sustainability

Article

Corporate Social Responsibility Index for Mine Sites

Marc Bascompta *, Lluís Sanmiquel, Carla Vintró and Mohammad Yousefian

Department of Mining Engineering-Industrial and ICT, Universitat Politècnica de Catalunya, 08242 Manresa, Spain
* Correspondence: marc.bascompta@upc.edu

Abstract: A new quantitative index to analyse the corporate social responsibility (CSR) level of mine sites was developed, providing an easy and friendly tool to analyse and apply a continuous improvement approach to CSR levels, being able to involve all the potential stakeholders. The index can be used in any type of project and stage: prospecting and exploration, development, mining, processing, closure and rehabilitation. The system consists of two dimensions, environment and socio-economic, formed by 30 elements that analyse potential positive and negative impacts. Moreover, it can be adapted to the specific characteristics of any mining activity, including new elements if necessary. The system proposed can help to improve the positive implications of the mining industry, as well as improving transparency or stakeholder engagement and returns of the mining activity.

Keywords: CSR index; mining; sustainability; ESG; mine site project

check for updates

Citation: Bascompta, M.; Sanmiquel, L.; Vintró, C.; Yousefian, M. Corporate Social Responsibility Index for Mine Sites. *Sustainability* **2022**, *14*, 13570. https://doi.org/10.3390/su142013570

Academic Editor: Wen-Hsien Tsai

Received: 1 October 2022
Accepted: 17 October 2022
Published: 20 October 2022

1. Introduction

Mining activities usually face physical, social and environmental challenging conditions due to orebody locations that cannot be chosen [1]. Their historical poor management, at least in part, adds a more problematic stating point, because of the lack of trust and credibility from the stakeholders [2,3]. Hence, it is absolutely crucial to approach the stakeholders, especially local and regional communities, in the correct cultural way and at the right time [4,5]. Despite the complexity of involving society in the development of a mining project [6], it can enrich the outcomes if it is properly handled [7]. The social licence to operate is embedded in the corporate social responsibility (CSR) framework and it describes the conceptualization of the way the company interacts with local communities and societies and its acceptance or approval [8], being intangible and not granted by the authorities [9].

On that interaction, CSR presents a holistic approach, linking the economic, social, and environmental dimensions with the company governance [10]. On the other hand, there is an intense debate on its usage and effectiveness [11–13], depending on each particular context [14]. Moreover, there is an increasing trend towards sustainable investment, such as the international network Principles for Responsible Investment (PRI) supported by the United Nations, as well as financial access [15]. Hence, the capital allocation requires effective and quantitative tools to improve the CSR quality of each mine site and, thus, strengthen the portfolio of the mining firms in the clear shift towards sustainability. In this regard, the value chains should also be reevaluated, with the idea of reducing the carbon footprint and creating new alliances and circular business models [16]. Research focused on CSR is an important topic in most of the economic sectors [17–20]. Some of them focused on the systems to analyse the stakeholders' perception on CSR, finding common dimensions such as economic, ethical, philanthropic, legal, environmental and social dimensions [21].

In this regard, CSR dimensions have been approached by many initiatives, such as the global reporting initiative (GRI) or the ISO 26000 [22]. There are also specific organizations focused on the mining sector, such as the responsible mining foundation (RMF), the initiative for responsible mining assurance (IRMA) or the international council on mining and metals (ICMM). However, most of them only give global information of each firm, while some others are focused on some specific parts of what should be included in a full CSR analysis. Moreover, most standards do not allow to obtain a quantitative value, which would be crucial for mining projects in order to determine which measures or modifications can add more value to a project, as well as focus on the most attractive projects from a global perspective.

Most of the organizations and standards defined include the most relevant elements related to governance, socio-economic and environmental spectra. However, always from a qualitative point of view. Additional initiatives try to transform the vision of the sector, such as the EU principles for sustainable raw materials supply [23]. Other specific actions have also been developed in the recent years, such as the Artic environmental responsibility index (AERI), focused on extractive industry companies in the Artic area and based on a survey among experts [24].

The usage of rankings, indicators and indexes can help to reduce poor practices and increase better governance, transparency, social and environmental conditions of the companies [25–28]. These elements can also have an influence on capital access [29,30], despite their real effectivity having been questioned due to the large quantity of different specific index and indicators [31,32]. Hence, it would be necessary a simple index that included all the technical characteristics involved in a mine and, at the same time, social and environmental issues, with the idea of achieving the best potential mining projects to work with.

The manuscript is not focused on the overall number of affected stakeholders, or its identification, but on the main technical, social and economic features of mine sites. Achieving an overall analysis that can be adapted to any context. The scope of the index proposed include the key stages of mining: prospecting and exploration; development; mining; processing; closure and rehabilitation.

2. Methods

2.1. Indicators Obtaining

The main standards and approaches to assess CSR have been analyzed, either for the mining sector or general industry, with the aim to extract the most relevant elements, or variables, and create an approach to quantify them for each mine site project.

Regarding the mine site, it is necessary to give a global context, including the situation of the mine with regard to life of the mine, expansion projects, exploration project, increase production projects, number of employees, etc. Moreover, it is necessary, and crucial, to have a community engagement tool, easy to use by all the stakeholders, transparent and effective.

The assessment of all the organizations mentioned in the introduction section has been used to define the elements used in the index proposed.

Responsible mining foundation (RMF): It has a system to evaluate companies and mine sites by means of the responsible mining index (RMI). The company analysis includes 44 topics grouped into six thematic areas: (1) economic development, (2) business conduct, (3) lifecycle management, (4) community wellbeing, (5) working conditions and (6) environmental responsibility. On the other hand, the mine site assessment is done by 15 indicators: local employment, local procurement, air quality, water quality, water quantity, rehabilitation and postclosure, tailings, safety of communities, community complaints and grievances, safety and health of workers, women workers, workplace deaths and injuries, training of workers, decent living wage, and worker complaints and grievances. The procedure to obtain a rating is giving marks based on only qualitative information from the company or mine site.

International Council on Mining and Metals (ICMM): The ICMM contemplates an extensive number of variables that may have an impact on: (a) environmental issues, such as climate change, nature or water; (b) social performance, including elements such as human rights, indigenous perspective or diversity and inclusion; (c) governance and transparency; and (d) health and safety, tailings and circular economy. However, it is not possible to obtain a global index applicable to a single project.

IRMA standard: The standard developed by the Initiative for Responsible Mining Assurance (IRMA) is focused on mine sites including elements such as health and safety, human rights, community engagement, pollution control, conflict-affected areas, rights of indigenous peoples, transparency and land reclamation once mining. Moreover, it discriminates the different stages of the mine site development, from exploration to development. However, it only uses qualitative analysis for mining projects.

Towards Sustainable Mining (TSM): It is an initiative focused on a mine site reporting system, but it is also based on qualitative analysis. It has a transparent reporting system to analyze sustainability performance annually. Having protocols for: (a) biodiversity conservation management, (b) climate change, (c) crisis management, (d) indigenous and community relationships, (e) prevention of child and forced labor, (f) health and safety, (g) tailings management and (h) water stewardship.

CSR hub: It analyses companies of any economic sector, not only mining, giving a rating based on four categories, with three dimensions by category: (1) community (community development and philanthropy; human rights and supply chain; product), (2) employees (compensation and benefits; diversity and labor rights; training, health and safety), (3) environment (energy and climate change; environment policy and reporting; resource management), (4) governance (board; leadership ethics; transparency and reporting). Although the approach is interesting, it only uses aggregated values to analyze the whole firm, not mine site projects.

Other initiatives: Some regional organizations have developed similar procedures and standards. The minerals council of Australia, based on the ICMM principals, proposes an enduring value framework on responsible resource development regarding elements such as land use, environment, continuous improvement on environment, health and safety, recycling, transparency, etc. Furthermore, Euromines have also made statements in the direction to increase climate, environment, biodiversity protection and social responsibility.

Some other generalist and specific initiatives have been analyzed and included in the index proposed.

- The initiative called ISEAL alliance defines some standards applicable to any economic activity, considering social, environmental and economic impacts.
- The global reporting initiative (GRI) gives very detailed information about the general elements to consider in any type of economic activity and also some specific considerations for certain sectors such as coal, oil and gas or agriculture. However, the mining sector is still under development. Moreover, it is not focused on quantitative analysis for mine sites.
- The ISO 26000 gives a good approach of the main elements to consider, but it does not give any value nor any technical or specific approach.
- The mining local procurement reporting mechanism (LPRM) is focused on local procurement of goods and services of the mining industry, without giving any rating.
- The extractive industries transparency initiative (EITI) promotes the correct management of natural resources, strengthening public and corporate governance and accountability by means of defining procedures.
- Some mining firms have developed similar qualitative tools. For instance, the Anglo-American socio-economic assessment toolbox (SEAT) helps to approach the needs of the communities where the mining operations are planned to be placed, with the idea to improve the socio-economic impact understanding to local and regional communities.

Based on the current standards and tools available, no quantitative information about specific mine site projects is used to obtain a CSR rating. That means that when a company makes a proposal for a new project or a brownfield wants to expand the life of the mine or a production expansion, the current CSR indexes do not allow us to properly analyze a project and, therefore, enrich the project involving all the stakeholders in a rational perspective.

Thus, Figure 1 gathers the two dimensions and 30 elements considered, based in the current standards, index and procedures.

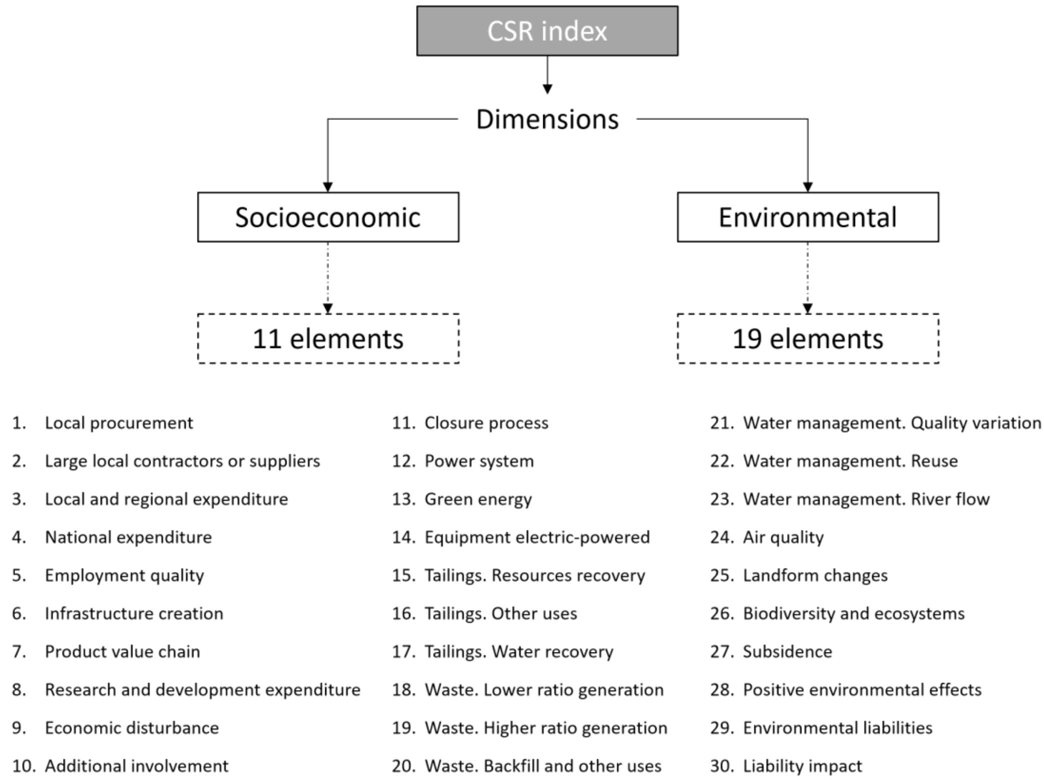

Figure 1. Structure of the CSR index proposed and elements included.

Overall, there are 20 positive elements and 10 negative elements. This means the elements can add or subtract value to the CSR assessment of a mine site.

2.2. Rating Definition

Each project has its own intrinsic conditions, such as orebody characteristics, surface environmental and socio-economic conditions, etc. Hence, some of the elements to evaluate the CSR of the project, defined in Section 3, could be irrelevant to consider, while some additional features could be required in a certain mine site. The following procedure should be applied to use the index proposed:

1. Definition of the relevant elements, including all the stakeholders in the process. New elements can be added if necessary.
2. Establish a scale, preferably transformed to a 100-point scale. Figure 2 shows a tentative scale based on five categories. This scale should be used only for an overall analysis or a dimension analysis.
3. Analyze each element included, giving a score for each of them based on the definition completed in Section 3. Each element is defined as a Likert 1–5 scale, evaluating the specific CSR performance.

Figure 2. CSR scale analysis for mine sites.

2.3. Scope of the Index

As previously mentioned, the index proposed is mainly focused on technical features related to the socio-economic and environmental dimensions that can be found in any mining stage. Other relevant elements, included by the standards and organizations, analysed in Section 2.1, such as health and safety, complaint and grievance communication procedures, child labour, conservation of World Heritage elements, spiritual or cultural resources, demographic changes, availability of natural resources, etc., are not included in the index, since they are basic and compulsory elements that must be complied to even being considered as a viable project. General factors such as legal or political dimensions are not considered either.

3. Index Proposal

All elements comprising the index are described and sorted in the two dimensions already mentioned: socio-economic and environment dimensions, with 11 and 19 elements, respectively.

3.1. Socio-Economic Dimension

The mining activity can be beneficial for the development of areas with low population density [33]. Engagement with local and regional communities is crucial for the successful development of the project [34,35]. Moreover, the basic standards must be complied, such as a worker's and human rights program [36] or a program for the integration and respect of indigenous peoples [5], among other elements mentioned in Section 2. In this regard, initiatives such as the EITI approach can help increasing transparency on contracts and mineral reserves, among other important elements. This is particularly important in areas with high levels of violence or conflicts [37].

The mining firm must stablish an engagement procedure with the communities affected by the project, being necessary to assess the outcomes. Considering the employment and workforce composition in number, gender and nationality. Additionally, differentiating direct employees vs. contract workers and local/regional employees. Hence, social-economic performance should be integrated into the operational management practices and actions taken, with the idea of maximizing the value of the mine project.

3.1.1. Local Procurement

Local procurement is an essential part of the community engagement. It is absolutely necessary to have local partnerships for services and supplies, whenever possible, with policies well-stablished to boost the local economy. Moreover, it can help the mine to secure the supply chain of the elements required by the correct operation of the mine [38]. In this regard, it would be positive to have integrated the local supplier in all the sections/departments of the mine, which, at the same time, would help to diversify the local/regional economy [39]. It has been considered a relative value based on the total expenditures (Table 1). However, it is necessary to have a procedure to analyse and verify the providers and contractors by means of an equitable and transparent system, such as the EITI approach, as well as provide training and information to improve their service and skills. In the case that local suppliers are not available, due to none or scarce population, it can be considered regional or even national, focusing on the closest communities when possible.

Table 1. Local suppliers used in the mine site.

Rating	Description
1	Less than 20% of the sections/departments
2	20% to 40% of the sections/departments
3	40% to 60% of the sections/departments
4	60% to 80% of the sections/departments
5	More than 80% of the sections/departments

The use of large local providers can be a source of self-economical development of the region and employment diversification, being able to self-impulse innovation and research, especially when the company has a medium or large size [40]. Following the European Commission recommendations, a large contractor is considered from a EUR 50 M turnover and more than 250 employees. Thus, it is considered a relative value based on the size of the local providers (Table 2), with an optimal mix range of large and small providers of 40% to 60%.

Table 2. Large local contractors or suppliers used by the mine site.

Rating	Description
1	In less than 20% of the sections/departments
2	Between 20% and 40% of the sections/departments
3	More than 80% of the sections/departments
4	Between 60% and 80% of the sections/departments
5	Between 40% and 60% of the sections/departments

Moreover, it would necessary a program to develop the local providers when there is a small percentage of its usage, <20%, especially for small and mid-size providers or there is a shortage of them. It is also necessary to verify that contractors and suppliers have programs regarding minorities and people at risk of exclusion, supporting freedom of association and excluding child, forced or compulsory labour. The information regarding local, regional and national procurement should be disclosed, helping them in the tender process at the beginning. Following procedures stablished such as the one from RMF.

3.1.2. Local Expenditure

Local expenditure includes the proportion of the mine operational expenditures (Opex), Table 3, considering direct and indirect employment, supply of services and goods. Although the local area should be prioritized, it can be impossible in some cases due to inhabited regions and, therefore, the regional and national spectrum should also be considered as positive in many cases; whereas, in certain cases, it is inevitable to use international human and material resources.

Table 3. Local and regional expenditure.

Rating	Description
1	10% to 20% of the mine site
2	20% to 40% of the mine site
3	40% to 60% of the mine site
4	60% to 80% of the mine site
5	Higher than 80% of the mine site

It is considered as local when the distance from where the resources are provided is less than 20 km from the mine site, regional for a distance between 20 and 200 km, national between 200 and 1000 km and international for more than 1000 km. Despite this, it could be the case that the resource was still national and further than 1000 km; it has been considered that the resource would have little economic impact greater than this distance [41,42]. If it was considered necessary, the transition between national and international could be modified.

As it could be the case that there are no local or regional possibilities, the national level could also be positive, Table 4, up to a certain extent.

Table 4. National expenditure.

Rating	Description
1	Between 20% and 40% of the mine site
2	Between 40% and 60% of the mine site
3	More than 60% of the mine site
4	N/D
5	N/D

Minorities, indigenous, disadvantaged groups and gender equality should be boosted, especially when the percentage used is very small. The type of employment is a key factor for the development of the local and regional communities (Table 5).

Table 5. Employment quality.

Rating	Description
1	Less than 20% of the intermediary staff and technical and senior positions are local, regional or national
2	Between 20% and 40% of the intermediary staff and technical and senior positions are local, regional or national
3	Between 40% and 60% of the intermediary staff and technical and senior positions are local, regional or national
4	Between 60% and 80% of the intermediary staff and technical and senior positions are local, regional or national
5	More than 80% of the intermediary staff and technical and senior positions are local, regional or national

The unskilled positions can be easily obtained. However, middle management, skilled works and senior positions and professionals are more difficult to get in the local communities. Hence, it is better to consider the national framework, despite local and regional employees who would be advisable to have whenever possible.

The rest of the employees that are not local, regional or national would be considered as expatriates. No differences in the salary should be established, for the same type of activity, between locals/indigenous and other staff. Boosting the integration of local and regional people to all the levels of the organization. Despite this being a relevant element to consider, it can be very difficult to achieve and vary in each particular case.

In addition, programs to reduce the salary disparity between mine workers and non-mine workers should be implemented, stablishing programs to enhance positive economic impacts for local communities (employment, procurement and training opportunities).

3.1.3. Permanent Infrastructures

The creation of the mine can provide better infrastructures to the local, regional and national level, such as energy supply, roads, railway, harbour facilities, schools, airport, etc. [34,43]. On the other hand, the mining activity could deteriorate the existing infrastructures in any stage of the mining activity, if it is not planned well, even after the closure. The five levels are considered as positive elements, Table 6, but all of them should also be analysed as a potential negative effect if the project is not managed properly [44]. The infrastructures related to water supply are included in other points.

Table 6. Infrastructure creation.

Rating	Description
1	Non-improvement or difference with respect to the previous mine site construction or expansion. No deterioration either
2	Slight improvement in the current infrastructure in any level (local, regional or national). Such as the creation of schools, hospitals, improvement of the current roads or railway
3	Improvements in the infrastructure system or creation of new infrastructures (with a positive impact on any level local, regional or national), useful to boost the economy
4	Important improvements or new infrastructures that have a positive impact in more than one level (local, regional or national), boosting the economy and creating emerging economic changes
5	Crucial improvements or new infrastructures that have a positive impact in all the levels (local, regional or national), that can also modify and boost the economy in the long term

In order to define the level of improvement or deterioration, the specific stakeholders must be included in the decision-making process. One example could be the road project in the Ring of Fire, Canada, where the communities are co-leading the project to have access to a potential mining region. Moreover, it is important that these infrastructures help to sustain the communities without the existence of the mining activity in the future [34].

3.1.4. Value Chain Creation

The creation of a mine opens the possibility, not only to create value with the mine, but also other subsequent industry related to the raw material itself. The basic part of the value chain is the extraction and mineral processing, obtaining a mineral concentrate that can be sold or shipped to another country. However, additional parts of the process can also be included in the project to add more value to the saleable product (Table 7), such as the whole metallurgic process [45].

This fact is crucial to boost the benefits of any mine site in terms of quality job creation. An additional added value would be the involvement of national technical schools and universities to develop new curriculum and research that could benefit the raw material extraction. In this regard, the expenditure in national universities regarding research and development projects related to the mine site can be analysed, as well as specialized training for the mine staff (Table 8).

Table 7. Product value chain.

Rating	Description
1	Obtaining a refined product that requires additional processes, but it has higher added value than the mineral concentrate. Process done in the same region or nation
2	Final product sold to another industry as a raw material or with the whole metallurgic process done in the same nation of the mine site, but far from it
3	Final product sold to another industry as a raw material or with the whole metallurgic process done in the same nation of the mine site, but far from it. Moreover, the product created is a raw material crucial for the development of the national industry, or supranational organizations such as the EU
4	Final product sold to another industry as a raw material or with the whole metallurgic process done in the regional area of the mine site. Moreover, the product created is a raw material crucial for the development of the national industry, or supranational organizations such as the EU
5	All the requirements of the previous point are met and, in addition, it is essential for the sustainable development of society

Table 8. Research and development expenditure.

Rating	Description
1	Less than 20% of mine expenditure in R&D projects and specialized training in national universities and research centres
2	Between 20% and 40% of mine expenditure in R&D projects and specialized training in national universities and research centres
3	Between 40% and 60% of mine expenditure in R&D projects and specialized training in national universities and research centres
4	Between 60% and 80% of mine expenditure in R&D projects and specialized training in national universities and research centres
5	More than 80% of mine expenditure in R&D projects and specialized training in national universities and research centres

The value chain improvement must also be completed including the different stakeholders, in order to be adequate and sustainable in the long term. Some examples could be business training for entrepreneurs, mentoring suppliers and contractors, financing access or advising in external projects and enterprises [46].

3.1.5. Economic Environment Disturbances

The creation of a mine can also have bad socioeconomic consequences due to land occupation and degradation, etc. Usually, it has an impact on agriculture, farming, fishing or tourism, as well as ancient/indigenous lifestyle, requiring even relocations in some cases [34,38,47]. These potential impacts should be compensated by the mining company, but it could have intangible value for the inhabitants [4,48]. This impact can be substantially reduced depending on the type of mining extraction method. It has been considered a negative impact of at least minus two, Table 9, due to its relevance when present.

In the case it does not have any relevant negative impact, this variable should have a value of 0 points. This analysis should be completed for existing communities previous to the mining project.

Table 9. Economic disturbance.

Rating	Description
1	N/D
2	Small impact: it partially jeopardizes the socioeconomic way of living during all the mine life, without having an equivalent option aside from the mining activity. Considering that the quantity of families affected is lower than 25% of the local employment created by the mine
3	Medium impact: it jeopardizes the socioeconomic way of living during all the mine life, without having an equivalent option aside from the mining activity of less than 25% or it partially jeopardize the socioeconomic way of living during all the mine life between 25–50% of the local employment created by the mine
4	Large impact: it jeopardizes the socioeconomic way of living during all the mine life, without having an equivalent way of living aside from the mining activity. Considering that the quantity of families affected is between 25–50% of the local employment created by the mine
5	Extremely large impact: it jeopardizes the socioeconomic way of living in the long term, even after the closure, without having an equivalent way of living aside from the mining activity. Considering that the quantity of families affected is, at least, 25% of the local employment created by the mine

3.1.6. Additional Involvement

Ideally, the mine project should consider more than just direct/indirect job opportunities or business linked to the mining activity, such as company shares, project equity, business skills training, staff volunteerism, etc., especially for the indigenous and local communities. Moreover, the mining activity is finite, being important to propose a post-extraction value to the local and regional area [47]. Some possible additional elements are listed below.

- Mine project equity
- Company shares
- Environmental control participation
- Involvement of indigenous/local communities and specialized NGO as part of the team in the development of the project
- Assistance to preserve traditions and cultural heritage of the region. It can be an additional source of independent incomes for the region during the mining activity and afterwards
- Render assistance in case of natural disaster
- Volunteerism staff hours

In this regard, Table 10 gathers the number of items included in the project to evaluate this variable.

Table 10. Additional involvement.

Rating	Description
1	At least one additional element
2	Two additional elements
3	Three additional elements
4	Four additional elements
5	Five or more additional elements

The type of additional involvement should be based on the communities and mine site characteristics. Despite charitable giving or donations of goods could also be included within this element, it is considered as more beneficious for the local and regional communities to provide self-sustainable elements [49–51].

3.1.7. Closure—Final Conditions

Reclaiming should be done using an integrated approach whenever possible [52,53]. It is necessary to have a closure management plan for design closure and control, with a financial provision considering the environmental and social aspects. Moreover, the firm should disclosure the closure and rehabilitation plan following the indications of organizations such as the RMF (Table 11). The restored area could be used to create added value, such as green energy provider, recycling centre, new or better crops, touristic place, etc. In this case, the long term must be evaluated, as well as the adequacy with the surrounding social, environmental and economic context [54,55].

Table 11. Closure process.

Rating	Description
1	Slight added long-term value
2	Moderate added long-term value
3	High added long-term value
4	High added long-term value, with a partial synergy with the specific context
5	High added long-term value, with an important synergy with the specific context

The adequate conditions should be maintained in the long term. Non-operating mines should be closed in the absence of a justified project that contemplates all the potential impacts. Otherwise, it could add important impacts to water and land, while illegal mining may also proliferate. Soil quality must also be kept at similar conditions as the previous mining stage, once the area affected by the mining activity is finished and restored [56].

In addition, actions to former mining employees due to the closure of the mine should be included in this element, considering reskilling programs, adequate planning for economic revitalization, social protection, labour transition, relocation assistance programs, etc. [54,55,57]. The plans and programmes must consider the goals of the communities affected.

3.2. Environment

A proper management of the environmental impacts generated by the mine site can create substantial benefits for the whole society, the environment and the company from short to long term [52,54], each time becoming more relevant as technology evolves.

Most of the indicators mentioned in Section 2.1 include an environmental aspect such as water, waste generation or energy consumption. The involvement of the stakeholders and organizations such as NGO's is crucial to improve, as much as possible, the environmental conditions of a mining project. Moreover, the company should publicly disclose the assessments of its environmental impacts and biodiversity conditions, with the corresponding regular updates, discussing it with the stakeholders.

In this regard, one of the most common elements is the mine waste management, which should be focused on ensuring the stability and effectiveness of the associated infrastructures in the long term, either waste storage or tailing facilities, considering the global best practices. Some studies indicate how tailings and waste generated should be characterised for future usage and raw materials extraction [58,59]. Moreover, the impact analysis on water, soil and air is fundamental in a mine project [60].

3.2.1. Energy

The usage of green energy and the achievement of an energy-efficient system are key issues in the sector [61–63]. Moreover, it helps to reduce the greenhouse gases (GHG) of the project, especially in a sector considered a major emitter [64].

The best available techniques should be used to reduce the energy consumption (Table 12). As the energy intensity depends on many different intrinsic characteristics of the mineral deposit, it is not considered the total value but the relative energy consumption.

In this regard, it is analysed if these best available techniques are applied in each stage of the mining activity.

Table 12. Best available techniques used in the power system.

Rating	Description
1	Only present in up to 20% of the mining operations
2	20% to 40% of the mining operations
3	40% to 60% of the mining operations
4	60% to 80% of the mining operations
5	More than 80% of the mining operations

A continuous improvement system should be included to reduce GHG, as much as possible, in the mining activity (Table 13). The usage of green energy sources can be a substantial improvement and it is an adequate alternative to also provide energy to the communities in the long term [65,66].

Table 13. Green energy sources installed.

Rating	Description
1	Up to 20% of the mining operations
2	20% to 40% of the mining operations
3	40% to 60% of the mining operations
4	60% to 80% of the mining operations
5	More than 80% of the mining operations

Aside from the generation source of energy, the usage of electrical equipment or hydrogen powered [67] also substantially reduce the GHG. Therefore, a similar analysis should be completed by the energy used in the equipment, as long as it comes from a green source (Table 14).

Table 14. Equipment electric-powered.

Rating	Description
1	Green energy used in up to 20% of the fleet
2	Green energy used between 20% to 40% of the fleet
3	Green energy used between 40% to 60% of the fleet
4	Green energy used between 60% to 80% of the fleet
5	Green energy used in more than 80% of the fleet

3.2.2. Tailings

The process of ore crushing usually generates a liquid slurry composed of fine particles and water, known as tailings. The global industry standard on tailings management must be followed in order to ensure its safety along its life.

There is a critical connection between social performance and safe tailings management [68,69], affecting the three ESG pillars: environmental, social and governance. More attention should be taken to the social, environmental and local economic context, considering vulnerability in the analysis of the mine site [70]. Thus, the implementation of new technologies can help to reduce or even eliminate the risk [71–73].

The approach commonly used about the conditions of the tailing's storage, only during the operational time, leads to higher life-cycle costs and increase the risks [74]. Not only the low operational cost of slurry should be considered, but also its closure and maintenance costs. Moreover, there are not much successful rehabilitated tailings.

The idea should be towards zero tailings, valorising and re-processing them to become a product. Tailings are considered as a potential source of mineral recovery in the future due to technological improvements and increase in the price of the mineral resources [73,75–77]. Hence, it is important to analyse the tailing characteristics in order to know if they are going to be considered as waste, that have to be monitored, or if it is reasonably possible that its bulk is going to be reduced, lowering the environmental impact, in the mid and long term and, at the same time, increasing the life of the mine and the economy of the area [78,79]. The feasibility of extracting minerals from tailings are analysed as a new mine, considering the cut off to be recovered. Linked to its safety, there is the water recovery [72], which could reduce the environmental impact of tailings disposal.

The recovery cut-off is crucial in order to know if it is feasible to recover the tailings, technically and economically. The classification applied in Table 15 considers them as sub-economical resources, if the ore concentration requires a price 10 times higher or there are no techniques available, it cannot be considered. These elements can be reassessed along the life of the mine as technology and demand evolves.

Table 15. Price increase requirement in the resources from tailings.

Rating	Description
1	8–10 times higher
2	6–8 times higher
3	4–6 times higher
4	2–4 times higher
5	up to 2 times higher

On the other hand, the usage of tailings as a source of construction materials, such as sand [80] or ceramics [78], has widely been studied. In this case, its usage will depend much on the distance to its usage, while they can also be used as backfill [76]. It has been considered that 50% of the total volume is used as an optimal reuse proportion (Table 16).

Table 16. Tailings used as construction or filling material.

Rating	Description
1	Up to 10% of the total volume
2	10% to 20% of the total volume
3	20% to 35% of the total volume
4	35% to 50% of the total volume
5	More than 50% of the total volume

Tailings can have large quantities of water content. Aside from the intrinsic risk of that type of tailings, it is also an inefficiency of the water usage, especially in areas where water availability is scarce (Table 17). Moreover, there is technology available to reduce its content in the tailings [72].

Table 17. Water recovery from tailings.

Rating	Description
1	Up to 20% of the total volume used
2	20% to 40% of the total volume used
3	40% to 60% of the total volume used
4	60% to 80% of the total volume used
5	More than 80% of the total volume used

3.2.3. Waste Management

Waste generation is directly related to the mining extraction system, varying from different surface mining conditions to underground mining. The waste ratio can be directly linked to the mining method used [81]. The correct waste disposal from mining is necessary from a safety point of view and to be able to recover it in the future [82], whether it is caused by an ore price increase, a technological improvement or finding new uses to waste. Moreover, its adequate management helps to prevent air, soil and water contamination. The best available techniques regarding mineral extraction and processing also allow us to reduce the waste generation. For instance, the usage of technologies such as ore sorting in underground facilities can help in some mining methods [83].

Nassar et al. [84] propose a rock-to-metal ratio based on the quantity of ore and waste rock mined to produce a unit of mineral commodity. This approach can be very interesting because it is based on the evolution of extraction characteristics of each commodity, including surface and underground mining. In the case of extracting more than one commodity, it is recommended to be focused on the main ones or the equivalent grade for polymetallic deposits [84]. Mudd [85] also gathers interesting data regarding the ratio waste/ore in case studies from Australia, whereas De la Vergne [86] mentions specific ratios for surface and underground mining, considering that open pits usually generate 2 to 5 tons of waste rock per ton of ore mined and about 0.25 tons of waste rock for an underground mine. Overall, the analysis should be done based on a verified and reliable source, analysing two possible scenarios: one with a lower ratio of waste (Table 18), compared to the mean value, and another one with a higher ratio, with an associated negative impact (Table 19).

Table 18. Lower waste ratio.

Rating	Description
1	Reduced up to 20% compared to the mean value of the industry
2	Reduced between 20% and 40% compared to the mean value of the industry
3	Reduced between 40% and 60% compared to the mean value of the industry
4	Reduced between 60% and 80% compared to the mean value of the industry
5	Reduced more than 80% compared to the mean value of the industry

Table 19. Higher waste ratio.

Rating	Description
1	Increased up to 20% compared to the mean value of the industry
2	Increased between 20% and 40% compared to the mean value of the industry
3	Increased between 20% and 40% compared to the mean value of the industry
4	Increased between 40% and 60% compared to the mean value of the industry
5	Increased more than 80% compared to the mean value of the industry

The reusage of mining waste as construction material (concrete aggregate, granular base, embarkment or fill), paint extenders, fertilizers, or backfill, among other options [87–90], is also important to reduce it as much as possible (Table 20).

Table 20. Backfill or waste use.

Rating	Description
1	Up to 20% of the total amount
2	20% to 40% of the total amount
3	40% to 60% of the total amount
4	60% to 80% of the total amount
5	More than 80% of the total amount

3.2.4. Water Management

The intensity of water usage in the mining sector is quite high, being one of the major consumers of water [91]. The water management of a mine requires the approval of the competent agency and the usage of the best available techniques, trying to reduce the water input used and a correct balance between surface and ground water.

Issues such as potential flooding, contamination, water management after closure should also been considered in the water management plan and it is mandatory to manage these risks properly. Aquifer overexploitation must also be analysed and avoided, as well as post-closure water management, if required. The leachates from waste and tailings must be managed to avoid surface and underground water contamination. Overall, the adequate infrastructure to manage the water impact must be provided, especially to local and regional communities [92].

PH variations due to extraction and processing operations can affect the quality of the water, either filtrations to groundwater reservoirs and to the hydrographic network. Particles concentration in the water volume must also remain in similar conditions upstream and downstream of the mining facilities, as well as salinity levels, heavy metals or any other contaminant. The comparison with previous natural conditions is very important, since each site can have important concentrations of some metals and Ph variations. The comparison with the upstream conditions is crucial, since it can have abnormal natural values due to the mineralization of the area [93,94]. In this regard, the following points consider a negative impact any variation compared to the upstream (Table 21).

Table 21. Water quality variation.

Rating	Description
1	Water characteristics variation lower than 10% with respect to the upstream conditions
2	Water characteristics variation between 10% to 20% with respect to the upstream conditions
3	Water characteristics variation between 20% to 30% with respect to the upstream conditions
4	Water characteristics variation between 20% to 30% with respect to the upstream conditions
5	Water characteristics variation higher than 30% with respect to the upstream conditions

As previously mentioned, the mining activity requires large amounts of industrial water and, sometimes, the mine site is placed in arid areas, being necessary to create desalination plants or obtain water from other sources. The creation of this new infrastructure can also allow us to improve the hydrographic network of the area, if planned properly [92]. In this regard, the reuse of water, grey water, is absolutely necessary to reduce the impact of the mining activity (Table 22).

Table 22. Water reuse.

Rating	Description
1	Up to 20% reuse
2	Between 20% and 40%
3	Between 40% and 60%
4	Between 60% and 80%
5	Higher than 80%

In addition, the minimum ecological river flow must be kept [95]. However, variations above this level also have an impact that should be considered. In this regard, Table 23 sets out an analysis considering as minimum the ecological river flow, with positive connotations.

Table 23. Waterflow reduction.

Rating	Description
1	60 to 100% waterflow reduction between previous conditions and the minimum ecological river flow
2	35 to 60% waterflow reduction between previous conditions and the minimum ecological river flow
3	20 to 35% waterflow reduction between previous conditions and the minimum ecological river flow
4	10 to 20% waterflow reduction between previous conditions and the minimum ecological river flow
5	No appreciable/minor variation from the previous waterflow

Water quality control should be done in collaboration with the affected stakeholders, defining the actions required to improve the quality, when needed.

3.2.5. Air Quality

It would be necessary a disclosure program regarding the emissions generated by the mine, the control program and the actions taken to reduce its values [96], including all the stakeholders affected, when necessary. The threshold limit values must be based on the international standards and the national regulations. The impact analysis should be completed based on a published reference, considered as maximum or recommended value, and the natural conditions before the mining activity (PM10, PM2.5, TSP, NO_2, SO_2, CO_2, dioxins, heavy metals, etc.), as gathered in Table 24.

Table 24. Emission increase.

Rating	Description
1	0 to 20% of the difference between previous air quality and the maximum admissible
2	20 to 40% of the difference between previous air quality and the maximum admissible
3	40 to 60% of the difference between previous air quality and the maximum admissible
4	60 to 80% of the difference between previous air quality and the maximum admissible
5	Higher than 80% of the difference between previous air quality and the maximum admissible

3.2.6. Landform Changes

Its change, with respect to the natural shape, should be considered as a visual impact and also as a relevant impact to the biodiversity, the ecosystem and the socioeconomical way of living [97]. Hence, it is considered a negative impact. This modification can be caused by the construction of buildings, infrastructures, waste disposals, tailings, etc. (Table 25).

3.2.7. Biodiversity and Ecosystems

Management plan to avoid/reduce/restore and/or compensate the impacts of mining activities is required (standardized, auditable and approved by the competent administration). There are some protocols for biodiversity conservation, such as the one from towards sustainable mining (TSM) developed in Canada. Providing an indicator of the biodiversity conservation management, despite it not being a guarantee of the effectiveness of biodiversity and it does not give a numeric value or specific elements to assess if it is completed properly or not, or the value added or missed in the mine site studied.

The indicator proposed in Table 26 is based on the fact that no net loss would be the best-case scenario. From that point, it should be considered a negative score as the mining project degrades the biodiversity.

Table 25. Landform changes impact.

Rating	Description
1	Small impact: Modifications of the land form, affecting less than 20% of the land used by the mine, recovering it after the mine life time or having an equivalent landform
2	Medium impact: Modifications of the land form, affecting between 20% to 40% of the land used by the mine, recovering it after the mine life time or having an equivalent landform
3	Important impact: Modifications of the land form, affecting more than 40% of the land used by the mine, recovering it after the mine life time or having an equivalent landform
4	Very important impact: Modifications of the land form, affecting more than 60% of the land used by the mine, recovering it after the mine life time or having an equivalent landform
5	Extremely important impact: Modifications of the land form, affecting more than 60% of the land used by the mine, without full recovery after the mine life time or having an equivalent landform

Table 26. Biodiversity and ecosystems degradation.

Rating	Description
1	Slight biodiversity loss during the mining activity.
2	Moderate biodiversity loss during the mining activity.
3	Important biodiversity loss during the mining activity.
4	Very important biodiversity loss during the mining activity.
5	Extremely important loss of biodiversity, not totally recovered after the mine reclamation process.

Special care must be taken if the mining operation affects areas with some degree of protection. The indicator should also consider the land clearance for pits, access routes, and expansion into new areas, the potential habitat fragmentation from access roads and other linear infrastructure required by the mining activity, as well as the possible disruption of surface water, wetland, and groundwater ecosystems [98,99]. The concentration of mining activities in a particular area can also have an important influence on the biodiversity and the whole ecosystem, fragmenting the habitat of animal species and, therefore, flora [100].

3.2.8. Subsidence

Subsidence can generate an important impact, especially in some underground extraction methods [81]. Hence, it is necessary to determine if the surface displacements can have an impact on infrastructures, buildings, groundwater, etc. Its acceptable value will depend on that [101,102]. In this case, it will only have a negative effect (−5) if it is incompatible with the surface anthropic or biotic conditions. Subsidence can be reduced using backfill in some cases, modifying the mining method or the mine design, among other options [81]. On the other hand, surface mining can also have an impact on subsidence due to groundwater or slope failure, as well as incorrect closure techniques.

3.2.9. Positive Environmental Effects

Sometimes, the creation of the mine can generate a positive environmental effect in the long term, Table 27, improving the quality of the land or water, faunistic ecosystems improvements, large-scale reforestation, etc. [98].

Table 27. Environmental conditions improvement.

Rating	Description
1	Slightly better
2	Moderately better
3	Better
4	Much Better
5	Extremely better

3.2.10. Environmental Liabilities

The project can have long term, or almost permanent, environmental liabilities such as tailings [103,104]. In this regard, they should be considered based on the extension of the land affected by these liabilities (Table 28).

Table 28. Extension of the environmental liabilities.

Rating	Description
1	Less than 20% of the area affected during the extraction stage
2	Between 20% and 40% of the area affected during the extraction stage
3	Between 40% and 60% of the area affected during the extraction stage
4	Between 60% and 80% of the area affected during the extraction stage
5	More than 80% of the area affected during the extraction stage

Regarding the potential impact on the environment and communities of these liabilities, the elements stated in Table 29 should also be considered.

Table 29. Environmental liability impact.

Rating	Description
1	Small impact. The potential risk does not affect the characteristics of the environment in the long term and can be easily amended
2	Medium impact: The potential risk does not affect the characteristics of the environment in the long term, but could require large amounts of money to repair it
3	Important impact: The potential risk could affect the characteristics of the environment in the long term and the way of living of the surrounding communities. Moreover, it could require large amounts of money to repair it
4	Very important impact: The potential risk could affect the characteristics of the environment in the long term and the way of living of the surrounding communities and at national or international scale. Moreover, it could require large amounts of money to repair it
5	Extremely important impact: The potential risk could affect the characteristics of the environment in the long term and the way of living of the surrounding communities and at national or international scale. Moreover, there is a high possibility that it could not be repaired, even with large amounts of money

3.2.11. Other Elements

Each mine project and the characteristics of the area where it is going to be developed are different. Factors such as noise level increasing, substantial traffic increase, local price inflation, among other potential issues, are also elements that could also be considered if needed, adding as much elements as necessary.

4. Discussion

The index can be used as an overall value or analysing each dimension separately, socio-economic and environmental, as well as element by element if considered necessary. The index allows us to engage with the different stakeholders in a quantitative and iterative approach, promoting a continuous improvement in the CSR levels of the mining sites and, therefore, the whole mining industry. Additional elements can be defined if necessary, being an adaptable tool to cover any specific characteristic. The analysis can be completed for a new project, greenfield, or an ongoing operation, brownfield.

Overall, it is a first global approach to quantify CSR in mine sites, with the idea of complementing the current qualitative analysis tools and more general approaches used to analyze companies. However, the presence of so many different standards, indexes and tools to assess mining firms can create confusion [105]. It would be advisable to merge them into a single system internationally recognized.

The important implications of mineral resources to the economy makes almost everyone a stakeholder, with different degrees of awareness and direct interaction with the mining activity itself. This fact should be considered, in detail, in the analysis of any mining project and in the usage of the index proposed. This approach can help the industry to improve transparency and, therefore, change society's behaviour towards the mining sector. Showing the way forward in the definition of a common CSR mine site index.

Moreover, the index can help to prioritize the impacts or features more critical regarding: license to operate, direct impact to the financial benefits, improve the company perception, improve the relationship with the communities, damage corporate reputation and decrease/increase the shareholders returns. Most of the impacts mentioned can be positive or negative. The index can also be a tool for the industry to change its investment portfolio, shifting towards the extraction of mineral resources with a lower CO_2 impact. As well as helping other firms involved in mining, not strictly focused on extracting ore, to improve the CSR level, such as the suppliers of goods and services, equipment operators or technological providers. The system proposed could also be adapted to sectors such as civil work or construction.

Some of the CSR elements included in the index deepens the idea of shifting the classical mining activity towards a raw materials provider industry. It is considered a very relevant concept, since it extends the value chain and reduces the temporal perception of the current mining industry. In addition, there are some elements considered in the index that helps to create more value once the mine is closed. For instance, the large amount of energy requested during the operation phase could be used to create an energy provider hub, either green or conventional. However, the knowledge acquired by the employees working in the processing plant could be used to build a recycling center, for instance, which could be implemented while the mining activity is working, as an alternative source of incomes, as well as an ongoing transitional plan. An interesting thought about the elements that make up the index is the greater chance of return and positive CSR performance when the mine site is located close to populated areas than in uninhabited locations.

Regarding the element quantification in the index proposed. Some points are considered as semiquantitative, such as biodiversity or positive environmental effects, since their impacts vary depending on the stakeholder's vision, being necessary to achieve a common point of view, instead of a fixed numerical value, between the parties involved. In this regard, the applicability of the system proposed, and any addition or modification must be completed by means of a transparent procedure and fully disclosed.

Future Works

Governance is not analyzed in the index proposed, further research could be focused on its inclusion. There are important governance elements such as best practices related to the board of the firm, how the relationship is with the stakeholders, the integration of environmental and social aspect in the strategy of the company, transparency and reporting or communication procedure with the different stakeholders and feedback with them. However, governance should be considered as a dimension that embraces the other two, social and environmental dimensions.

Additional research could also be focused on analysing potential weights of each element or dimension. A weight for specific elements extracted from the mine site could also be interesting to consider, since they can represent strategic raw materials for certain areas of the world such as UE, USA or any other region, as well as considering the UN

Sustainable Development Goals (SDGs). The system could also be adapted to quarrying, simplifying the index detailed for small- and medium-scale mining.

Significant indirect economic impacts regarding changes in the local economic composition such as employment induced by the mining activity (public services, employment generated in the region by community social investment, local business development, etc.) should also be deeply studied.

On the other hand, the presence of small-scale mining and artisanal mining is common in the surroundings of large mining activities in some countries. It would also be important to define tools to set a collaboration with them.

5. Conclusions

A new quantitative index has been proposed to analyse the corporate social responsibility (CSR) performance at the mine site level, focused on the socio-economic and environmental dimensions from a technical point of view by means of 30 analysis elements. The approach proposed can be a very useful tool to engage the stakeholders and increase the value of a mining project. Moreover, it is a flexible system that is easy to adapt to any specific mine site characteristics.

Regarding the structure of the index proposed, it has been found that it is always better to use a relative analysis instead of aggregate values, since each mining project can be different and, at the same time, dependents of the geological characteristics (depth, ore body shape and size, ore grade, etc.). The applicability of the index proposed, the selection of the elements and assessment, requires a transparent procedure and fully disclosed; otherwise, there is a risk of losing confidence in the proposed system.

Author Contributions: Conceptualization, M.B., L.S., C.V. and M.Y.; methodology, M.B. and C.V.; validation, M.B., L.S., C.V. and M.Y.; formal analysis, M.B. and M.Y.; investigation, M.B. and L.S.; writing—original draft preparation, M.B., L.S., C.V. and M.Y.; writing—review and editing, M.B., L.S., C.V. and M.Y. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Gandhi, S.M.; Sarkar, B.C. Mineral Deposits. *Essent. Miner. Explor. Eval.* **2016**, *2016*, 23–52. [CrossRef]
2. Joyce, S.; Thomson, I. Earning a social licence to operate: Social acceptability and resource development in Latin America. *Can. Min. Metall. Bull.* **2000**, *93*, 1037.
3. Boutilier, R.; Thomson, I. *Encyclopedia of Business and Professional Ethics*; Springer: Berlin/Heidelberg, Germany, 2020; Volume 1. [CrossRef]
4. Banerjee, S.B. Whose land is it any way? National interest, Indigenous stakeholders, and colonial discourses: The case of the Jabiluka uranium mine. *Organiz. Environ.* **2000**, *13*, 3–38. [CrossRef]
5. Barber, M.; Jackson, S. Indigenous engagement in Australian mine water management: The alignment of corporate strategies with national water reform objectives. *Resour. Policy* **2012**, *37*, 48–58. [CrossRef]
6. Meissner, K.; Everingham, J.A. Information control and competence: Participant experience of public participation in EIA for proposed mining projects in Queensland. *Australas. J. Environ. Manag.* **2021**, *28*, 287–304. [CrossRef]
7. Viveros, H. Responsibility in the mining sector. *Resour. Policy* **2017**, *51*, 1–12. [CrossRef]
8. Parsons, R.; Lacey, J.; Moffat, K. Maintaining legitimacy of a contested practice: How the minerals industry understands its social licence to operate. *Resour. Policy* **2014**, *41*, 83–90. [CrossRef]
9. Franks, D.M.; Cohen, T. Social licence in design: Constructive technology assessment within a mineral research and development institution. *Technol. Forecast. Soc. Change* **2012**, *79*, 1229–1240. [CrossRef]
10. Porter, M.E.; Kramer, M.R. Strategy & society: The link between competitive advantage and corporate social responsibility. *Harv. Bus. Rev.* **2006**, *84*, 78–92.
11. Hilson, G. Corporate social responsibility in the extractive industries: Experiences from developing countries. *Resour. Policy* **2012**, *37*, 131–137. [CrossRef]

12. Andrews, N. Challenges of corporate social responsibility (CSR) in domestic settings: An exploration of mining regulation vis-à-vis CSR in ghana. *Resour. Policy* **2016**, *47*, 9–17. [CrossRef]
13. Wilson, S.A. Measuring the effectiveness of corporate social responsibility initiatives in diamond mining areas of sierra leone. *Resour. Policy* **2022**, *77*, 102651. [CrossRef]
14. Shipton, L.; Dauvergne, P. The influence of home country institutions on the adoption of corporate social responsibility policies by transnational mining corporations. *Extr. Ind. Soc.* **2022**, *10*, 101077. [CrossRef]
15. Cheng, B.; Ioannou, I.; Serafeimi, G. Corporate social responsibility and access to finance. *Strateg. Manag. J.* **2014**, *35*, 1–23. [CrossRef]
16. Deloitte. Tracking the Trends 2022: Redefining Mining. 2022. Available online: https://www2.deloitte.com/content/dam/Deloitte/au/Documents/energy-resources/deloitte-au-global-tracking-the-trends-2022-digital020222.pdf (accessed on 18 April 2022).
17. Jenkins, H.; Yakovleva, N. Corporate social responsibility in the mining industry: Exploring trends in social and environmental disclosure. *J. Clean. Prod.* **2006**, *14*, 271–284. [CrossRef]
18. Maloni, M.J.; Brown, M.E. Corporate social responsibility in the supply chain: An application in the food industry. *J. Bus. Ethics* **2006**, *68*, 35–52. [CrossRef]
19. Khan, A.; Muttakin, M.B.; Siddiqui, J. Corporate governance and corporate social responsibility disclosures: Evidence from an emerging economy. *J. Bus. Ethics* **2013**, *114*, 207–223. [CrossRef]
20. Xia, B.; Olanipekun, A.; Chen, Q.; Xie, L.; Liu, Y. Conceptualising the state of the art of corporate social responsibility (CSR) in the construction industry and its nexus to sustainable development. *J. Clean. Prod.* **2018**, *195*, 340–353. [CrossRef]
21. Latif, K.F.; Sajjad, A. Measuring corporate social responsibility: A critical review of survey instruments. *Corp. Soc. Responsib. Environ. Manag.* **2018**, *25*, 1174–1197. [CrossRef]
22. Ranängen, H.; Zobel, T.; Bergström, A. The merits of ISO 26000 for CSR development in the mining industry: A case study in the zambian copperbelt. *Soc. Responsib. J.* **2014**, *10*, 500–515. [CrossRef]
23. European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, EU Principles for Sustainable Raw Materials, Publications Office of the European Union. 2022. Available online: https://data.europa.eu/doi/10.2873/789368 (accessed on 16 May 2022).
24. Overland, I.; Bourmistrov, A.; Dale, B.; Irlbacher-Fox, S.; Juraev, J.; Podgaiskii, E.; Stammler, F.; Tsani, S.; Vakulchuk, R.; Wilson, E.C. The Arctic Environmental Responsibility Index: A method to rank heterogenous extractive industry companies for governance purposes. *Bus. Strategy Environ.* **2021**, *30*, 1623–1643. [CrossRef]
25. Amato, L.H.; Amato, C.H. Environmental policy, rankings and stock values. *Bus. Strategy Environ.* **2012**, *21*, 317–325. [CrossRef]
26. Urueña, R. Indicators as political spaces: Law, international organizations, and the quantitative challenge in global governance. *Int. Organ. Law Rev.* **2015**, *12*, 1–18. [CrossRef]
27. Dilling, P.F.A. Reporting on long-term value creation-The example of public canadian energy and mining companies. *Sustainability* **2016**, *8*, 938. [CrossRef]
28. Bullock, G. *Green Grades: Can Information Save the Earth?* MIT Press: Cambridge, UK, 2017.
29. Prakash, A.; Potoski, M. Voluntary environmental programs: A comparative perspective. *J. Policy Anal. Manag.* **2012**, *31*, 123–138. [CrossRef]
30. Trumpp, C.; Guenther, T. Too little or too much? Exploring U- shaped relationships between corporate environmental performance and corporate financial performance. *Bus. Strategy Environ.* **2017**, *26*, 49–68. [CrossRef]
31. Potts, J.; Wenban-Smith, M.; Turley, L.; Lynch, M. Standards and the extractive economy. In *State of Sustainability Initiatives Series*; International Institute for Sustainable Development: Winnipeg, MB, Canada, 2018.
32. Ranängen, H.; Zobel, T. Revisiting the 'how' of corporate social responsibility in extractive industries and forestry. *J. Clean. Prod.* **2014**, *84*, 299–312. [CrossRef]
33. Antão, M.; Carolino, A.; Vieira, R. The Strategic Importance of the Lithiniferous Deposits of Gonçalo (Guarda, Portugal) in Sustainable Development of Low Density Regions—The Lithium Project. *Mod. Environ. Sci. Eng.* **2018**, *4*, 590–599. [CrossRef]
34. Lin, P.T.; Li, B.; Bu, D. The relationship between corporate governance and community engagement: Evidence from the Australian mining companies. *Resour. Policy* **2015**, *43*, 28–39. [CrossRef]
35. Prno, J.; Pickard, M.; Kaiyogana, J. Effective community engagement during the environmental assessment of a mining project in the canadian arctic. *Environ. Manag.* **2021**, *67*, 1000–1015. [CrossRef]
36. Cassotta, S.; Cueva, V.P.; Raftopoulos, M. Australia: Regulatory, human rights and economic challenges and opportunities of large-scale mining projects: A case study of the carmichael coal mine. *Environ. Policy Law* **2020**, *50*, 357–372. [CrossRef]
37. Idahosa, P. Business ethics and development in conflict (zones): The case of talisman oil. *J. Bus. Ethics* **2002**, *39*, 227–246. [CrossRef]
38. Xing, M.; Awuah-Offei, K.; Long, S.; Usman, S. The effect of local supply chain on regional economic impacts of mining. *Extr. Ind. Soc.* **2017**, *4*, 622–629. [CrossRef]
39. McHenry, M.P.; Doepel, D.G.; Urama, K.C. Making extractive industries-led growth inclusive: An introduction. *Extr. Ind. Soc.* **2017**, *4*, 235–239. [CrossRef]
40. Baumann, J.; Kritikos, A.S. The link between R&D, innovation and productivity: Are micro firms different? *Res. Policy* **2016**, *45*, 1263–1274. [CrossRef]

41. Coval, J.; Tobias, M. The Geography of Investment: Informed Trading and Asset Prices. *J. Political Econ.* **2001**, *109*, 811–841. [CrossRef]
42. Portes, R.; Rey, H. The determinants of cross-border equity flows. *J. Int. Econ.* **2005**, *65*, 269–296. [CrossRef]
43. Monteiro, N.B.R.; da Silva, E.A.; Moita Neto, J.M. Sustainable development goals in mining. *J. Clean. Prod.* **2019**, *228*, 509–520. [CrossRef]
44. Rolfe, J.; Miles, B.F.; Lockie, S.; Ivanova, G. Lessons from the Social and Economic Impacts of the Mining Boom in the Bowen Basin 2004–2006. *Australas. J. Reg. Stud.* **2007**, *13*, 134.
45. Kamenopoulos, S.; Agioutantis, Z. The Importance of the Social License to Operate at the Investment and Operations Stage of Coal Mining Projects: Application using a Decision Support System. *Extr. Ind. Soc.* **2021**, *8*, 100740. [CrossRef]
46. Fessehaie, J. What determines the breadth and depth of Zambia's backward linkages to copper mining? The role of public policy and value chain dynamics. *Resour. Policy* **2012**, *37*, 443–451. [CrossRef]
47. Lockie, S.; Franetovich, M.; Sharma, S.; Rolfe, J. Democratisation versus engagement? Social and economic impact assessment and community participation in the coal mining industry of the Bowen Basin, Australia. *Impact Assess. Proj. Apprais.* **2008**, *26*, 177–187. [CrossRef]
48. MacInnes, A.; Colchester, M.; Whitmore, A. Free, prior and informed consent: How to rectify the devastating consequences of harmful mining for indigenous peoples. *Perspect. Ecol. Conserv.* **2017**, *15*, 152–160. [CrossRef]
49. Martin, F. Aboriginal and torres strait islander peoples' use of charities as a structure to receive mining payments: An evaluation of the rationale through three case studies. *Griffith Law Rev.* **2013**, *22*, 205–237. [CrossRef]
50. Owen, J.R.; Kemp, D. Social licence and mining: A critical perspective. *Resour. Policy* **2013**, *38*, 29–35. [CrossRef]
51. Mehahad, M.S.; Bounar, A. Phosphate mining, corporate social responsibility and community development in the Gantour Basin, Morocco. *Extr. Ind. Soc.* **2020**, *7*, 170–180. [CrossRef]
52. Laurence, D. Establishing a sustainable mining operation: An overview. *J. Clean. Prod.* **2011**, *19*, 278–284. [CrossRef]
53. Hendrychová, M.; Svobodova, K.; Kabrna, M. Mine reclamation planning and management: Integrating natural habitats into post-mining land use. *Resour. Policy* **2020**, *69*, 101882. [CrossRef]
54. Marot, N.; Harfst, J. Post-mining landscapes and their endogenous development potential for small- and medium-sized towns: Examples from Central Europe. *Extr. Ind. Soc.* **2021**, *8*, 168–175. [CrossRef]
55. Arratia-Solar, A.; Svobodova, K.; Lèbre, É.; Owen, J.R. Conceptual framework to assist in the decision-making process when planning for post-mining land-uses. *Extr. Ind. Soc.* **2022**, *10*, 101083. [CrossRef]
56. Pietrzykowski, M.; Krzaklewski, W. Reclamation of Mine Lands in Poland. In *Bio-Geotechnologies for Mine Site Rehabilitation*; Elsevier Inc.: Amsterdam, The Netherlands, 2018. [CrossRef]
57. Frejowski, A.; Bondaruk, J.; Duda, A. Challenges and opportunities for end-of-life coal mine sites: Black-to-green energy approach. *Energies* **2021**, *14*, 1385. [CrossRef]
58. Kelm, U.; Baumgartl, T.; Edraki, M.; Gutiérrez, L.; Jerez, O.; Morales, J.; Novoselov, A. Mineralogy of tailings: Challenges to usual routines of characterization. In Proceedings of the IMPC 2018-29th International Mineral Processing Congress, Moscow, Russia, 17–21 September 2018; pp. 108–114.
59. Carmignano, O.R.; Vieira, S.S.; Teixeira, A.P.C.; Lameiras, F.S.; Brandão, P.R.G.; Lago, R.M. Iron ore tailings: Characterization and applications. *J. Braz. Chem. Soc.* **2021**, *32*, 1895–1911. [CrossRef]
60. Rodrigues, P.M.; Antão, A.; Rodrigues, R. Evaluation of the impact of lithium exploitation at the C57 mine (Gonçalo, Portugal) on water, soil and air quality. *Environ. Earth Sci.* **2019**, *78*, 533. [CrossRef]
61. Carvalho, M.; Romero, A.; Shields, G.; Millar, D.L. Optimal synthesis of energy supply systems for remote open pit mines. *Appl. Therm. Eng.* **2014**, *64*, 315–330. [CrossRef]
62. Linkov, S.A.; Olizarenko, V.V.; Radionov, A.A.; Sarapulov, O.A. Energy-efficient power supply system for mines. *Procedia Eng.* **2015**, *129*, 63–68. [CrossRef]
63. Ernst & Young (EY). *Top 10 Business Risks and Opportunities for Mining and Metals in 2022*; Ernst & Young (EY): London, UK, 2022.
64. Gan, Y.; Griffin, W.M. Analysis of life-cycle GHG emissions for iron ore mining and processing in China—Uncertainty and trends. *Resour. Policy* **2018**, *58*, 90–96. [CrossRef]
65. Kalantari, H.; Sasmito, A.P.; Ghoreishi-Madiseh, S.A. An overview of directions for decarbonization of energy systems in cold climate remote mines. *Renew. Sustain. Energy Rev.* **2021**, *152*, 111711. [CrossRef]
66. Xu, Z.; Zhai, S.; Phuong, N.X. Research on green transition development of energy enterprises taking mining industry as an example. *Nat. Environ. Pollut. Technol.* **2019**, *18*, 1521–1526.
67. Voronin, V.A.; Nepsha, F.S.; Ermakov, A.N.; Kantovich, L.I. Analysis of electrical equipment operating modes of the excavation site of a modern coal mine. *Sustain. Dev. Mt. Territ.* **2021**, *13*, 599–607. [CrossRef]
68. Owen, J.R.; Kemp, D.; Lèbre, E.; Svobodova, K.; Pérez Murillo, G. Catastrophic tailings dam failures and disaster risk disclosure. *Int. J. Disaster Risk Reduct.* **2020**, *42*, 101361. [CrossRef]
69. Laurence, D. The devolution of the social licence to operate in the Australian mining industry. *Extr. Ind. Soc.* **2021**, *8*, 100742. [CrossRef] [PubMed]
70. Saes, B.M.; Muradian, R. What misguides environmental risk perceptions in corporations? Explaining the failure of Vale to prevent the two largest mining disasters in Brazil. *Resour. Policy* **2021**, *72*, 102022. [CrossRef]

71. Islam, K.; Murakami, S. Global-scale impact analysis of mine tailings dam failures: 1915–2020. *Glob. Environ. Change* **2021**, *70*, 102361. [CrossRef]
72. Cacciuttolo, C.; Valenzuela, F. Efficient use of water in tailings management: New technologies and environmental strategies for the future of mining. *Water* **2022**, *14*, 1741. [CrossRef]
73. Chen, W.; Yin, S.; Zhou, G.; Li, Z.; Song, Q. Copper recovery from tailings through bioleaching and further application of bioleached tailings residue: Comprehensive utilization of tailings. *J. Clean. Prod.* **2022**, *332*, 130129. [CrossRef]
74. Sanders, J.; McLeod, H.; Small, A.; Strachotta, C. Mine closure residual risk management: Identifying and managing credible failure modes for tailings and mine waste. In *Mine Closure 2019*; Australian Centre for Geomechanics: Perth, WA, Australia, 2019; pp. 535–551.
75. Falagán, C.; Grail, B.M.; Johnson, D.B. New approaches for extracting and recovering metals from mine tailings. *Miner. Eng.* **2017**, *106*, 71–78. [CrossRef]
76. Behera, S.K.; Mishra, D.P.; Singh, P.; Mishra, K.; Mandal, S.K.; Ghosh, C.N.; Mandal, P.K. Utilization of mill tailings, fly ash and slag as mine paste backfill material: Review and future perspective. *Constr. Build. Mater.* **2021**, *309*, 125120. [CrossRef]
77. Song, X.; Pettersen, J.B.; Pedersen, K.B.; Røberg, S. Comparative life cycle assessment of tailings management and energy scenarios for a copper ore mine: A case study in northern Norway. *J. Clean. Prod.* **2017**, *164*, 892–904. [CrossRef]
78. Liu, T.; Li, X.; Guan, L.; Liu, P.; Wu, T.; Li, Z.; Lu, A. Low-cost and environment-friendly ceramic foams made from lead-zinc mine tailings and red mud: Foaming mechanism, physical, mechanical and chemical properties. *Ceram. Int.* **2016**, *42*, 1733–1739. [CrossRef]
79. Pan, H.; Zhou, G.; Cheng, Z.; Yang, R.; He, L.; Zeng, D.; Sun, B. Advances in geochemical survey of mine tailings project in china. *J. Geochem. Explor.* **2014**, *139*, 193–200. [CrossRef]
80. Golev, A.; Gallagher, L.; Vander Velpen, A.; Lynggaard, J.R.; Friot, D.; Stringer, M.; Chuah, S.; Arbelaez-Ruiz, D.; Mazzinghy, D.; Moura, L.; et al. *Ore-Sand: A Potential New Solution to the Mine Tailings and Global Sand Sustainability Crises*; The University of Queensland: Brisbane, QLD, Australia, 2022.
81. Hustrulid, W.A.; Bullock, R.C. *Underground Mining Methods: Engineering Fundamentals and International Case Studies*; Society for Mining, Metallurgy and Exploration: Littleton, CO, USA, 2012.
82. Kalisz, S.; Kibort, K.; Mioduska, J.; Lieder, M.; Małachowska, A. Waste management in the mining industry of metals ores, coal, oil and natural gas—A review. *J. Environ. Manag.* **2022**, *304*, 114239. [CrossRef] [PubMed]
83. Kruukka, A.; Broicher, H.F. Kiruna mineral processing starts underground—bulk sorting by LIF. *CIM Bull.* **2002**, *95*, 79–84.
84. Nassar, N.T.; Lederer, G.W.; Brainard, J.; Padilla, A.; Lessard, J. The rock-to-metal ratio—A foundational metric for understanding mine wastes. *Environ. Sci. Technol.* **2022**, *56*, 6710–6721. [CrossRef]
85. Mudd, G.M. Sustainability and Mine Waste Management—A Snapshot of Mining Waste Issues. In Proceedings of the Waste Management & Infrastructure Conference, Tucson, Arizona, 25 February–1 March 2007; pp. 1–12.
86. De la Vergne, J. *Hard Rock Miner's Handbook*, 5th ed.; Stantec Engineering: Edmonton, AB, Canada, 2014; ISBN 0-9687006-1-6.
87. Jiang, H.; Cao, Y.; Huang, P.; Fang, K.; Li, B. Characterisation of coal-mine waste in solid backfill mining in china. *Trans. Inst. Min. Metall. Sect. A Min. Technol.* **2015**, *124*, 56–63. [CrossRef]
88. Krishna, R.S.; Mishra, J.; Meher, S.; Das, S.K.; Mustakim, S.M.; Singh, S.K. Industrial solid waste management through sustainable green technology: Case study insights from steel and mining industry in Keonjhar, India. *Mater. Today Proc.* **2020**, *33*, 5243–5249. [CrossRef]
89. Sözen, S.; Orhon, D.; Dinçer, H.; Ateşok, G.; Baştürkçü, H.; Yalçın, T.; Yağcı, N. Resource recovery as a sustainable perspective for the remediation of mining wastes: Rehabilitation of the CMC mining waste site in northern Cyprus. *Bull. Eng. Geol. Environ.* **2017**, *76*, 1535–1547. [CrossRef]
90. Sołtysiak, M.; Dąbrowska, D.; Krzykawski, T.; Barczyk, M.; Domagalska, P. Environmental effects of mining waste usage during a gravel pit reclamation in the vistula valley in Oswiecim (southern Poland). *Int. Multidiscip. Sci. GeoConference Surv. Geol. Min. Ecol. Manag.* **2019**, *19*, 199–206. [CrossRef]
91. Szyplinska, P. *CEO 360 Degree Perspective of the Global Mining Water and Wastewater Treatment Market*; Frost Sullivan: San Antonio, TX, USA, 2012; p. 11.
92. Admiraal, R.; Sequeira, A.R.; McHenry, M.P.; Doepel, D. Maximizing the impact of mining investment in water infrastructure for local communities. *Extr. Ind. Soc.* **2017**, *4*, 240–250. [CrossRef]
93. Edwards, H.G.M.; Vandenabeele, P.; Jorge-Villar, S.E.; Carter, E.A.; Perez, F.R.; Hargreaves, M.D. The rio tinto mars analogue site: An extremophilic raman spectroscopic study. *Spectrochim. Acta-Part A Mol. Biomol. Spectrosc.* **2007**, *68*, 1133–1137. [CrossRef]
94. Rufo, L.; Rodríguez, N.; de la Fuente, V. Plant communities of extreme acidic waters: The Rio Tinto case. *Aquat. Bot.* **2011**, *95*, 129–139. [CrossRef]
95. Tharme, R.E. A global perspective on environmental flow assessment: Emerging trends in the development and application of environmental flow methodologies for rivers. *River Res. Appl.* **2003**, *19*, 397–441. [CrossRef]
96. Asif, Z.; Chen, Z.; Han, Y. Air quality modeling for effective environmental management in the mining region. *J. Air Waste Manag. Assoc.* **2018**, *68*, 1001–1014. [CrossRef] [PubMed]
97. Tukiainen, H.; Kiuttu, M.; Kalliola, R.; Alahuhta, J.; Hjort, J. Landforms contribute to plant biodiversity at alpha, beta and gamma levels. *J. Biogeogr.* **2019**, *46*, 1699–1710. [CrossRef]

98. Sonter, L.J.; Ali, S.H.; Watson, J.E.M. Mining and biodiversity: Key issues and research needs in conservation science. *Proc. R. Soc. B Biol. Sci.* **2018**, *285*, 20181926. [CrossRef]
99. Huang, X.; Sillanpää, M.; Gjessing, E.T.; Peräniemi, S.; Vogt, R.D. Environmental impact of mining activities on the surface water quality in Tibet: Gyama valley. *Sci. Total Environ.* **2010**, *408*, 4177–4184. [CrossRef]
100. Rigina, O. Environmental impact assessment of the mining and concentration activities in the kola peninsula, Russia by multidate remote sensing. *Environ. Monit. Assess.* **2002**, *75*, 11–31. [CrossRef]
101. Sanmiquel, L.; Bascompta, M.; Vintró, C.; Yubero, T. Subsidence Management System for Underground Mining. *Minerals* **2018**, *8*, 243. [CrossRef]
102. Song, J.; Han, C.; Li, P.; Zhang, J.; Liu, D.; Jiang, M.; Zheng, L.; Zhang, J.; Song, J. Quantitative prediction of mining subsidence and its impact on the environment. *Int. J. Min. Sci. Technol.* **2012**, *22*, 69–73. [CrossRef]
103. Ishchenko, M. Mining and beneficiation companies liabilities figures correction. *Econ. Ann.-XXI* **2013**, *11–12*, 58–61.
104. Cardoso, A. Behind the life cycle of coal: Socio-environmental liabilities of coal mining in Cesar, Colombia. *Ecol. Econ.* **2015**, *120*, 71–82. [CrossRef]
105. Burger-Helmchen, T.; Siegel Erica, J. Some thoughts On CSR in relation to B Corp Labels. *Entrep. Res. J.* **2020**, *10*, 1–19. [CrossRef]