare facilities, and other essential services are often established due to mining operations, benefiting local communities. By creating jobs and contributing to economic growth, mining companies offer alternate livelihoods to those left behind by society. This responsibility is fundamental for any modern mining company.

Figure 1: Mining and the 17 SDGs. A selection of most major issue areas where mining may have an impact (positive or negative) on each of the 17 goals. Readers are referred to the individual chapters and diagrams for each goal for a detailed and more comprehensive discussion. Icons adapted from http://www.globalgoals.org/. Abbreviations: EIDs = emerging infectious diseases; OSH = occupational safety and health; TVET = technical, vocational, and educational training; CCS = carbon capture and storage; IFFs = illicit financial flows; FPIC = free, prior, and informed consent; PPPs = public-private partnerships.

Figure 1. Major Issue areas for mining and the SDGs (Source: Sonesson, et al., 2016)

SDG 2 – Zero hunger: The main goals are to ensure food security, improved nutrition, and sustainable agriculture. Mining can have an adverse impact on the availability of land and quality of soil for agriculture, affecting its sustainability and ability to ensure food and nutritional security. However, post-mine closure planning can mitigate adverse impacts and even improve overall outcomes. Additionally, mining can ensure the production of phosphates and other “fertilizer minerals” necessary for agriculture.

SDG5 – Gender Equality: In many countries, mining laws and regulations neither fully mainstream the principle of gender equality nor acknowledge women as active participants in the sector. This often results in women receiving only a minimal share of the benefits of the mining sector while being disproportionately affected by its environmental, social, economic, and cultural impacts. Governments need to act proactively to remedy gender inequalities exacerbated by the sector and implement mining policy frameworks that ensure the empowerment of women, girls, and others that are negatively impacted by mining operations.

Sadan and Dan (2021) observe that “gender is often completely overlooked in development policy approaches to small-scale mining because of assumptions that mining is intrinsically a male concern”.

SDG6 – Clean Water and Sanitation: The 2030 Agenda for Sustainable Development sets an ambitious goal of achieving universal access to improved and reliable water and sanitation for all) by 2030. Despite significant progress in providing clean drinking water and improved sanitation infrastructure over the past decades, persistent gaps in access still exist. In 2017, 2.2 billion people lacked access to safely managed drinking water, and 4.2 billion people lacked access to safely managed sanitation facilities (UN,2020). However, achieving this goal requires substantial resources, which are particularly scarce in regions that are currently far from meeting SDG 6. Ensuring equitable access to water and sanitation remains a critical challenge, and addressing it is essential for the well-being of people and the planet. Mining projects can put additional strains on often already overburdened water and sanitation systems in communities.

SDG7 – Energy Access and Sustainability: Mining enables the use of Technology Metals, Energy Critical Metals and Rare Earth Metals which have applications in energy efficiency and renewable energy generation presenting opportunities for greater efficiency as well as expanding access to energy.
SDG8 – Decent Work and Economic Growth: New economic opportunities for citizens and members of local communities, including jobs, training, and business development relating to mining operations, associated service providers, or new local economies linked to the mine, can be generated by mining.

SDG9 – ***Infrastructure, Innovation and Industrialization:*** Economic development and diversification can be driven by mining through direct and indirect economic benefits and by spurring the construction of new infrastructure for transport, communications, water and energy. Additionally, mining provides materials critical for renewable technologies and the opportunity for companies to collaborate across the supply chain to minimize waste, and to reuse and recycle.

SDG10 – Reduced Inequalities: Inequality jeopardizes sustainable social and economic progress, undermines poverty alleviation efforts, and erodes individuals’ feelings of fulfillment and self-worth. This was avoided in Peru through mining which has a dual impact on local communities. First, the better educated immigrants required and attracted by mining activity and, second, the jobs that some community natives obtain in industries and services related to mining (Loayza & Rigolini, 2016)

SDG 11- Inclusive, safe, resilient, and sustainable cities and human settlements: Mining is an essential industry that significantly impacts our lives. The modern economy heavily relies on mining. From the inner workings of computers and chips to the batteries inside cars, metals and minerals extracted from the earth directly touch the lives of countless individuals. These resources are vital for providing infrastructure and supporting services like energy and transportation. Metals extracted from mining contribute to the construction of buildings, roads, bridges, and other essential structures. As the world aims to transition to clean energy and combat climate change, the demand for these resources is skyrocketing. The World Bank projects a 500% increase in graphite, cobalt, and lithium production by 2050 (World Bank, 2020). To prevent supply shortages, more than 300 new mines extracting critical minerals will be required by 2030. Technologies critical to the green revolution, such as electric vehicles (EVs), solar panels, and wind power, rely heavily on minerals and metals. Despite the growing demand, the world remains largely unprepared to meet it. Only about 25 new greenfield mineral discoveries are made each year, and financing for new mines is limited. The time required to move from identifying a mineral deposit to extraction poses further challenges. Increasing mineral supply is crucial for achieving environmental and development goals. Mining plays a pivotal role in shaping our future, from powering clean energy solutions to building resilient structures. Public awareness of its importance is essential to garner support for increased mining activity.

SDG 12 - Ensure sustainable consumption and production patterns.
This goal includes the following targets that are particularly relevant to mining:
- Achieve the sustainable management and efficient use of natural resources.
- Achieve the environmentally sound management of chemicals and all wastes throughout their life cycle.
- Substantially reduce waste generation through prevention, reduction, recycling, and reuse.
- Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle.
- Ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.
- Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production.

SDG 13 – Climate Action: Energy Access and Sustainability is linked to climate change and climate action. The mining activities can influence on decrease in emissions and increased energy efficiency (and green energy) in mining operations. However, the most mining activities are very aggressive for climate.

SDG 15 – Life on Land**:** Mining affects life and biodiversity mostly negatively. Mining and its related infrastructure can have disruptive effects on ecosystems that provide valuable services to society and rely on biodiversity. The 'mitigation hierarchy,' which includes steps like avoidance, minimization, restoration, enhancement, and offsetting, offers a framework for mining companies to evaluate and implement measures to safeguard ecosystems and biodiversity. Additionally, since mining leases often cover extensive land areas beyond the immediate mining footprint, mining companies have a significant role to play in biodiversity conservation and management.

SDG16 – Peace, Justice and Strong Institutions**:** The extractive industry is often associated with social conflict due to the perceived unequal distribution of benefits. However, the mining industry can contribute to peaceful societies and the rule of law by preventing and resolving conflicts between companies and communities, respecting human rights and the rights of vulnerable groups, avoiding illegal transfers of funds to public officials or other individuals, ensuring transparent reporting of revenue flows, and supporting the decision-making of citizens and communities in extractive development.

Sustainable development in mining context requires commitments to respect environmental and human rights standards throughout its lifecycle (Hilson & Murck, 2000). This commitment is crucial in obtaining social license to operate (SLO) which refers to the project's social acceptance contingent on its actual performance (Hall et al., 2015; Slack, 2012).

The extractive industry uses term Corporate Social Responsibility (CSR) to refer to these commitments and in their annual reports (called Sustainability Report) they are offering data on their investments in biodiversity hotspots and healthcare, not reporting about the adverse impacts of their actions. From the ecological point of view, mining is inherently unsustainable, and CSR is used as a strategy to mask adverse effects and neutralize criticism (Kirsch, 2010). The intention to conceal certain environmental impacts or overlook mitigation measures is evident in the Environmental Impact Assessment, as companies often prioritize the benefits they provide over costs (Slack, 2012). Consequently, there is a deviation in the company's actual actions compared to what it asserts as part of its CSR. This is a key factor contributing to the loss of community trust, and potential for enforced suspension of their operations.

Addressing this requires open and inclusive dialogues with communities, attentiveness to their concerns, making realistic promises and thereby fostering a mutually beneficial relationship. The community should be consulted throughout the life of a mine. The government should establish policies and regulations that encourage sustainable mining practices and ensure that mining companies comply with these policies and regulations. In addition, partnerships with academic communities, research institutions, NGOs, and other prominent groups can provide essential support to the mining sector in achieving higher level of sustainability (Hilson & Murck, 2000).

It is important to note that sustainable management is not just the sole responsibility of one sector but requires a collective effort. Governments, company, and community all have a role in promoting sustainable practices. Governments can create policies and regulations that encouraging sustainable practices, companies can adopt sustainable supply chain management practices and promote resource efficiency. Community can contribute by making sustainable choices in their daily lives, such as reducing waste and conserving energy. In conclusion, sustainable management is a complex issue that requires collaboration and cooperation across all sectors.

Sustainable and Responsible Initiatives, labels

It is worth mentioning that a number of labels were established in order to evaluate and "grade" the sustainability or compliance to ESG criteria by companies. The list of labels now being sought by companies aware of the need to respect best practices to produce metals and by-products that respect sustainability and ESG criteria in given below.

In the mining sector

- EITI: Extractive Industries Transparency Initiative. a set of international standards to improve resource management in terms of transparency and accountability in the oil, gas and mining sectors (EITI Standard 2023)
- The International Council on Mining & Metals (ICCM) 10 Sustainable Development Principles: a framework of good practice for sustainable development
- The MMDD - Mining, Minerals and Sustainable Development Project 2022
- RMI: Responsible mining initiative 2019
- The Natural Resources Charter (https://resourcegovernance.org)
- ISO committee on mine rehabilitation management (ISO/TC 82/CS 7)
- Initiative for Responsible Mining Assurance (IRMA) Independent verification of compliance with standards
- Science-based Targets Initiative (SBTi): verification of compliance with the Paris Agreement on greenhouse gas emissions

Inter-governmental frameworks

- UN Global Compact (UNGC): Ten principles to integrate into strategies and policies to strengthen cultural integrity and ensure long-term success.

Environmental

- Convention on Biological Diversity (CBD)
- Forest Stewardship Council (FSC)

In the field of batteries

- The Global Battery Alliance (GBA): a partnership of over 150 companies, governments, academics, industry players, and international and non-governmental organizations, the GBA is working to ensure that battery production not only supports green energy but also protects human rights and promotes health and environmental sustainability.
- Critical Minerals Advisory Group (CMAG) from the GBA https://www.globalbattery.org/critical-minerals/: principles adopted for the management of critical minerals by the alliance of battery manufacturers.

Case studies

Societal Unrest: The Obstacle to Commencement the 'Jadar' Lithium Mine Project

Project Overview

The ‘Jadar’ Project is an initiative involving the underground extraction and subsequent processing of the mineral jadarite, a new mineral discovered in 2004 in the Jadar River valley in Western Serbia. It is one of the word’s larges lithium deposits, essential to produce lithium-carbonate and boron which can be used to produce batteries for the electric cars, energy storage batteries for the renewable sources, and equipment such as solar panels and wind turbines.

The project falls within the territories of the municipalities of Loznica and Krupanj, covering an area of 239.91 km². It occupies eight settlements with 4,265 inhabitants in 2011 (3,271 inhabitants according to the last census from 2022). Project started in 2017 by signing the memorandum of cooperation between the Rio Sava Exploration company and Serbian government. It comprises three zones: the mining activity zone and its environmental impact, encompassing an area of approximately 854.8 hectares; the industrial-production zone, where the production and processing of ore will take place to obtain lithium carbonate, boric acid, and sodium sulfate, including the environmental impact zone, with a total area of 646.54 hectares; and the zone designated for industrial waste disposal and the construction of roadways, covering 358.57 hectares.

The potential lifespan of the mine is 50+ years, with a projected ore production of 1.6 million tons per year based on estimated reserves of 147 million tons, with an average content of 1.8% Li_2O and 14.80% B_2O_3. The excavation is planned for 7,305,500 tons of waste material and 2,095,000 tons of low-mineralized ore, totaling 9,400,500 tons of material that needs to be deposited on a 19.5-hectare surface. For this purpose, the construction of a landfill with a height of 60 meters is planned.

Social and Environmental Impact

According to the Strategic Environmental Impact Assessment the expected positive impacts of project on the social community are direct and indirect economic benefits (job creation, income generation, investments, and donations) as well as strengthening of capacity in knowledge and skills through the utilization of modern technologies. Additional positive impacts are related to infrastructure development and the improved exposure of cultural heritage.

However, the project also has a negative effect on the social and environmental impacts. There are some strong negative impacts on the population that will be displaced from the zone of mining activities and the zone under its influence. The local community, which relies on cultivating farmland, will incur heavy losses due to the loss of agricultural land. A major negative impact is the loss of forest land due to land-use change as well as the subsidence of the terrain. The negative impact that is expected is exceeding the prescribed values of pollutants in the air, changing the regime of groundwater during ore mining and when forming landfills for soil from excavation, negative impact on water quality if leachate without treatment gets into the recipient. The landscape will be completely changed, and ultimately lose its natural beauty. The explosive storage facility in the event of an accident can manifest a risk to the environment and community. In the zone of the industrial waste deposits, impacts on the land and water resources are expected to be greater, intensifying the impact on the environment compared to the mining working zone. These negative impacts can also adversely affect the population and social aspects of development (resettlement, health impact).

Project criticism, protests, and suspension

The project received support from the Serbian government and one part of the society primarily due to the economic benefits. Nevertheless, it faced opposition from the local community, a fraction of the academic community, numerous environmental movements, and non-governmental organizations due to concerns about environmental and social impacts.

The project was criticism from the academic community, which has identified several disadvantages. One of them is exposure to cumulative negative environmental impacts in the city of Loznica due to the presence of the pulp factory ' Viskoza', lead mine and smelter in Zajača, antimony mine in Stolice, and the planned 'Jadar' project that will caused loss of agricultural land (316 ha), loss of forest (203 ha) and loss of 6.922 t of organic carbon from the first 10 cm of the soil (Ristić et al., 2021). In addition, there is a lack of climate change impact assessment on the project, as well as the risks associated with future water availability due to the competition between different stakeholders, and risk of intensive rainfall and occurrence of floods (Đurđević, 2022). The interview conducted with citizens in May of 2021 introduces the community priorities, concerns, and expectations of future lithium project (Ivanović et al., 2023). The findings lead to the conclusion that the surveyed population is concerned about the environmental impact due to the company's business history, which includes negative incidents. There is a lack of trust in both the mining company and the government, with a perception that they only represent their own interests. Additionally, there was insufficient involvement of the local community in the decision-making process. Due to all the protests organized across the country, in January 2020, the government of the Republic of Serbia decided to revoke the individual acts for the implementation of the 'Jadar' Project.

The Talvivaara mine in the context of responsible mining

Finland has several atypical nickel mines. These are not large intrusions of ultrabasic rock like those at Norilsk (Russia), Sudbury (Canada) or Buschweld (South Africa). One is located in the north, in the Petsamo region, which was partially annexed by the USSR in 1944 and where the nickel deposits straddle the Russian-Finnish border. The second operation, Talvivaara, is located north of the capital, Helsinki, in the Kainuu region of central Finland. In one of the few deposits in Europe, Talvivaara (Finland), cobalt can be recovered from poor but polymetallic ores. The deposit consists of 2-billion-year-old black shales containing mainly iron sulphides rich in Ni and Co, such as pyrites and pyrrhotite. Mining began in 2008.The deposit is mined by acid heap leaching, i.e. after crushing, the shale is sprayed with a little acid, which leads to bacterial growth. The process works very well, particularly in winter, as the bacterial oxidation generates heat. The juices are recovered from the bottom of the heap and then processed in a hydrometallurgical plant,by successively precipitating Cu, Zn and Co-Ni sulphides from the solution. Terrafame is the only company to produce mixed nickel-cobalt sulphides (40% Ni) from sulphide ore. The ore, which comes from the Sotkamo deposit in Finland, is treated using a heap bioleaching process. In June 2021, Terrafame will launch its sulphate production from MSP, reaching 37 kt Ni at total capacity, making it a significant player in the industry. This production should supply one million electric vehicles with nickel and 300,000 vehicles with cobalt. After processing, the nickel concentrates (mattes) are delivered to two hydrometallurgical plants in Norway that produce pure metal: Boliden and Glencore.

Environmental aspects

However, local environmentalists have been concerned by two significant leaks of acidic juices from a cracked liner under the heap leachate, contaminating the water table sub-surface in this region. In November 2012, a leak occurred at one of the tailings facilities (Bedford & Lyseon, 2021; WISE Uranium Project). Contaminated mine effluents were released into the environment. This environmental problem has been highly criticized and was a concern for the local Finnish population as well as administrative people (Lesser, 2021).

The environmental problems of the Talvivaara mine began to spread in the media around 2011 (Heikkinen et al., 2016; Lyytimäki & Peltonen, 2016). Some consider this to have been the starting point for a more nuanced discussion of mining (Solbar, 2018). Long before this event, tailings dam failures were considered one of the most severe environmental risks of mining. But following this major ecological problem, a network was set up in 2014, The Finnish Network for Sustainable Mining, to define the Finnish mining industry's responsible criteria, which was followed by the creation of the Finnish standard: Finnish Toward Sustainable Mining, based on the Towards Sustainable Mining (TSM) principles of the Mining Association of Canada and the Initiative for Responsible Mining Assurance (IRMA) standard (Franken, et al., 2020).

Economics and sustainability

The mine uses very low-grade ores, such as black shales, with low Ni, Co (U) concentrations. Furthermore, the prices of these raw materials have fluctuated, but the expected price rises have not occurred, making nickel mining always risky when the ores are poor. Such a context may explain why the mine was nationalised to avoid bankruptcy as part of the Finnish government's autonomy policy in supplying the raw materials needed for the energy transition. After investing €700 million of public money in the mine since 2014, the Finnish government has undertaken costly clean-up and maintenance operations. At the time, the mine's losses exceeded one billion euros. At the end of 2016, the Finnish government allocated new public funds to bail out the mine, one of the largest nickel extraction sites in the European Union. In 2017, the Finnish mining company Terrafame was bailed out. The company has indicated that it plans to increase nickel production at Talvivaara.

Governmental decisions and plans

From the standpoint of the Finnish government, this is a strategic choice for Finland and Europe, as it is one of the few mines in Europe that mines nickel and cobalt. These are two critical elements for the battery manufacturing in gigafactories. The aim is to sell more than half of the mine's production sales of Ni and Co to the electric vehicle industry. Ore sales reached 120 million euros. The end of the crisis is not yet wholly assured, as the mine continues to lose nearly 10 million euros a month, primarily due to fluctuations in the price of nickel and cobalt. In September 2023, the prices of these two metals suddenly fell back to what they were ten years ago.

From a social point of view, the Finnish government's investment is justified by employment. The Taalvivaara mine and its surrounding activities account for more than ten percent of revenue in the Kainuu region and provide work for around a thousand people. The Talvivaara mine has always had a positive cumulative effect on employment in Kainuu despite environmental accidents (Torma et al. 2015). The results for the period 2015-2022 suggest that full implementation of the rejected restructuring plan would have been a tolerable solution for employment and the population of the Kainuu region. Sustainable mine operations should focus on maintaining employment over a sufficient period (Suopajärvi et al. 2017).

The government has, in fact, defined a real "batteries strategy" with a desire to support sustainability and the objectives of Finland's climate policy".

One environmental campaigner, Antti Lankinen, believes producing batteries without any environmental impact is challenging, citing the constant risk of leaking acid solutions.

However, it must be acknowledged that Finnish mines follow much stricter standards than those in other cobalt-producing countries such as the Democratic Republic of Congo. BASF and Umicore have, therefore, chosen to invest in Finland.

Per Geijer Rare Earth Element-bearing deposit, Sweden

Context

A recent example of a dialogue between the mining company and the local population is the example of the Per Geijer REEs (Rare Earth Elements) deposit in northern Sweden.

The deposit was discovered in the proximity of the Kiruna iron ore mine operated by state-owned enterprise LKAB. During the press-conference held in January 2023 (accessed on 17/01/2024 via vimeo.com), the President and CEO of LKAB Jan Moström announced that LKAB has been conducting exploration activities for the past 4-5 years which allowed to significantly increase the number of resources and reserves of iron ore, as well as to discover a particular ore body - Per Geijer. Per Geijer is an iron ore deposit with elevated content of REE oxides and phosphorous (lkab.com, accessed on 17.01.24). At the moment, it is considered to be the largest REEs deposit in Europe, containing more than one million tons of REE oxides.

Rare Earth Elements (REEs) are a group of 17 metallic elements – 15 lanthanides, yttrium and scandium. It is rare to find high concentrations of REEs occurring naturally, therefore, the deposits containing elevated concentrations are of high importance and value. As of 2022, the biggest world producers of REEs were China and United States, responsible for 70% and 14% share of world's production, respectively (U.S. Geological Survey, 2023).

Local community and Indigenous people

The strategic importance of Per Geijer discovery for Swedish and European raw materials supply quickly became evident. It also became clear that the little city Kiruna situated in the in the mine's proximity will have to be moved to allow for safer exploration (see the map in the figure 2).

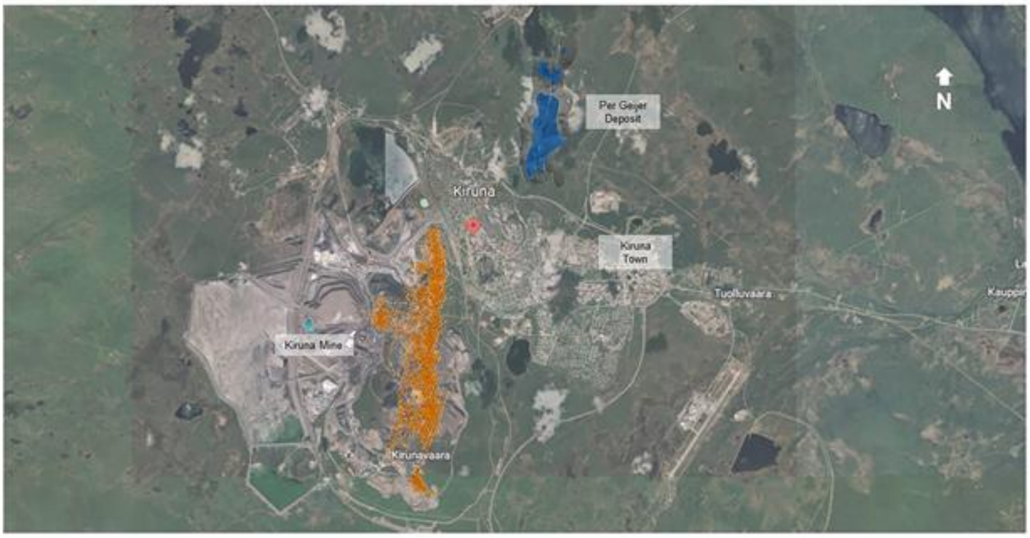

Figure 2 – Map of the Kiruna area; Kiruna deposit in orange, Per Geijer deposit in blue (image from lkab.com, assessed on 8/02/2024)

In the documentary “Made in Europe - From mine to electric vehicle” (documentary available on https://vimeo.com/884346837, accessed on 18/12/23) several Kiruna citizens explain their opinion on the matter. They believe that the city of Kiruna cannot exist without the mine and that they are ready to move, generally taking the mine expansion positively. A unique building - beautiful Kiruna’s church will be preserved but moved in its entirety because of this expansion.

On the other hand, Jukkasjärvi, Sweden, some 20 minutes away by car from Kiruna, is a home for the Indigenous Sami people. The Indigenous Sami population believes that the potential expansion of the mine will put pressure on their way of living that depends on fishing, hunting and, most importantly, reindeer husbandry. It is the latter that can be impacted by the mining activity. In the thesis from 2023, I. Zaza states that the formal ability of Sami people to influence the permitting for mining activity is limited, which leaves place for force imbalance. The author conveys that a state-owned company is expected to lead by example, respecting human rights. The necessary adjustments to the legal framework must be made to accommodate for the Indigenous peoples needs and the principle of free, prior, and informed consent must be strictly respected.

Conclusion

This Report analyzes both the positive and negative social impact of the extractive industry, offering examples for each impact and outlining potential risks associate with them. Additionally, the report emphasizes the opportunities for contributing to the sustainable development goals through responsible company operations.

Positive influences covered in this report include community development, reflecting primarily in the construction of new infrastructure and business opportunities, contribution to the national economies, direct and indirect employment opportunities, and investments in education. Some impacts such as migration, and resettlement, can have both positive and negative aspects. Environmental impacts, however, are predominantly negative and their magnitude depends on the mining companies' effort to implement measures to avoid or mitigate environmental concerns, foster community engagement, prioritizing the well- being of local population.

Some of the identified risks to the environment and society include gender inequality, child labour, bribery and corruption, poverty, mining within protected and conserved areas, as well territories of Indigenous People. Additionally, there are environmental risks such as water depletion and scarcity, water contamination, health and safety risk (including the potential failure of tailing) and presence of illegal mining activities. The main driver of these risks are attributed to the irresponsible practices of mining companies, non-compliance with regulations, and a lack of enforcement by state authorities.

To achieve greater alignment with sustainable development goals, it is imperative to enhance adherence to the environmental standards. Adopting a management approach based on the principles of 'plan, do, check, act' for environmental protection is crucial. Environmental and social responsibility of mining companies is of the vital importance for the social acceptance of mining practice within a region. The report has considered case studies demonstrating three different scenarios of social acceptance or non-acceptance of mining operations: (1) Jadar deposit in Serbia, (2) Talvivaara deposit in Finland, and (3) Per Geijer deposit in Sweden.

Sustainable management is a shared responsibility that requires a collective effort from various sectors and stakeholders. To advance the agenda of responsible mining, it is important to delineate the specific role and contribution of each stakeholder group – citizens, students, researchers, companies, and policy makers. In pursuit of this objective, we have proposed a way of knowledge transfer to each identified group, along with recommended actions to them to consider and implement.

In addition, it is important to operate the same terminology. An official glossary, where clear definitions of the terms are readily available to all and for free is a good idea. This would hinder the use of meaningful and important terms as buzzwords of fuzzwords.

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