Table of Contents

List of figures

List of Abbreviations

GRI   Global Reporting Initiative

KPI   Key Performance Indicator

List of tables

1. Introduction and problem statement

1.1. Introduction

Mining activities can give rise to social hazards and challenges that affect nearby communities. Displacement of communities disrupts the social fabric and livelihoods of people, while environmental degradation impacts natural resources vital for sustenance. Mining-related health issues and conflicts over land rights can arise, and the distribution of mining benefits may be uneven. Cultural heritage sites may be damaged or destroyed, leading to a loss of identity. Addressing these hazards requires transparent and inclusive engagement with communities, fair compensation, sustainable livelihood alternatives, protection of cultural heritage, and responsible mining practices.

Mining activities also have significant hazards and impacts on the environment. Mining releases pollutants into water bodies, air, and soil, leading to the degradation of natural resources and harming aquatic ecosystems. Excavation can weaken geological structures, causing land subsidence and instability. Mining also contributes to greenhouse gas emissions and climate change. Mitigation efforts involve environmental assessments, sustainable mining practices, reclamation of mined areas, pollution control measures, and the adoption of cleaner technologies. Regulatory frameworks and international standards play a crucial role in promoting responsible mining and reducing the environmental impact of mining operations.

On the other hand, mining is closely linked to the energy transition, which involves shifting from fossil fuels to renewable energy. Mining is essential for extracting minerals needed in renewable technologies like batteries, solar panels, and wind turbines. Scaling up renewable energy increases the demand for mining raw materials.

1.2. Problem Statement

Although mining activities have been increasingly subject to government regulations and international standards, whilst industry best practices have guided mining companies in mitigating these hazards and promoting positive social outcomes in recent years, their controversial practices regarding nature and human rights continue.

Workplace safety comes first in this sector for social concerns. For instance, the primary cause of coal mine fires, spontaneous heating (endogenous fires), depends on various mining, geological, and environmental factors. Additionally, unscientific coal exploitation and other exogenous factors make coal mine fires more catastrophic (Pandey et al., 2016). The number of deaths of employees because of these fatal incidents is shown in Figure 1.
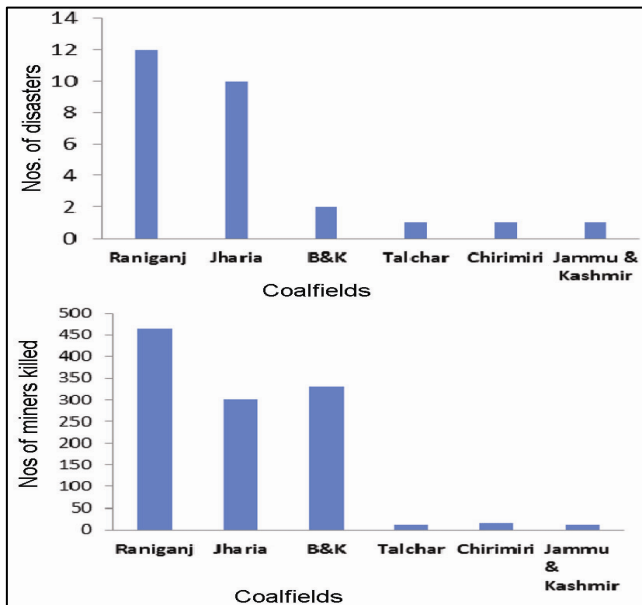
Figure 1 Statistics of disasters and total numbers of fatalities of miners due to coal mine fire (Pandey et al., 2016)

Nearly 100,000 ha of deforestation due to Artisanal-scale gold mining (ASGM) in the 34-year study period, an increase of 21% compared to previous estimates. While deforestation rates are declining globally, they are increasing in the Western Amazon. ASGM is a major cause of this deforestation and brings with it extensive environmental, social, governance, and public health impacts, including large carbon emissions and mercury pollution (Espejo et al., 2018). Figure 2 indicates that 53% of that deforestation has occurred since 2011, and that 10% of it occurred in 2017, the year with the highest annual amount of deforestation during the study period.
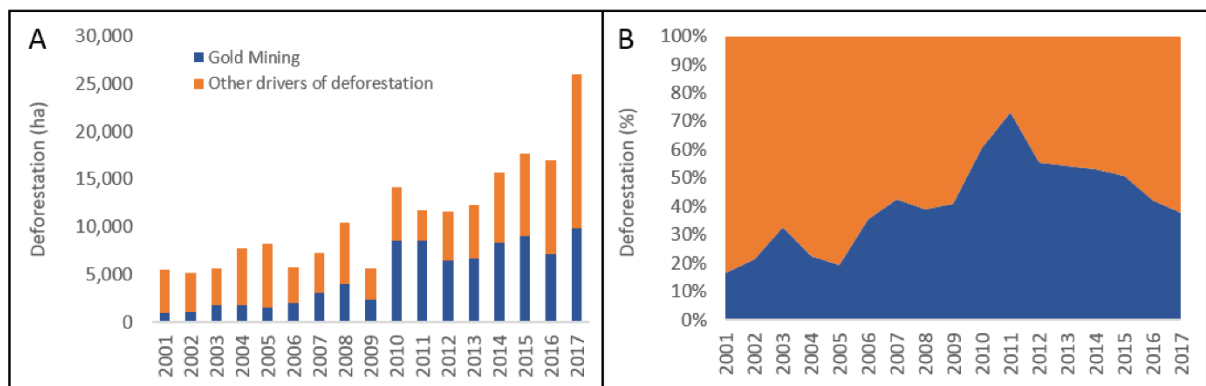
Figure 2 Forest Degradation Due to Gold Mining in Amazon (Espejo et al., 2018)

Some of the hazards that cause controversies and risks are intertwined and difficult to isolate from each other; such as the acidity increase in air and the safety of employees. Despite all these dangers, there is no expectation that mining will stop soon. One of the most important reasons for this is that some of the extracted materials have an exceptionally large market share and are the basis of most industries, while some elements show promise for green solutions. The most concrete proof of this is the types of batteries used in electric vehicles and consisting of various compositions. Thanks to these material accretions, the interest in fossil fuels will gradually disappear. The variety of lithium batteries greatly differentiates according to their different material composition and different kind of metals are used in market (Figure 3).

2

Figure 3 The market share of different kind of Li-Ion Batteries in India (Maximize Market Research Pvt Ltd, 2023)

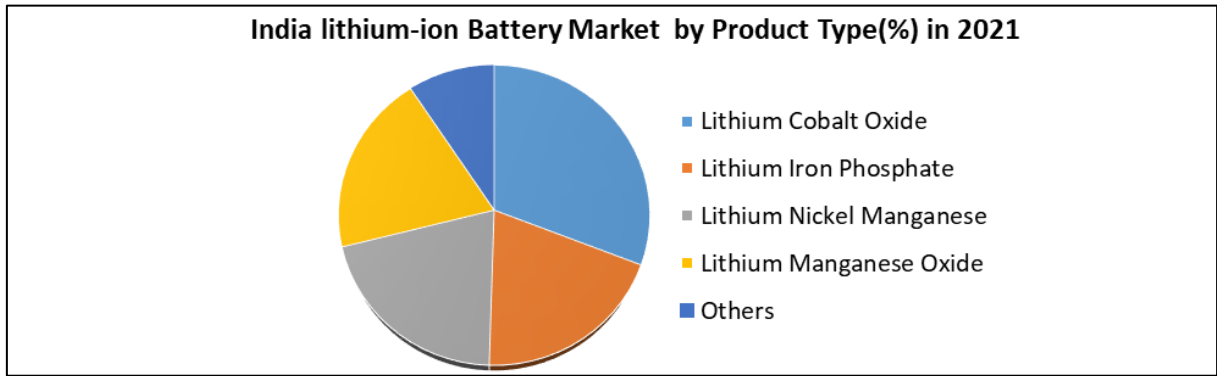Considering all these factors, it is inevitable for both a sustainable industry and a sustainable environment to act now. However, stakeholders do not universally agree on the definition of sustainable mining practices or the specific indicators that should be evaluated. This lack of consensus results in varying frameworks and guidelines across different organizations and countries, leading to inconsistencies and difficulties in making meaningful comparisons between assessments.

In detail, since there is no reference point in the mining sector, the only chance to visualize the current situation of projects is through large-scale comparisons. By rating mining activities, they are brought in line with the principles of sustainable development, allowing for the adoption of exemplary practices like responsible resource extraction, ecosystem preservation, community involvement, and equitable labour standards. Through the integration of social, environmental, and economic factors, standardized mining activities can contribute to long-term sustainability and yield favourable socio-economic results.

2. Methodology

To evaluate the sustainability of mines, this tool incorporates the three dimensions identified in the Life Cycle Assessment (LCA): Environmental, Social, and Economic factors (Zamagni, 2012). These dimensions act as Key Performance Indicators (KPIs) that contribute to the overall rating of the mine. With the collaboration of the Chair of Land Management and considering the standards set by the Global Reporting Initiative (GRI), specific parameters have been identified to assess each KPI (GRI, 2023). Each of the KPIs with its associated parameters can be found in Table 1, 2, and 3, respectively.

To determine the mine's score, the following procedure is used: each individual parameter is assigned a rating on a scale of 0 (worst / no action) to 10 (best / multiple actions). The parameters have been grouped together, resulting in two or three sub-groups for each KPI (e.g., impact on air for the Environmental KPI). Each sub-group score carries equal weight, regardless of the number of parameters it comprises. The average score of the sub-groups then determines the ranking for each KPI. Finally, the average score of all KPIs determines the overall ranking of the mine.

To gather data for each parameter, both quantitative and qualitative methods are used. Quantitative data involves the collection of numerical information, such as measurements, statistics, and metrics related to the specific parameter being assessed. Means through which this data is obtained include on-site monitoring, laboratory analysis, reports of NGOs and research institutes, and statistical databases.

Additionally, qualitative data will also be gathered to provide a deeper understanding of the parameter's impact and performance. This qualitative information is obtained through interviews, surveys, observations, and stakeholder consultations. These methods allow for the capture of subjective perspectives, opinions, and insights from individuals directly involved or affected by the mining operations.

In order to analyse the data, we employ the Excel-standardise function. For data visualisation purposes, we utilise Power BI. As an illustrative demonstration, we employed two mines to showcase the functionality of the tool and standardised the data in Excel to conform to a 0-10 scale.

Environmental		
Impact on air	**Impact on water**	**Impact on land**
Energy efficiency measures	Interactions with water as a shared resource	Reporting on biodiversity
Electrification of equipment	Management of water discharge-related impacts	Preventive actions
Use of renewable energy systems	Report on water withdrawal, water discharge, water consumption	Minimize impacts where avoidance is not possible
Support for reforestation projects		Reporting on waste and waste disposal
Report on air emissions		Waste disposal management procedures in place?
		Commitment with Global Industry Standard on Tailings Management
		Reporting on tailing disposal management
		Report on response plan

Table 1 Environmental KPI

Social		
Human Rights	**Health and Safety**	**Community Engagement**
Rights of Indigenous People	Occupational health and safety	Local communities
Land and resource rights	Security practices	Conflict-affected and high-risk areas
Artisanal and small-scale mining	Critical incident management	

4

Social		
Child labour		
Forced labour and modern slavery		
Freedom of association and collective bargaining		
Non-discrimination and collective bargaining		

Table 2 Social KPI

Economic	
Revenue	**Cost**
Current Mineral Prices	Exploration & Development
Production volume	Site Preparation and Infrastructure
Ore Grade	Labor & Workforce
Recovery Rate	Energy & Fuel demands for whole process
By-Products Credits	Logistic
Current Market Demands	
Potential Market Demands	

Table 3 Economic KPI

3. Our solution

3.1. Our Prototype for the "Rate My Mine" Tool

The extraction industry yields an extensive array of parameters, resulting in the generation of complex mega data that presents challenges in terms of comprehension and establishing connections between variables. To facilitate a clear understanding of this mega data, it must be meticulously structured. The primary objective of Rate my mine is to enhance transparency in mining projects conducted by extraction companies across the globe through the implementation of data visualization techniques that can be comprehended by individuals with varying levels of information. To achieve this goal, a comprehensive dashboard equipped with slicing options and visualization components has been developed.

3.1.1. Main Dashboard

The main dashboard is the page encountered at first. It has interactive components linked to other pages, charts, and graphs.
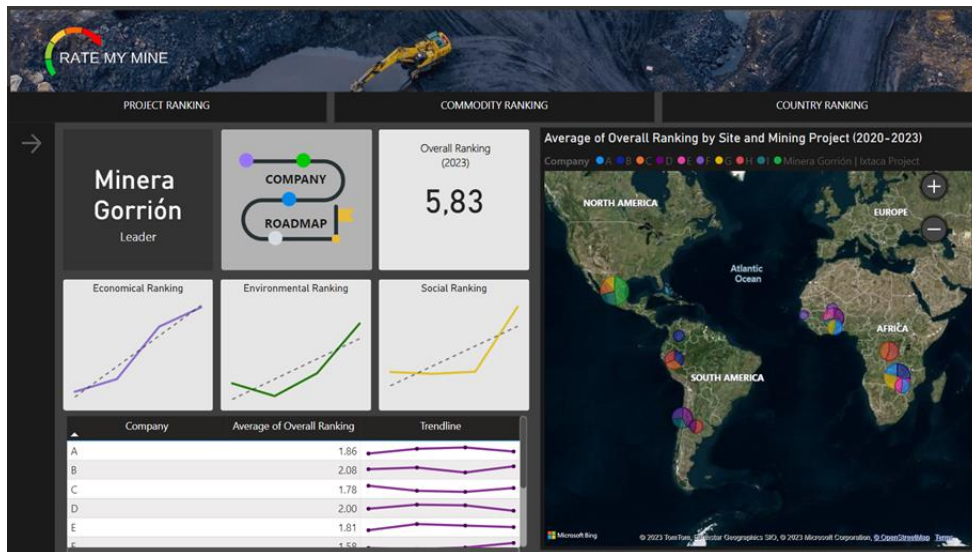
Figure 4 Main page of the prototype

An interactive world map that allows users to evaluate the company activities based on their sites in various locations is displayed on the main dashboard. Pie charts indicate the ranks of the company projects on that site and their proportions. Bigger slices mean a higher rank. The values can be shown by moving the mouse pointer on them.
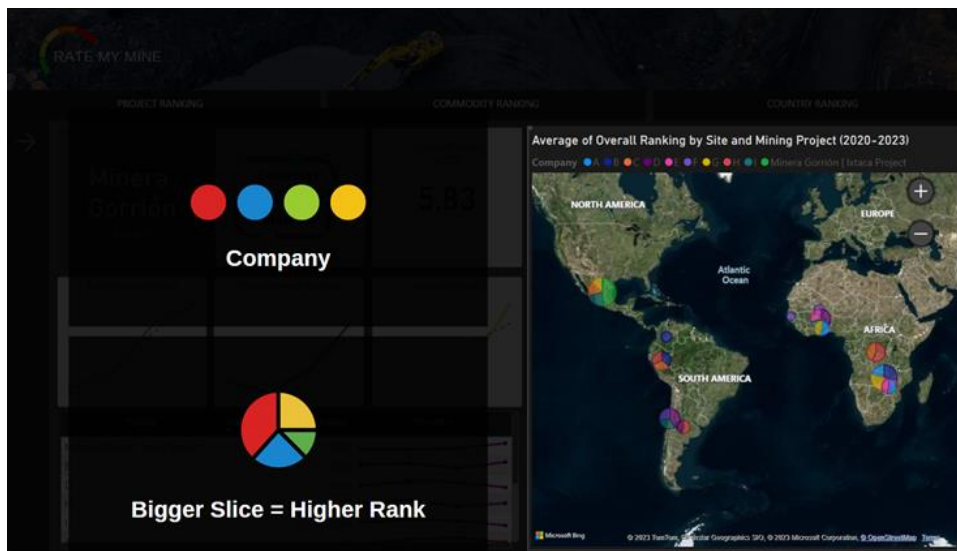
Figure 5 Interactive world map with pie charts

The Leader Project Section provides information on the company roadmap, overall ranking of the current year, and trendlines for performances of three KPIs: Environmental, Economic, and Social. The Company Roadmap is built for tracking the past actions of the leader company on their best mining site to see the effort behind their success.
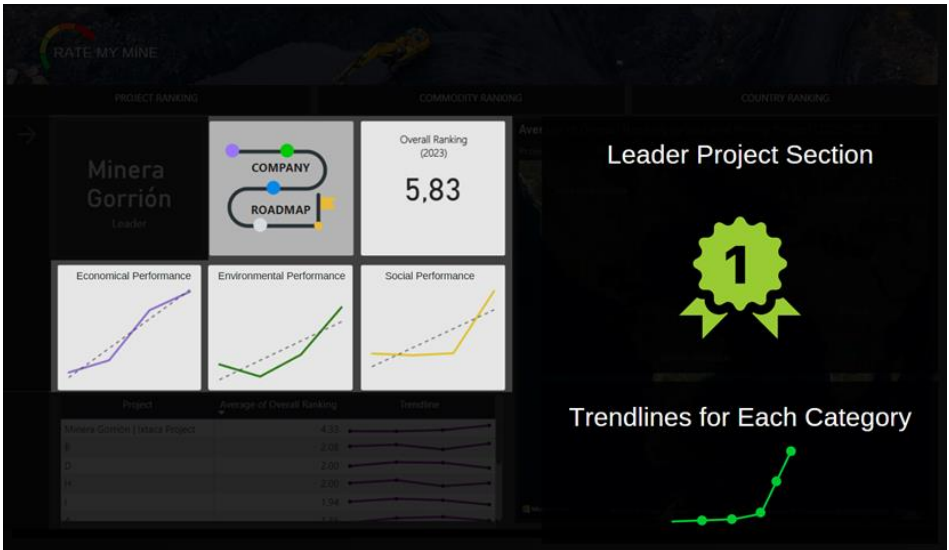
Figure 6 Trendlines, Current Rank & Roadmap of the Leader Company

The slicer panel is created to filter the values by project, year, and site according to the user's desire.
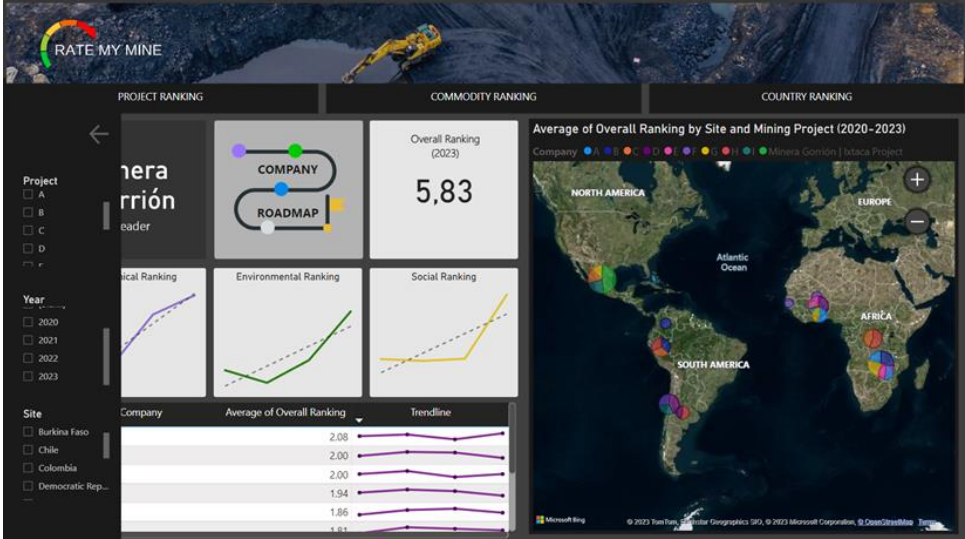
Figure 7 Slicer Panel to filter the values by Project, Year and Site

The Leader Project Button is added to jump into a more detailed, informative page aiming for a comprehensive evaluation of performance values.
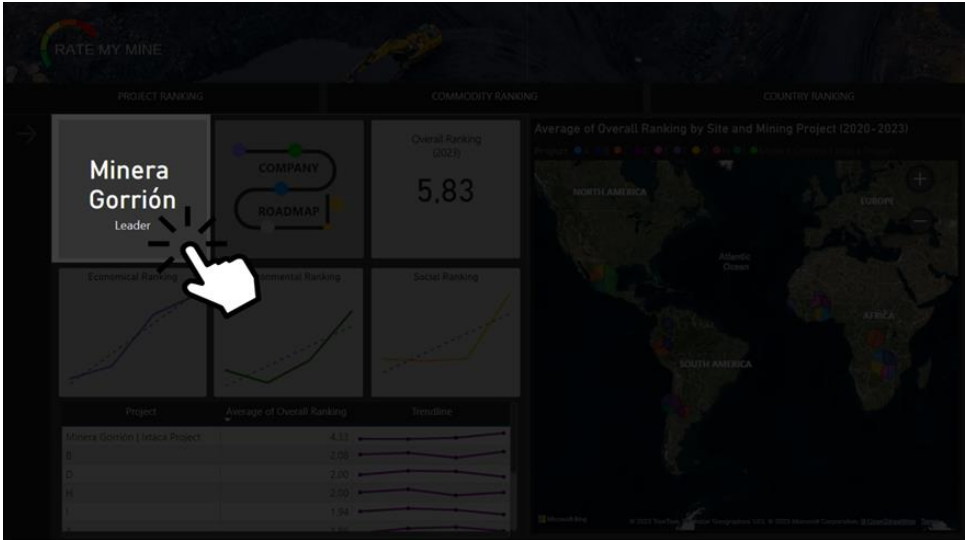
Figure 8 Button linked to the leader project's dashboard

3.1.2. Leader Project Dashboard

The Leader Project Dashboard contains a general overview, the KPI values, and parameters belonging to these KPIs.
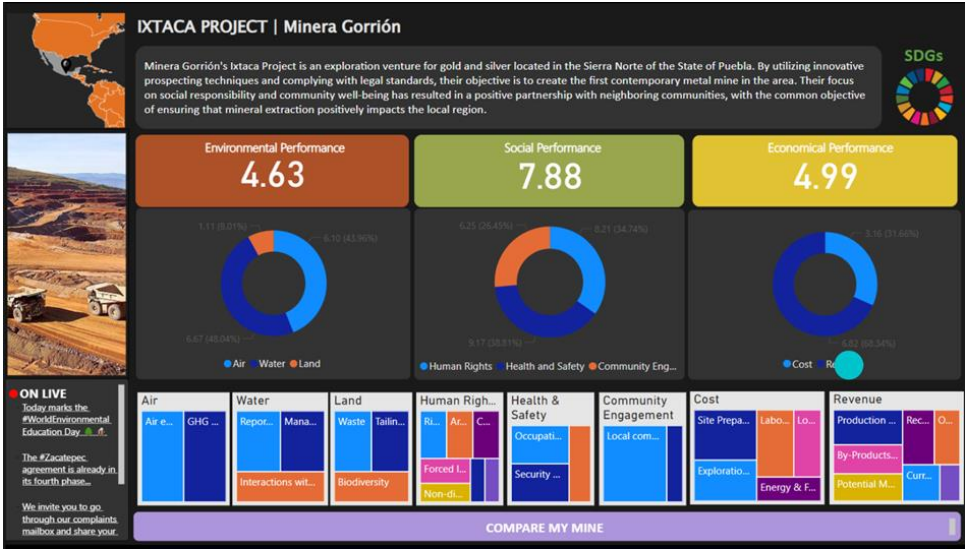
Figure 9   Leader Project Dashboard with detailed values

At the centre of the dashboard, the KPI values for Environmental, Social, and Economic performance, and sub-categories with their propositions and percentages, are shown.
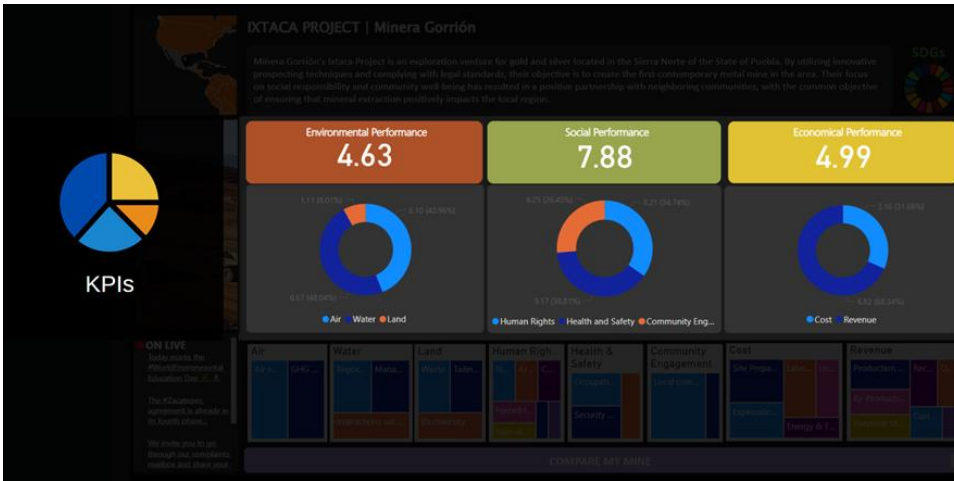
Figure 10 Donut charts of categories used to evaluation of KPIs

The parameters considered to evaluate the KPIs, and their propositions are also visualized by using the tree maps.
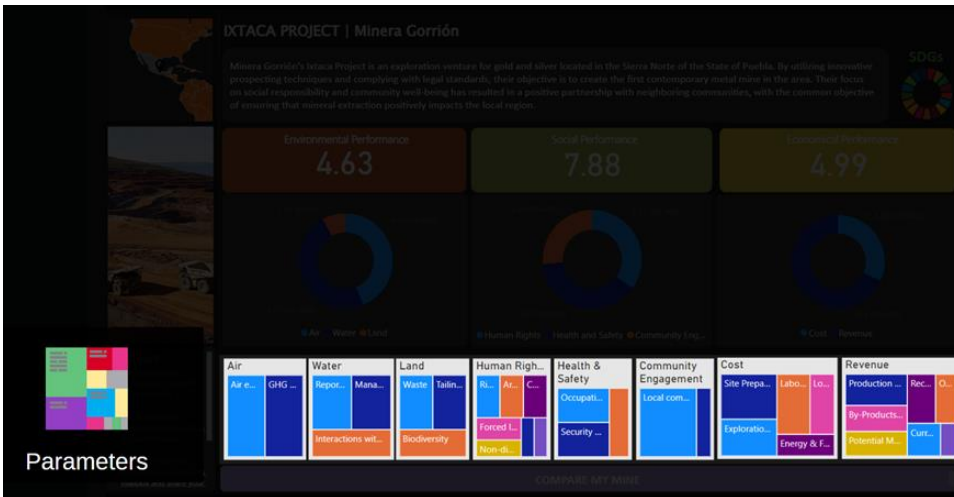
Figure 11 Tree maps of parameters

By clicking on the SDG icon, the user could display the SDGs that the project meets.

Figure 12 SDGs that the project meets

9

3.2. Business model

As the key partners, NGOs, research institutes, and government institutions are offered a platform for further investigation into crucial projects. The drive of this project is to give full disclosure of sustainability aspects of mining based on the three KPIs, by offering rankings of mines, and in the future of mining companies and countries, giving indications for potential for improvement in the sustainability area, and visualization in the form of an interactive dashboard. Close partnerships with NGOs and research institutes are initiated by offering free versions of the tool, so to enhance the visibility of our platform. The customers of our tool are investment banks and investment companies looking for investment opportunities in the mining sector, manufacturing companies using the raw materials extracted from mines, NGOs working in the mining area, countries in which a lot of mining takes place, mining companies, and consulting companies, among others.

The sustainability rating system brings value to investors and stakeholders, and it serves as a crucial tool for promoting sustainable investment practices and driving positive environmental and social change. By actively participating in sustainability rating systems and achieving positive ratings, mining companies can improve their reputation, attract investors, and enhance stakeholder trust through transparency.

For investors, our tool brings the benefit to obtain easier fulfilment of compliance topics with due diligence procedures, support for risk assessment and mitigation strategies. For local communities environmental and social inequalities will be reduced, and workers will work in a safer environment. NGOs get more visibility into the mining sector's sustainability practices. Manufacturing companies using extracted materials get insights into their value chain activities. It is essential to bring together all stakeholders' opinions, so our aim is to bring them all to one table. It empowers investors to support projects that prioritize sustainable practices.
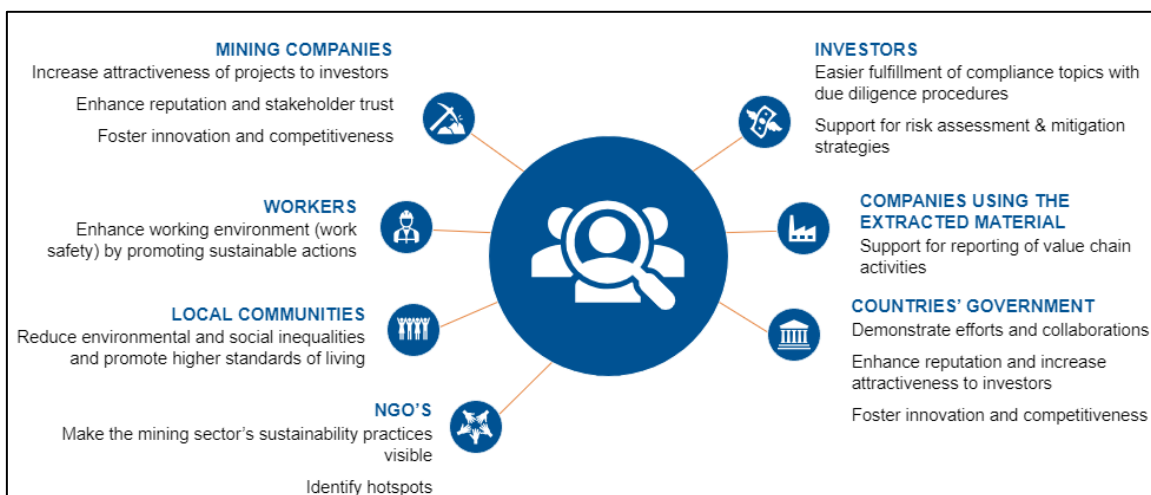
Figure 13 Stakeholder benefits

The costs of this project can be subdivided: research and development costs for developing the tool and researching the parameter data, labour costs, consulting, and sales. The revenue streams of this project are the model offered to customers that can purchase a license (6, 12, or 24 months) to use the platform. NGOs and research institutes are offered a free version of the tool for enhancing their projects towards more sustainability in mining. A free version is offered as a standard and is a restricted version of the platform, with limited data on only a few

mining projects and countries, and not all commodities will be shown. This way we can capture the interest of potential customers.

Please see Appendix B for an overview of our Business Model Canvas.

4. Outlook and conclusion

4.1. Outlook

The subsequent paragraphs will delve into potential areas for further exploration and improvement of Rate my mine.

The next steps involve further testing and fine-tuning of the tool, incorporating stakeholder feedback, and refining the parameters to ensure their relevance and reliability. This iterative process aims to enhance the robustness and credibility of Rate my mine, paving the way for its broader implementation in the mining industry to promote sustainable practices and inform decision-making processes.

Further collaboration with Chair of Land Management and Professorship of Resource Economics

The outlook of the prototype rating tool for assessing the sustainability of mines holds immense potential through the partnership with the Chair of Land Management and the Professorship of Resource Economics. This collaboration offers opportunities to explore further possibilities for future projects and enhancements. Discussions with Dr. Arch. Pamela Durán Díaz from the Chair of Land Management and Prof. Svetlana Ikonnikova from the Professorship for Resource Economics revolve around leveraging their expertise in mining operations and their collaborations with local mining projects. By incorporating their knowledge of mining practices, the rating tool can capture a comprehensive understanding of the industry's sustainability aspects. Additionally, the Chair's extensive data on investment decision-making parameters for mines could be integrated, enriching the tool's evaluation capabilities. Furthermore, their expertise in utilizing machine learning techniques could be applied to optimize the efficiency of data utilization, thereby enhancing the tool's accuracy and reliability. The incorporation of these findings and expertise will make the parameters of the rating tool more significant, quantifiable, and aligned with the realities of the mining industry. This collaborative effort ensures that the rating tool remains at the forefront of scientific advancements, empowering stakeholders to make informed decisions and promote sustainable practices in the mining sector.

Finalization of GRI Sector Standards

Another essential aspect of the outlook is the inclusion of the last version of the Global Reporting Initiative (GRI) Sector Standards which is set to be published in Q4 2023 (GRI, 2023). These standards will serve as a benchmark and reference point for the sustainability parameters used in the rating system. By aligning our parameters with the finalized version of the recognized industry standards, we enhance the credibility and comparability of the sustainability ratings.

Including other stakeholders' views

To ensure a fair evaluation of mining projects, it is crucial to consider individual project characteristics. This includes incorporating stakeholders' views and addressing specific aspects of each project's context. By doing so, we can capture a broader perspective and provide a comprehensive assessment of a mining project's sustainability performance. Additionally, the

incorporation of trends in the raw material's market and the country where the mine is located will further enrich the rating system, offering insights into the contextual factors influencing a project's sustainability performance.

Rating for companies and countries

Expanding the rating system to include a rating for mining companies based on their mining project's sustainability rating and sustainability reports is an important future step. This additional rating would provide stakeholders with a holistic view of a company's commitment to sustainable practices across its various projects. Moreover, establishing a country rating would enhance transparency and foster a competition for sustainability among nations. This will enable NGOs and research institutes to identify trends and areas that require support, thus facilitating targeted interventions to improve sustainability performance.

Establishing a Consultancy Network

Beyond rating mining projects, the future could include establishing a consultancy or consulting network to promote sustainable practices within the mining industry. This network would provide guidance, support, and best practices for mining companies aiming to improve their sustainability performance. By offering tailored recommendations and expertise, the consultancy network would contribute to the widespread adoption of sustainable practices throughout the sector.

Rating Conducted by Neutral Agency

As the sustainability rating system evolves, the vision is to establish an independent agency responsible for conducting the ratings. This neutral agency would gather and verify information directly from mining projects, ensuring the credibility, impartiality, and independence of the rating process. By separating the rating function from the entities being rated, we enhance the transparency and objectivity of the system, instilling greater trust among stakeholders fostering its wider adoption and acceptance within the mining sector.

Full Traceability of Value Chains

The sustainability rating system will be just the first step towards achieving full traceability and transparency of value chains in the mining sector. The goal is to create a future where consumers can scan their electronic devices, for example, and obtain a sustainability rating that reflects the entire value chain. This vision emphasizes the importance of transparency and enables consumers to make informed choices, fostering the demand for sustainable products and practices.
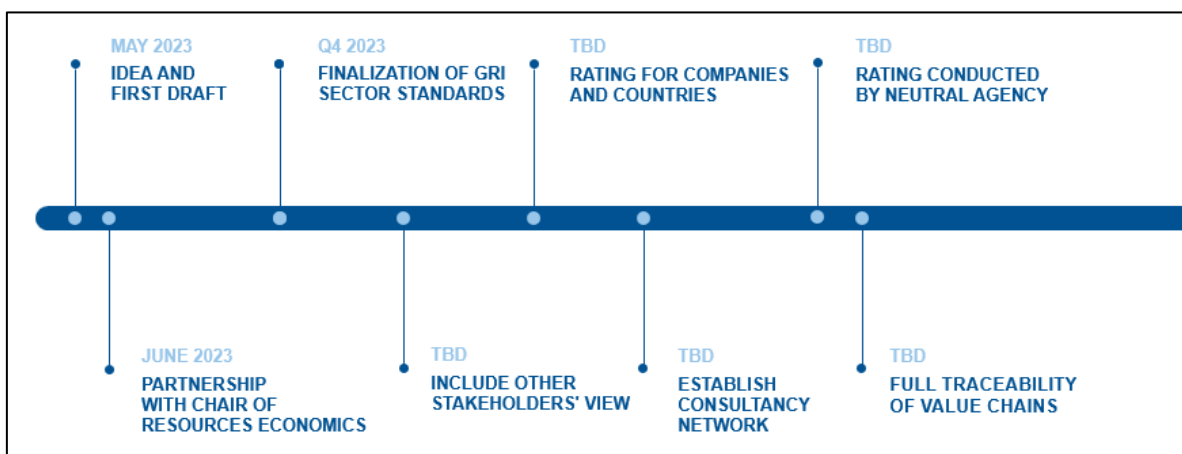

Figure 14 Current status and outlook of prototype "Rate my mine"

4.2. Conclusion

This report introduces a prototype for a sustainability rating tool designed specifically for the mining sector, addressing the industry's main challenges encompassing both environmental and social issues while also considering economic aspects. The lack of visibility and transparency in these areas has been a significant concern. Our solution aims to tackle this problem by providing a sustainability rating tool that makes sustainability practices in mining visible and comparable. By utilizing KPIs and parameters aligned with sector standards, the tool effectively measures sustainability practices across Environmental, Social, and Economic dimensions. The user-friendly website design enhances accessibility for stakeholders, while the introduction of a subscription model ensures the tool's potential for profitability.

Although the prototype currently requires refinement and validation, it exhibits the capacity to establish a standardized and quantifiable framework for assessing the sustainability performance of mines. This initial iteration serves as a solid foundation for future investigations and enhancements.

The outlook for the sustainability rating in the mining sector is promising. Through partnerships, collaboration, and the incorporation of industry standards, stakeholder perspectives, and contextual factors, the rating system could evolve to provide a comprehensive and credible assessment of mining projects. Furthermore, expanding the rating system to include company ratings and country ratings will strengthen transparency and encourage competition for sustainability. This will facilitate the identification of trends and areas in need of support, benefiting not only NGOs and research institutes but also the mining companies themselves, as they strive to improve their sustainability practices.

By entrusting the project to the Chair of Land Management and the Professorship of Resource Economics, the opportunity arises for them to undertake the subsequent development, refinement, and expansion of the tool, thereby unleashing its complete potential and fostering the adoption of sustainable practices within the mining sector. Through their expertise and insights, these esteemed chairs can engage in further exploration and enhancement of the tool, allowing for its optimization and alignment with the evolving needs and challenges of the industry. Their involvement holds promise in propelling the tool towards broader acceptance and utility, contributing to the advancement of sustainable practices in the mining sector.

References

GRI. (2023, June 9). *GRI - Sector Standard Project for Mining*. https://www.globalreporting.org/standards/standards-development/sector-standard-project-for-mining/

Environmental and socio-economic impacts of fire in Jharia Coalfield ... (n.d.). https://www.researchgate.net/publication/301946156_Environmental_and_Socio-Economic_Impacts_of_Fire_in_Jharia_Coalfield_Jharkhand_IndiaAn_Appraisal

India lithium-ion battery market (2022 to 2029) – growth factors, opportunities in market, market segmentation. MAXIMIZE MARKET RESEARCH. (2023, February 28). https://www.maximizemarketresearch.com/market-report/india-lithium-ion-battery-market/29994/

Caballero Espejo, J., Messinger, M., Román-Dañobeytia, F., Ascorra, C., Fernandez, L. E., & Silman, M. (2018, November 29). *Deforestation and forest degradation due to gold mining in the Peruvian amazon: A 34-Year perspective*. MDPI. https://www.mdpi.com/2072-4292/10/12/1903

Zamagni, A. (2012). Life cycle sustainability assessment. *The International Journal of Life Cycle Assessment, 17*, 373–376.

Appendixes

Appendix A: Team member contribution

OUR BUSINESS MODEL

EuroTeQ TUM
Engineering
University

KEY PARTNERS

- NGOS
- Research institutes
- Government institutions

KEY ACTIVITIES

- Offer a platform
- Offer consulting services
- Work with research institutes

KEY RESOURCES

- NGO reports (e.g. Environmental Justice Atlas)
- Government reports
- Own investigations and research

VALUE PROPOSITION

- Give full disclosure of sustainability aspects of mining based on triple bottom line
- Offer ranking of countries and mining companies for competition for sustainability
- Give indications for potential for improvement in the sustainability area
- Visualization in the form of an interactive dashboard

CUSTOMER RELATIONSHIP

- Close partnerships with NGOs and research institutes
- Content marketing to investors and companies

CHANNELS

- Offer free version
- Content marketing
- Work with sustainability board and associations

CUSTOMER SEGMENTS

- B2B
- Investment banks
- Investment companies
- Producing companies using the raw materials

- NGOs
- Countries who "offer" mining
- Mining companies
- Consulting companies

COSTS

- Research and development costs
  - For developing the tool and researching the parameter data
- Other labor costs
  - Consulting, sales, etc.

REVENUE STREAMS

- **Investor/company model** 6/ 12/24 month license to use data, think about restrictions (limited data e.g. 5 countries, commodities, companies vs unlimited)
- **NGO model**: for free, brand ambassadors, marketing usage
- **Research model:** reduced price, depending on the partnership level
- **Consultancy**

14

16

Declaration of authorship

We hereby declare that the project paper submitted is our own unaided work. All direct or indirect sources used are acknowledged as references.

We are aware that the thesis in digital form can be examined for the use of unauthorized aid and in order to determine whether the thesis as a whole or parts incorporated in it may be deemed as plagiarism. For the comparison of our work with existing sources we agree that it shall be entered in a database where it shall also remain after examination, to enable comparison with future papers submitted. Further rights of reproduction and usage, however, are not granted here.

This paper was not previously presented to another examination board and has not been published.