The experience of two European projects on how to combine social, environmental, and economic values in mining

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1. Introduction

Mining and its impact is usually a multifaceted topic due to the complex and sometimes conflicting relations between different parties involved in the value ecosystem and due to a dynamic business environment. It is indeed challenging to combine the societal need for raw materials, environmental protection, legal context, the business and profitability requirements of the companies, and social fairness [1]. The topic of social equity is crucial as environmental and economic impacts often end up in impacts and risks for societal stakeholders [2]. Furthermore, this issue becomes even more critical when dealing with indigenous populations, which show a land and water culture that represents an unquestionable value to be preserved [3]. In addition, the concept of a Social Licence to Operate (SLO) has become a popular topic in the mining industry; however, there is a need to rethink this principle due to a number of related ambiguous issues, such as the way a SLO is obtained and maintained [4]. In comparison to the assessment of economic impacts and environmental issues, the evaluation of social aspects is far less straightforward and consolidated. Indeed, the complexity of the social issues is increased by each region's distinctive features, making it impossible to generate a universal/one-size-fits all solution.

The mining industry has recently acknowledged its role in mitigating and monitoring the impacts that the sector has contributed to generate for decades. This has been supported by a number of global, European, and national policies and initiatives. The present work reports on how the challenges related to social, environmental, and economic sustainability in mining have been addressed by two European projects, namely ITERAMS, funded by the European Union H2020 programme, and SERENE, funded by the European Institute of Innovation and Technology (EIT). The first project focuses on efficient water recycling and tailings valorization, while the second one foresees a dynamic predictive solution for a sustainable water balance management.

2. Materials and methods

The purpose of this work is to explore the approach (and related challenges) aimed at identifying the social, environmental, and economic values generated by the two mining projects and how these values may be combined and achieved with the reduction of potential harmful impacts and risks of mining. In fact, values can be produced by both generating positive impacts and reducing risks and negative issues. The approach is based on (1) mapping the stakeholders and actors directly and indirectly affected by the novel solutions foreseen by the two projects; (2) the definition of the social, environmental, economic, and business values potentially generated by the two projects and identification of methods to assess them; (3) the definition of the social, environmental, and economic pressures and risks, and study of the relations among them.

A number of tools and methodologies were used to guide and perform the above-mentioned steps. Literature research was indeed crucial to understand the novel mining sector solutions under study and the local context of the mining activities. Qualitative cause-effect relationships between the different variables and stakeholders were explored with a causal loop diagram. A social analysis was performed by consulting different sources, such as national and international institutes, primary data from the mine sites, and thematic interviews with different key actors. In addition, a preliminary Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) screening study was crucial to orient the sustainability assessment of the new mining solutions for which a full LCA, LCC, and risk assessment evaluation are foreseen.

3. Results and discussion

The first step of the developed approach is the categorization and definition of stakeholders, value elements, risks, and pressures at a general level. This is an important phase as the novel mining solutions are planned to be implemented globally. Secondly, the situations and topics identified are characterized for the project validation sites in Finland, Portugal, and South Africa. This characterization is based on the identification of

background situations which can affect the values, risks, and pressures. The values held and recognized by the different stakeholders together with the risks, pressures, and background situations are shown in Figure 1. The methodology and tools applied during the identification process are listed in Section 2.

Aspects	Values	Risks	Pressures	Background situations
Social - Local communities	Water availability	Water scarcity, depletion of local water reserves	Water withdrawal and consumption for ore processing	Dependence of communities on local water reserves
	Water quality	Water contamination, e.g. groundwater	Release of pollutants into water, e.g. AMD	Presence of groundwater reserves, monitoring activities
	Trust	Bad relations with local populations, protests and conflicts	Non-financial reporting, use of local resources, indigenous presence	Communication channels, transparency
	Land preservation	Relocation, resettlement	Land use for tailings disposal and mine facilities	Tailings disposal methods, e.g. wet/dry. Tailings valorization, e.g. backfilling
Social - Workers	Safety at the workplace	Dam failures, instability of the water cycle	Accidents at the work place	Accidents prevention measures, monitoring
	Jobs creation (IT, monitoring)	Not enough skilled workers to be hired locally	Workforce supply	Digitalization, unemployment rate in the area, working conditions
	Human health	Toxic emissions release, e.g. during ore processing. Dust and noise production	Human toxicity (cancer and non-cancer effects)	Monitoring of emissions, tailings composition, working conditions
Economic - Mining companies	Productivity	Decrease in competitiveness, economic losses	Return on investments, presence of competitors	Efficient planning of water resources and investments
	Visibility of the system and related risks	Impossibility to monitor the water cycle in remote areas	Real-time, predictive and efficient management of resources	Digitalization, monitoring tools, seasonal variation
	Respect of emissions and pollutants regulatory standards	Exceeding water pollution/emission standards	Legal framework: national, international and local targets and standards	Regulations on the topic, severity of the fines
Environmental - Ecosystems	Water quality	Environmental degradation, water contamination, e.g. tailings leaking	Freshwater and marine ecotoxicity	Tailings composition, waste water treatment effort, seasonal variations
	Water balance (WB) management	High amount of water (positive WB) or lack of water (negative WB)	Water use	Quality of process water, open/closed water cycle, seasonal variations
	Land preservation	Destruction of material resources, loss of plant and animal species	Land use for tailings disposal and mine facilities	Presence of areas of natural value, nature tourism in the area of the mine, local and national regulations on the topic

Figure 1: Sustainability aspects and related values, risks, pressures, and background situations for the two projects

It is interesting to reflect on how the values achievable with the implementation of the two projects can be regarded as global. However, the meaning of these values may be different from one location to another because the risks and pressures which interact with these values are strictly dependent on the local environmental, social, socio-economic, cultural, and political context. For instance, the mining industry in South Africa has often been associated with apartheid [5], hence it is clear that the social background cannot be regarded as equivalent to Finland, which shows instead other specific features in the areas of the mines under study, such as nature tourism and reindeer farming.

4. Conclusions

This work contributes to the research and practices on how a combination of social, environmental, and economic challenges in mining can be achieved starting from the positive concept of value generation. Once the values for the different stakeholders are identified, it is possible to assess, interpret, and work on the impacts which prevent their attainment. Furthermore, balancing social, environmental, and economic issues should not mean that impacts can be shifted or compensated by another sustainability dimension, but rather the performance should be equally good and acceptable for all the stakeholders and topics involved.

5. References

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