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Review

The Status of the Local Community in Mining Sustainable Development beyond the Triple Bottom Line

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Abstract: Mineral products provide essential fuels and raw materials for industrialization and our daily life, but their influences on other aspects of life need to be taken into consideration. While the whole world benefits from mining's contributions, most of the resulting detrimental impacts on the environment and society fall on the local communities. The participation of the local community is one solution to decrease the risks from community-related problems. Subsequently, the requirements of mining sustainable development can be met. A literature review was conducted on mining sustainability and stakeholder participation, and the shortcomings of existing research and difficulties of further study were discussed in detail. This study covers a broad understanding of mining sustainability from a mining community's perspective. In addition, it offers a new mining sustainability scope based on the literature review. Besides the balance of economic, environmental, and social aspects, the mine owner and local community have to be engaged in the new mining sustainability scope. This literature review could improve community engagement and help mining companies to better understand local mining communities.

Keywords: mining sustainability; local community; stakeholder engagement

1. Introduction

Mineral products provide important energy sources and raw materials for industry and civilian uses. Mining is the operation to separate useful ore from waste rocks, which often impacts the local geological and ecological environment. More than 6000 officially registered mining companies and about 20 million small-scale and artisanal miners are in operation across 30 countries [1,2]. Over 14,000 mines provide metal and non-metallic mineral products in the United States of America alone based on a survey in 2012 [3].

The economic impact of US mining is huge. At the local level, mining provides a significant employment opportunity to the local community. In 2012 alone, 634,000 jobs were provided by U.S. mines directly, and about 1.27 million job opportunities were created to support their operation. Thus, there was a total of 1.9 million full-time and part-time jobs created by US mining [3]. In addition, over \$46 billion in labor income was created directly by U.S. mining industry and the total amount related to mining reached \$118 billion. At the national level, mining provides government revenues as well as foreign and domestic investment. According to the National Mining Association [3],

mining activity (directly and indirectly) generated total taxes of \$46 billion. In the year of 2012, a contribution scale of \$225 billion to the U.S. gross domestic product (GDP) was achieved by the domestic mining industry.

Mineral products provide essential fuels and raw material for the industrialization and our daily life, but its related influences also need to be taken into consideration. The adverse environmental and social problems of mining have garnered the attention of local and national governments. Non-governmental organizations (NGO), general citizens, and stakeholders are also affected by and responded to these issues related to mining. In recent years, the consideration of sustainable development (the ability of current generations to meet their needs without compromising the ability of future generations to meet their own needs [4]) has been seen as a great importance all over the world [5–14]. Metal and metalloid distribution in soils from the Katanga Copperbelt (Democratic Republic of Congo) were investigated in order to characterize the environmental impacts of mining and smelting activities in that area [15]. The general public believes that the world is rapidly running out of the metals on which our modern society is based [16]. The long-term socioeconomic sustainability of natural resource extraction in resource-abundant countries is understudied on the local level [17]. The case study of the brownfields in Karvina, Czech Republic found that awareness about problems connected to brownfields is quite limited [18]. A study conducted in Colombia recommended the preparation and better coordination of stakeholders in order to engage complex relationships and protect community assets in a collaborative governance scenario [19]. The policy of selected leaders in the mining industry in Poland is an example of promoting good practices within the corporate responsibility of enterprises. Also, developing an integrated model and assess the level of sustainable development of hard coal mining industry has been suggested [20,21]. Abandoned mine areas using renewable energy systems at the tailings dam of the abandoned Sangdong Mine of Korea is an example of a sustainable development project [22]. In general, mining operations cannot proceed with mining as in the past, since global expectations have changed the role of the business. How to realize sustainable development has thus become an active research topic for mining.

Industries have evolved from mere environmental compliances (to associated standards such as ISO 14001) to engaging in non-profit programs such as corporate social responsibility (CSR) and then to operating with a social license. Now, standardized sustainability reporting (often with the Global Reporting Initiative) is applied [23–29]. The majority of international mining companies presented audited sustainability reports that annually record and announce their sustainability concerns during the year [30]; this suggests that mining operations and relevant businesses, like counterparts in other sectors, operate under the same rules that create shared value for all stakeholders [31]. The above information shows that sustainable development should involve mines and mining businesses in their host communities and internationally at large. However, this can only be done with a concerted effort to develop and operate mines sustainably.

While the whole world benefits from mining's contributions, most of the resulting detrimental impacts on the environment and society fall on the local community or communities. Compared to other stakeholders, protecting the local communities' benefits contributes to greater sustainable development efforts in mining [32,33]. Hence, community engagement is the key to sustainable development in mining, while also being the main challenge for mines.

There are many mining operations that have been delayed, disturbed, and even shut down because of poor community engagement [23,24,34–36]. These delays mainly result from the stakeholder-related risk, which is often regarded as major non-technical risks [34,37]. Davis and Franks claimed that the cost of delay could be roughly US\$ 10,000 per day within the exploration stage of a newly developing mining operation. During production, the cost of labor, equipment renting, and deferred schedule are involved, so this amount can be much higher. From the company owner's standpoint, the rational response to community-related risks is to encourage communities' engagement and achieve sustainable development.

2. Stakeholder Engagement

The features of stakeholders have been proven to impact the decision-making process greatly, either individually, or by teams or sectors. Stakeholder engagement analysis is used as a tool to study this impact and has obtained increasing attention. As early as the 1930s, stakeholder engagement was first established and applied in the business management field [38]. After a long development period lasting until the 1990s, the tool regained significance for researching policy-making procedures [39]. From the 2000's on, this tool has become an active research topic and is widely studied [38,40–44].

Stakeholder engagement is the technique used to investigate the behavior and preference of selected stakeholders who share similar characteristics. It is possible to affect and change the attitude and behavior of the organization and then optimize existing projects and policies supported by surveys and statistical analyses [45–47]. The outputs can be used to organize stakeholders when their preferences are clarified and to promote the decision-making progress. Policymakers and managers gain an improved understanding of stakeholders from the technique in order to formulate more rational and pointed policies and management regulations.

Bryson provided a fundamental analysis tool in Reference [48]. It presented a practical way of organizing stakeholders and their interests together with some key strategic issues need to be identified; for example, stakeholders' attitude about a local organization should be clarified, so as to initialize the identifying coalitions of opposition and support. Bryson explained how this technique works to bring about an effective impact on a state natural resources department in the U.S. because it showed how participants (in an existing strategy) ignored the importance of stakeholders, who should not be ignored, and what could be done to ensure stakeholders' satisfaction. The tool involved nine steps, starting with brainstorming to find the list of potential stakeholders and ending with identifying and recording longer-term issues with individual stakeholders and with stakeholders as a group [48].

Currently, the most accepted stakeholder engagement method was published by Reed et al. [49]; this method has been cited 165 times. The method, shown in Figure 1, has three main steps: (i) stakeholders are identified; (ii) stakeholders are differentiated and categorized, and (iii) relationships between stakeholders are investigated.

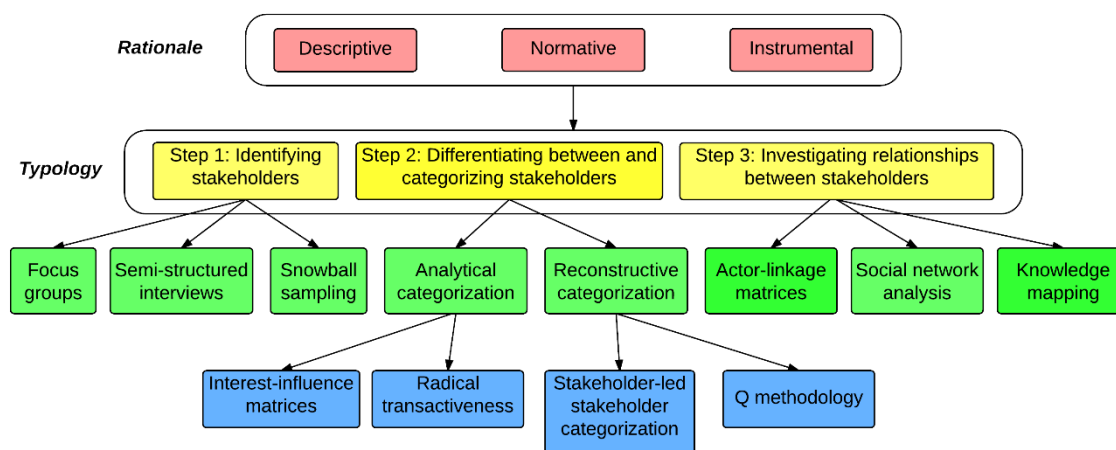


Figure 1. Schematic representation of rationale, typology, and methods for stakeholder engagement [49].

Stakeholder engagement has been studied by organizations like the International Finance Corporation (IFC) and International Council on Mining and Metals (ICMM) [50–59]. These studies shed light on this area [23,34,35,60–64]. Other burgeoning methods have been developed for the discussion of stakeholder engagement in mining. This method includes three main parts, as recommended by Reed et al. [49]: stakeholder identification, stakeholder engagement, and iterative consultation [54,56]. This stakeholder engagement activity seeks to maintain the major evaluation routines. The stakeholders' opinions are considered in a mining operation. Then, the results of stakeholders' engagement are

critical and provide the key to evaluating stakeholders' opinions of a mining project during the iterative consultation process.

While the local communities are listed first in the ICMM [54] checklist of possible stakeholders, their particular situations do not result in differential solutions in the stakeholder analyses process. Compared with government, employees, unions, and regulators, the local community is the most voiceless group. However, this group has the most diverse preference and demands. Its situation is extremely remarkable when a mine site is located on land belonging to Native Americans, and communities with low income and vulnerable status. This situation increases the complexity of leading community engagement, often demanding different treatment that should be extended with special care [56]. In the following sections, the main shortcomings of existing mining community engagement research, difficulties, and suggestions for further research are addressed.

3. Shortcomings of Existing Researches

First, mining community engagement is often reduced to the triple bottom line.

Laurence [65] defined sustainability in the mining industry, describing that "mining is sustainable when it is conducted in a manner that balances economic, environmental, and social considerations". Similar to other areas, sustainable development can be described as the triple bottom line. However, mining projects require a more extensive comprehension of sustainable development. Beyond the triple bottom line, mine governance is a significant aspect that will affect a community's adoption of a mining project. In the authors' previous study, two important factors were found including "the mechanism for making permit decisions" and the "availability of transparent information" [66]. The mechanism of decision-making explained how to make decisions under the condition of disagreements arising from the influences (both positive and negative) of mining. The information should be independent and transparent, as well as facilitate the local community's engagement with the decision-making process, and finally be beneficial to the community development. Without considering the mining community in the decision-making mechanism, the understanding of sustainable development is fragmented. The triple bottom line allows the mining company, government, and experts to make a decision for the local community. Consequently, the designed sustainable mining project for a mining company may not be sustainable from a community's perspective. The mine governance should have an integrated approach to open the gateway for communicate.

Second, demographics of the local community are often missing in sustainable development design.

Without considering the differences among people, the understanding of sustainable development in mining is one-dimensional. For example, demographic differences were investigated in natural resource management [49,67]. Women and men were found to possess different attitudes, responsibilities, and knowledge towards natural resources. Gender divisions of labor also were related substantially with race, age, ethnicity, and income standard [68].

Compared to other natural resources, there are fewer research study demographic factors that impact an individual's chance of backing a (proposed) mining project in the vicinity of their community. Only the gender divergence has been brought to the forefront recently [69]. Mining is a masculinized industry, whereas females have less incentive to support the development of this activity. In Australia, gender differences, community development, and power relations are considered major difficulties [70]. In the U.S., Tallichet [71,72] stated that, based on the assumption that males and females are physiologically differentiated in athletic ability, the viewpoints of sexualization and differentiation in the workplace are reinforced. These studies explain why females show less acceptance to mining projects than males. Women generally felt like subordinates where men dominate, especially when engaged in a profession stereotyped as a masculine pursuit such as mining. After understanding the gender divergence, the Rio Tinto mining group suggested the significance of considering the gender perspective, with the aim of obtaining and maintaining a social license. Such a consideration

may improve the life standard and social welfare of both genders, as well as mitigate the adverse influences of the mining industry [69,73].

The other important demographics (i.e., age, education and income) have not been studied in detail as has the gender divergence. The understanding of the diversity of people could help mining companies avoid unnecessary contradiction in mining operation and management. The varied demands from different people can be considered from the beginning of the design. From a general perspective, there is a deficit in community analysis, both from mining impacts and people's divergence. Future research should take this into account.

Third, the qualitative analysis method is predominant.

Local community engagement is an important aspect of modern mines or project management in the minerals sector. It is the main factor in regulating mines or other functional departments for sustainable development [1]. Numerous institutions, including the International Council on Mining and Metals (ICMM) and the International Finance Corporation (IFC), have investigated community engagement in different aspects [50–59]. However, most of their investigations involve qualitative methods of assessment. Take the ICMM [54] as an example. The goal of community analysis is to understand the local community by classifying community members into a few stakeholder groups (e.g., highly influential supporter, neutral, and highly influential opponent of the project—Table 1).

Table 1. Stakeholder engagement matrix [54].

Name/Group of Stakeholders	View of Project			Influence			Impact		
	Positive	Neutral	Negative	High	Middle	Low	High	Middle	Low
X	✓			✓					✓
Y		✓			✓				✓
Z			✓	✓			✓		

Current stakeholder engagement procedures for engaging local communities [54] are mainly qualitative, which can, therefore, be prone to subjectivity, and sometimes be inadequate. There are two main limitations to qualitative methods: (1) classifying stakeholders does not guarantee that they are represented or treated fairly [74]; and (2) stakeholder classification based on the project's impact on a resident and the resident's views (positive or negative) and influence does not necessarily facilitate effective engagement, since the classification is not linked directly to the issues that affect residents' views. Only a quantitative method can give detailed information for improving local mining community engagement.

4. Difficulties of the Further Investigation

Researchers should analyze the results and determine how they can be explained by previous studies and the available hypotheses. The achievements and their implications should be evaluated in the broadest context possible. The promising research directions may also be highlighted.

First, how to communicate with local communities effectively.

In the community engagement process, the first difficulty is how to make the local community understand the mining projects and the possible impacts. In particular, the respondents do often not thoroughly understand the terminology used in describing the project. Take air pollution as an example. It is difficult to describe the possible impact of mining on air pollution in the local community. The air quality is quantified by four major air pollutants claimed by the Clean Air Act(CAA): PM (particulate matter) pollution, ground-level ozone, SO₂, and CO₂ [75]. However, these technical terms may not be well understood by the local community. In the authors' previous study, the possible air pollution due to the impacts of mining was described in three levels to help the local community to understand. The descriptions were borrowed from the Air Quality Index (AQI) as "slight impact", "moderate impact", and "unhealthy for sensitive groups" [75]. The authors obtained feedback questions from

the mining community like “Is moderate impact better or worse than the level of air pollution that is unhealthy for sensitive groups?” and “Would even a slight impact of air pollution be unhealthy for the sensitive groups?”. Then, the levels were revised as “less air pollution than similar mine in the area”, “same air pollution as similar mine in the area”, and “more air pollution than similar mine in the area”. The feedback of respondents showed that the revised descriptions were much more understandable. The other environmental aspects (i.e., water, land, and noise pollution) also bring up similar difficulties in explaining possible impacts to the local mining community. The cultural impacts are another challenge, since the definition of a cultural impact is even more unclear.

There is no perfect right answer to describe each mining impact for different local communities. The rule of thumb is to balance the professional, clear, and easy-to-understand aspects when designing a question. In this case, the authors suggest including an information validation process. A focus group should be used to examine the clarity and difficulty of the initial dissemination of information. The study can use self-reported levels of difficulty and clarity, which are confirmed by the completion time. Open questions also should be asked in order to identify where the confusions are or what the obstacles to understanding may be. The feedback can be used to revise the disseminated information to enhance the clarity.

Second, how to adjust the mine planning.

The initial mine planning should be adjusted based on the local community’s preference, thus presenting a great challenge to be faced by mining companies. This challenge depends on how much information from the local community can be received by the mining company. The community analysis should answer three questions.

The goals of community analysis should include: (1) the factors and their reasons that influence stakeholders’ decisions; (2) the representativeness of demographics in the individual preferences; and (3) individuals’ attitudes towards environmental and social values in the community.

The first goal is to obtain the factors and their reasons that influence stakeholders’ decisions. The total budget is fixed. If water pollution is more important than other pollutions for the local community, more money should be spent on water pollution treatment instead of being divided equally. If the analysis result shows that job opportunities are preferable to income increases, the mining company could choose to hire more people rather than to pay a higher salary for each individual. The answers to these questions could provide a guideline to the mining company, and mining projects can be designed based on the perspective of the local community. This is a solid stepping stone from which to start a successful business.

The second goal is to determine the representativeness of demographics in individual preferences. The answer could help mining companies to identify the target group for consultations. Take gender for example. The previous study found that females harbor more unkindly attitudes to mining projects than males. Special participation should, therefore, be increased for local women. A national leader, Women in Mining Canada [76], emphasized the significance of enhancing the importance of female engagement in its final report if the industry is going to have a bright future. The report described that the advantage of such engagement involves the increase of well-trained workers, achieves a better variety of inspirations, enhanced creativity, better market outcomes, and greater leadership in the mining field. These encouraging findings push for the inclusion of women at an international level. Latin American countries support this concept and are initializing the process. At the end of the 1990s, women were involved in the Mexican mining industry in some particular production positions that had never been made before. The engagement of women is highly rated, especially thanks to their exceptional performance in loyalty, self-regulation, sense of responsibility, and greater carefulness that resulted in a higher outcome of the machinery.

The third goal is to identify individuals’ attitudes towards environmental and social values in the community. To balance the economic, social, and environmental aspects of sustainable development is challenging. This could be resolved by transferring environmental and social impacts into economic

measurement units. The equivalent value of environmental and social damage to individuals that can be compensated should be considered as a crucial part of mine planning.

What is more, future research should take another challenge into account. The technology part of a mine plan may be restricted by its nature, e.g., geology and current technology condition; but it is flexible when making some decisions, e.g., determining the triple bottom balance. In addition to answering the above questions, further research is needed to find out which of the several existing mining plans is the most sustainable for the local community, or to predict the acceptance probability for each mine design. The research could provide a successful understanding of the sustainability of mining operations from a mining community's perspective.

5. The Proposed Scope of Sustainable Mining Development

The sustainable development of mining projects for local communities not only requires the balance of economic, environmental, and social aspects. The proposed scope of mining sustainability is shown in Figure 2. The effect of the mine owner and local community have to be engaged in the sustainability scope. First of all, transparent and independent information need to be provided to the local community. Then, a quantitative method is required to analyze the local community itself and local individuals' understanding of the triple bottom line. The decision-making mechanism determines how a community's preference affects a mine owner's decision; moreover, the mine planning needs to be adjusted based on the analysis of the local community. Subsequently, a new cycle starts until an agreement is reached between the local community and mine owner based on their agreed scope of sustainable development.

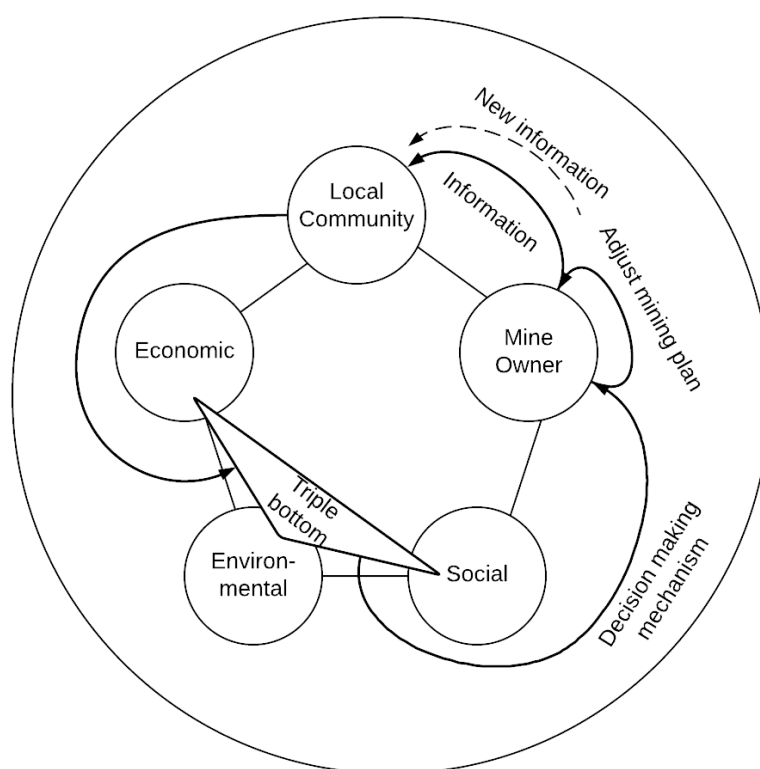


Figure 2. The proposed scope of mining sustainable development.

6. Conclusions

This study performed an extensive investigation on the topic of mining sustainability. It offered a new scope of mining sustainability based on the literature review. Besides the balance of economic, environmental, and social aspects, the mine owner and local community were involved. The cycle

of bargaining starts with mine owner and goes back and forth between the owner and the local community until an agreement is achieved; an equilibrium is reached when the profit is maximized for both sides.

In addition, the shortcomings of existing methodologies of sustainable mining are discussed. Mine governance and demographic divergence are missing in the current triple bottom model. Without considering these two important factors, the understanding of sustainable development in mining is immature. Also, a quantitative method should be used to analyze the preference of the community for improving the local mining community's engagement.

The future challenges include obtaining useful information and mine planning adjustment for the selected local mining community. This research could improve the understanding of the sustainability of mine operations from the mining community's perspective.

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