

SUSTAINABILITY IN SMALL-MEDIUM-ARTISANAL MINING ENTERPRISES IN BRAZIL

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ABSTRACT

Small-Medium and Artisanal (SMA) companies from the mining sector have an important role on the regional development of the community and areas where they are located in Brazil. These companies should then be considered as drivers to disseminate and promote the principles of sustainability to their stakeholders. Nonetheless, these companies face many challenges on implementing good environmental practices, due to their characteristics, such as, operating under illegal situation

INTRODUCTION

Over the last five decades the mining industry, wherever it takes place, has undergone significant changes, increasingly emphasizing the importance of regional development issues. According to Söderholm and Svahn (2015), during the mid-1990 great attention has been given to these companies, due to their contribution to economic and social development in many regions . One important factor which has been taken into account in the current literature is the discussion about the major problems and socio-economic benefits originated by Small-Medium and Artisanal (SMA) mining companies to a number of developing countries. In recent years, a considerable effort has been devoted in literature, to

impact human quality-of-life, mainly because operations in the majority of these companies possess rudimentary conditions to operate, low tech and employ uneducated, as well as poverty-stricken workers (Hilson, 2002). In many parts of the world, small-scale mining activities are at least as important as large-scale mining activities' with an important role in poverty alleviation and rural development; most of the stakeholders involved are poor and mining represents the most promising, if not the only, income opportunity available. Nonetheless, SMAs from the mining sector are mostly known for their high environmental costs and poor health and safety record, as

and poor conditions, low educational level of their workers, lack of support from the government, among others. This research addresses practices implemented by projects and countries reported in the literature to support SMA mines towards sustainability achievement. The Brazilian mining situation was characterized and the particular case of SMAs was analysed. Main barriers for the effective implementation of sustainability in SMA were identified and good practices were used to derive possible interventions to overcome these barriers

well as less profitable and fundamentally unsustainable activity (Hentschel et. al., 2002), even if sustainability may have different interpretations.

The discussion about *sustainability management of small scale mining* can be considered a concept with different definitions and an abstract matter - the abstractness of the concept of "sustainability" and the different understanding of the definition of "small scale" in mining is discussed by different organization. Hence, there is a need to begin with few definitions to sustainability in SMA mining enterprises (Seccatoree et. al., 2014).

Considering the abstractness of the sustainability concept to mining SMAs, Almeida and Torres (2004), addressed

so that a mining (1) Improvement of operations where mines take place; (2) Improving safety conditions in the mines; (3) Mitigation of environmental impact; (4) Usage of the right equipment for the conditions of each site; (5) Rational and comprehensive use of mineral resources and mineral community benefits; (6) Reduction of geo-environmental and geodynamics threats and hazards.

It can be argued that SMA have an important role on the economic growth as well as on the development of local communities where these businesses are located. Following these lines many studies such as Tschakert (2009), Langston et al. (2015), Canavesion (2014),

Hilson (2012), Kotilainen (2015), Majer (2013), Oramah et al. (2015), Seccatore et al. (2014), have been showing the contribution of small-scale companies to the stakeholders of the mining sector addressing the substantial mining investments provided by these companies in remote regions.

According to DNPM a small-scale mining installation is classified according to productivity in Brazil and mean values are applied by the National Mineral Research Department (DNPM, 2015): productivity between 10,000 t/year and 100,000 t/year is used a criteria to define a mining installation as a “small-scale”, companies with productivity lower than 10.000 t/year are classified as “micro” and productivity between 1 million t /year and 100 thousand t/year classifies medium. For this study both “small” and micro are considered as SMAs. Figure 1 shows the share of companies of Brazilian mining sector by size, according to parameters defined by DNPM.

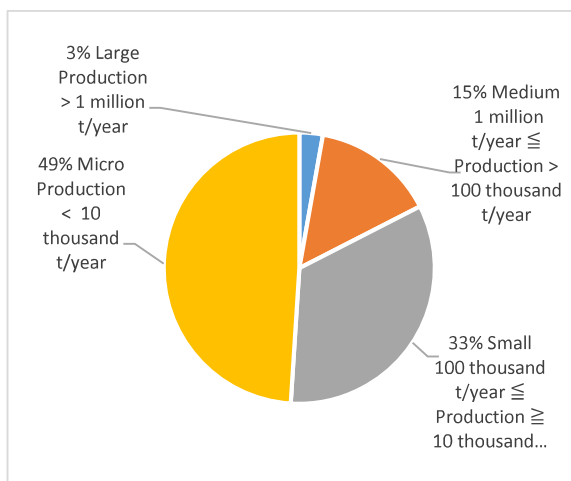


Figure 5: Brazilian mining companies by size in 2013. Source: DNPM (2013)

As illustrated in the figure 1 SMAs have an important role to mining sector in Brazil. Given the importance of sustainability to SMAs mining enterprises, this study aims to provide insight about sustainability in Brazilian mining SMAs, taking into account good environmental practices developed by different organizations in countries where SMAs are considered an important player to economic as well as to local community development (DNMP, 2015).

Moving beyond the importance of mining SMAs to Brazil, firstly this paper presents an analysis of the Brazilian mining sector, considering the role of SMAs and identifying some barriers related with sustainability. Secondly, the research addresses good environmental practices in SMA mining companies developed and implemented by organizations and projects presented in the current literature in countries where mining is considered an important player for the economic development. It will be examined how mining SMAs

have been considering sustainability, focusing on strategies, stakeholders and barriers. Thirdly, this paper will provide further insights about sustainability in the Brazilian mining SMAs aiming at characterising their actual sustainability stage and contributing by selecting suitable environmental practices to be further implemented to increase the integration of sustainability concerns in the mining business practices.

THE BRAZILIAN MINING SECTOR

According to Wellington and Mason (2014), Brazil is considered a country which tends to have the greatest influence on supply of minerals. Mining in Brazil is centred on the extraction of iron, gold, niobium and copper. According to the International Council on Mining and Metal, the contributions of the mining sector for the Brazilian macro economy are increasingly significant in the last decades.

Data provided by the Brazilian Mining Association (IBRAM, 2015a), indicates that Brazil has a territory with notable geological diversity propitious to the existence of deposits of many minerals comprising metallic and non-metallic ones, some of them with relevance in the global scenario, both as regards to mineral reserves and production. In 2014 the mining sector in Brazil has reached a product value of US\$ 40 billion, representing about 5% of the Brazilian industrial GDP.

Regarding jobs generated, this sector is considered an important player, according to IBRAM (2015). It takes into account the following activities: coal mineral extraction, non-metallic mineral extraction, metallic mineral extraction and activities to support minerals extraction in the extractive mineral industry and accounts to a total of 214.070 direct jobs in the first trimester of 2015 which given the multiplicative effect results in more than 2.7 millions of workers involved in mining activities.

Due to the global economic crisis since the second semester of 2013, jobs generated by the mining sector in Brazil have been decelerating, but this sector is still considered as having a highly significant level of employment.

Brazil's mining potential is significant, also on regards to HDI - the Human Development Index. Data from IBRAM shows that the HDI of mining towns tends to be the highest one among all towns in each state. Even when mining projects are set up away from major urban areas or even in areas with low social support, it is perceived that these projects bring a tangible potential for regional sustainable development (IBRAM, 2012a).

Due to the large number of mining companies operating in Brazil, it is necessary to verify how mining companies are represented in regards to the size, in order to understand the role of SMA mining companies when compared with large mining companies.

Small Medium and Artisanal (SMA) mining in Brazil

According to the last survey developed in 2013 in Brazil (DNPM, 2015), 8.870 mining companies were operating in different states and producing a total of 72 mineral substances, divided by metallic (23), non-metallic (represented by SMAs) (45) and energetic (4) minerals. Given the importance of SMAs to the mining sector in Brazil and the need to improve their sustainability performance, it is necessary to understand how sustainability is being taken into account by these companies in different countries, namely which initiatives have been adopted which consider environmental and social aspects.

The following section provides a synthesis of the main existing projects and lessons learned developed for many countries where SMAs play an important role, identifying important issues and methodological challenges, to learn from, select and propose to the Brazilian counterparts.

SHARING EXPERIENCES: GOOD PRACTICES TOWARDS SUSTAINABILITY

This section aims at examining examples of good projects and experiences developed by different countries to improve the sustainability level of their mining sector. Projects and lessons developed to support mining SMAs towards sustainability will subsequently be presented.

BGR and MMSD projects: focus on environmental issues and sustainable development for SMAs

BGR - Bundesanstalt für Geowissenschaften und Rohstoffe is a Program from the Federal Institute for Geoscience and Natural Resource in Hannover. This program involves a working cooperation with partner countries and organizations in Latin America, Asia, Africa and Middle East, to support sustainability in small-medium and artisanal mining enterprises. One of the topics of this program aims to assist SMAs taking into account their main challenges, such as economic aspects, barriers to obtain financial support from the government to improve their activities, support to form cooperatives and associations to organize the sector and support in the business management.

MMSD - Mining, Minerals and Sustainable Development, is a project supported by the International Institute for Environment. This research project aimed to support mining and minerals sector, through research projects, analysis and consultation in order to achieve sustainable development for SMAs mining companies. The MMSD has been supporting mining industries to improve the social and environmental performance in many regions taking into account aspects which are considered as big challenges to be faced by mining SMAs.

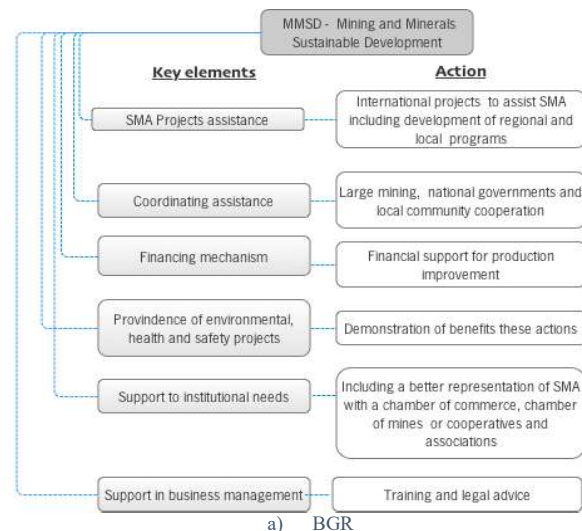
Studies from MMSD project have been elaborated taking into account relevant developing countries, namely Ghana, India, Ecuador and Peru among others. Results from MMSD show that SMAs must be considered an

important player on regards to generation of rural livelihoods and that they have potential to poverty reduction. This project is considered a tool to support these companies to achieve sustainable development.

Figure 2 represents the experience obtained from BGR (a) and MMSD (b) in order to assist mining SMAs in different countries. The left column on each section of the figure represents the key elements of the challenges faced, and the right column represents actions used to face each challenge.

Figure 2 (a), illustrates actions developed through MMSD projects namely: i) involving local development programs to assist SMAs with their activities, ii) coordinating assistance from large companies and from the government, since SMAs usually do not have any assistance to operate; support to business management is also considered, iii) financial mechanism to SMAs for improving their manufacturing process and infrastructure; it is justified because one of the main characteristic of SMAs is the lack of funds, and iv) development of actions to demonstrate to SMAs that environmental, health and safety actions could be key elements to produce benefits.

Figure 2 (b) illustrate key elements listed for the BRG partners as challenges faced by SMAs, such as certification on the mineral supply chain, which could assist SMAs in regards to transparency. The program illustrates with a specific project Namrio, that lists a set of actions to achieve this certification. Additional inclusion of more players, projects to support reuse of the mining residues and projects to attain sustainable extraction were key elements suggested by BGR to foster SMAs sustainable development.



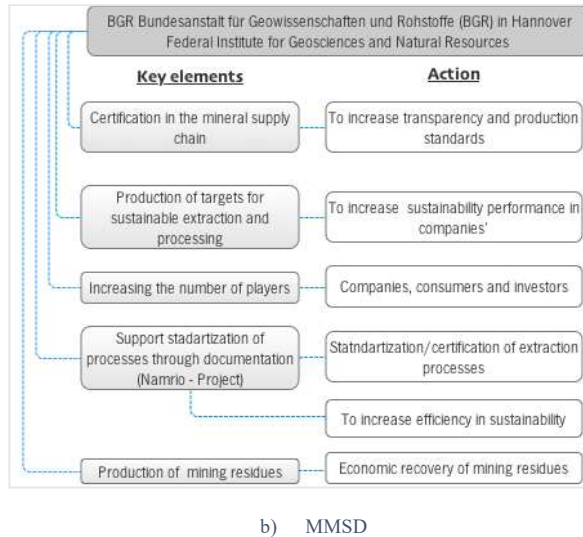


Figure 6: Good practices adopted by BGR and MMSD towards sustainability in SMAs from the mining sector: BGR (a) and MMSD (b)

In sum several positive actions can be drawn from BGR and MMSD projects. Initiatives and experiences from both summarize benefits achieved by SMAs in many countries. They give indications that good-practices when developed for these companies can be a guide to pursue sustainability achievement.

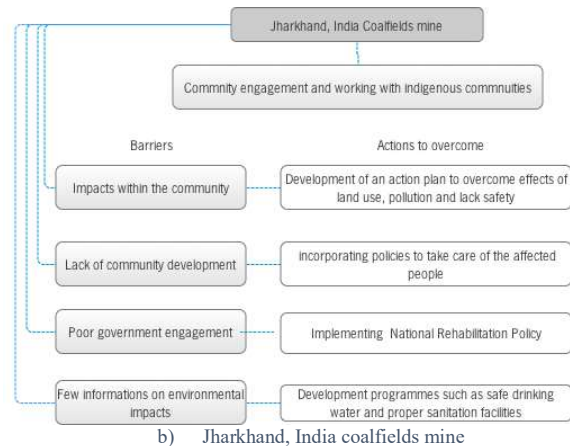
Community development and engagement: good practices learned from Eastern Kalimantan- Indonesia and Jharkhand-India

In order to support SMAs towards community development Eastern Kalimantan- Indonesia and Jharkhand-India have been developing several efforts to overcome the barriers faced for them. Figure 3 shows in the left column the barriers faced for these cases and in the right column the actions developed to overcome.

In Eastern Kalimantan, community development programs were created through a participatory action research project with the community. The main mines' operations in that region are related with coal production, which has been increasing over the last years; consequently, negative effects on the community have also increased.



a) Eastern Kalimantan, Indonesia



b) Jharkhand, India coalfields mine

Figure 7: Barriers to achieve sustainability focusing on community development - Eastern Kalimantan case (a) and Jharkhand Case (b)

Mining projects developed in these regions have addressed actions to improve engagement between mines and the communities, mainly trying to understand how local communities could contribute to sustainable development in mining activities. As summarized in Figure 3 (a), this project has been working on actions as: a) provide information about sustainable benefits to local communities, through corporate responsibility programs; b) community development, applying development principles to social and economic processes triggered by mines and, c) community engagement, creating cooperative working relationships aiming to include men and women in the mines.

The good practices from Jharkhand in India were developed towards resource utilization working with indigenous people within community engagement. Figure 3 (b), shows the barriers which were carried out matching the actions considered (left column) with suggested ways to improve performance (right column). The following barriers were highlighted: a) impacts within the local communities from mining activities: faced through implementation of the national rehabilitation policy to mining by government; b) lack of community development was also a barrier, overcome through the incorporation of national policies to take care of people negatively affected by mining activities, and finally c) few information on environmental impacts: for this barrier, development of programs to safe drinking water and proper sanitation facilities were made.

Technology development to SMAs: lessons learned from Quang Ninh- Vietnam and Shamva Mining Centre Project

The SMA mining companies are based on traditional production methods involving low level of technology, and the majority of their production processes are developed manually. They employ basic extraction technology, thus justifying the lack of investment to improve their manufacturing processes, as illustrated

previously in the MMSD project. Figure 4 illustrates practices developed by countries as Zimbabwe and Vietnam to face this aspect.

In Quang Ninh province case in Vietnam (figure 4 (a)), mining companies have been making efforts to implement new technologies in the underground mining, addressing technology focusing on resource utilisation, risk management and automatization of the production process as illustrated in the left column. For this case the right column shows strategies developed for each aspect focused.

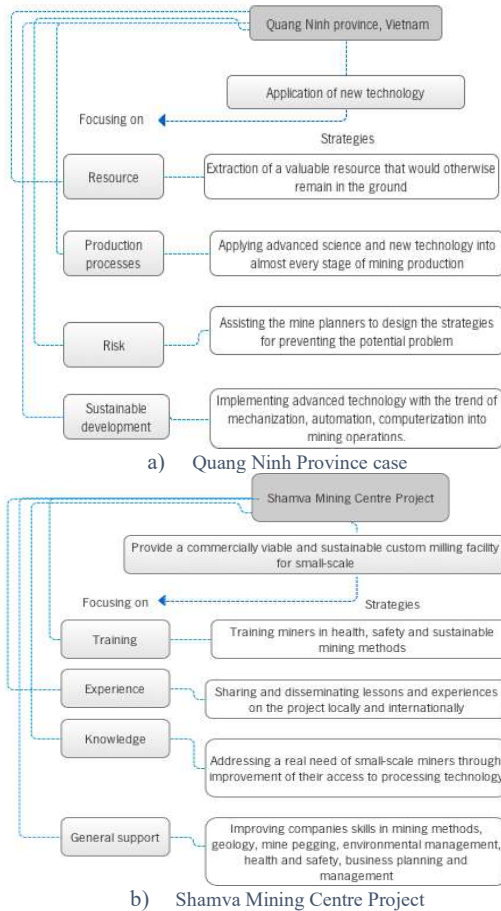


Figure 8: Development of technology to SMAs: Quang Ninh Province case (a) and Shamva Mining Centre Project case (b)

As illustrated in Figure 4 case (a): i) resource utilization in mining – a database has been built with the classification of resources that could be reused after extraction, with this strategy likely outcome of using valuable resources that would otherwise remain in the ground; ii) new technology implementation to production processes - it is provided applying techniques such as automatization, computerization and mechanization to reduce rudimentary and hard labour activities in mining production and finally, iii) risk management was also an alternative developed for the mines in Quang Ninh province - this aspect was considered important given the lack of workers' safety conditions and the planned

actions were designed to assist miner planners in order to prevent potential safety risks.

The Shamva Mining Centre Project was a joint initiative developed in Zimbabwe, which aimed to support small-scale miner offering training on mining, health and safety, and development of methods environmentally sustainable. Figure 4 case (b) left column summarizes aspects that were taken into account for this case. The first one was i) training - for this purpose programs were developed for miners' training in aspects as health and safety, as well as methods towards sustainability achievement in the mines; than ii) experience - for mining sustainability, for this international lessons and experiences from sustainable techniques on mining were shared with locals; iii) knowledge - addressing knowledge about mines - within this aspect projects providing access to processing technology by miners were disclosed, and, finally iv) general support to mining activities - it includes improvement of skills in SMAs mining methods, such as geology, mine pegging, business planning and management.

Over time all these practices implemented have been supporting SMAs from the mining sector in regions where they take place, with the expectation that challenges faced by SMAs, would be better tackled with the implementation of the proposed practices.

Lessons learned from projects and countries consulted: an overview

Figure 5 summarises from the experiences reported, environmental, organization and social initiatives that must be taken into account to support SMAs towards the improvement of their mining activities, bringing sustainability to their agenda.



Figure 9: Key for the implementation of good sustainability practices in mining SMAs.

As illustrated in Figure 5, there are initiatives that should be supported by stakeholders, for that, three main stakeholders which should be taken into account as follows.

In the first one, environmental level, government is the stakeholder direct related to the initiatives proposed. Its engagement in giving special attention to SMAs in order to support the legal formalization of these companies, thus creating specific legislation to cover these companies, including environmental regulations they will need to comply with, as suggested by MMSD project and Shamva Mining Centre projects.

Regarding environmental concerns, the majority of the projects consulted have been able to implement good environmental practices in SMAs, illustrating the likely possibility of SMAs from mining sector becoming sustainable.

Practices addressing sustainability in the supply chain management, namely through environmental requirements identification, resource efficiency for the optimization of resources extraction, planning and environmental assessment, optimization of the design and layout of the mines to reduce energy consumption, reprocessing of mining residues, environmental responsibility programs and elaboration of environmental impact assessment were the main strategies illustrated by projects and cases consulted in this research.

The second one, initiatives to organizational level, workers' stakeholders are addressed. Training and education of workers are key infrastructure factors assets. As mentioned previously, another strongly negative characteristic of SMAs is the miners' lack of education, which would be a prerequisite to improve their activities with upgraded technology and business management skills, as well as understanding and embedding sustainability concerns.

Also for this level, social license is an important tool to surrounding, when is used by companies as a tool to support local development. Thomson and Boutilier (2011), define the social license to operate as the community perceptions of the acceptability of a company and its local operations. For this reason, projects and cases consulted have been investing in training to community and miners, in order to give the possibility to assist them to a better use social of the license to provide benefits to both community and companies.

Specialized workers were also considered an important stakeholder under the category of workers, worthy of separate identification, given their technical knowledge fragility, thus to assist SMAs in the development of knowledge to their upgraded activities, as well as assisting in technology investment selection and implementation.

The third one, initiatives to social level, the community was considered in all projects and cases consulted in this research as a strong stakeholder, due to the required involvement of the community in the activities of SMAs.

There has been ongoing communal debate in all projects related with sustainability in mining sector.

Discussion on the challenges faced for SMA from the mining sector in Brazil

The majority of studies in Brazil have been focused on large mineral companies. Only a few studies have been found in the current literature focused on SMAs sustainability in mining enterprises, which can be surprising considering the economic importance of SMAs in the Brazilian mining sector.

Authors as Gomes et. al., (2013), Silvestre and Neto (2014), Bouzon, et. al (2015), Viana (2012), and DPNM (2015), have pointed out some of the barriers that SMAs in Brazil are facing to incorporate sustainability concerns in their operation, such as: the culture of mining companies; the low involvement with stakeholders, especially with the local community; the Mineral Brazilian legislation that is not sufficient to regulate this sector; the local government which has lack of proper control of these companies and the lack of knowledge or competencies of workers in mining companies. Also, sustainability has been highly associated in these companies with high costs, which is another important barrier to be faced by SMAs.

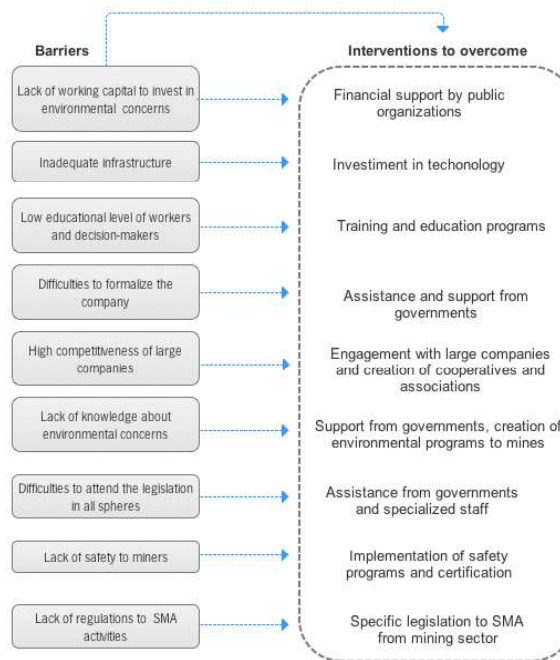


Figure 10: Towards to sustainability in SMA in Brazil: barriers and lessons.

Data from IBRAM (2014) and Seccatore et. al., (2014), show that the use of good environmental practices by SMAs in Brazil is still insipient given the many challenges faced by these companies. On the other hand, evidences from other countries where these companies have been playing an important role, show that sustainability could be achieved, whereas, it is important to emphasize that key stakeholders such as, government, specialized workers and community figures are of absolute relevance for this purpose.

From the literature analysed dealing with the Brazilian SMAs Figure 6 was elaborated identifying the main barriers found and adapting the lessons learned from the international experiences consulted in this research, in order to suggest actions to be used by SMAs from mining sector in Brazil to overcome these barriers.

Furthermore, due to the low-level of implantation of good practices by SMAs in Brazil and as pointed out in Figure 6, the proposed analysis attempts to address a deeper understanding of the structural changes needed by these companies in Brazil, towards sustainability achievement. These will include several aspects, namely the financial support required by public authorities, implementation of new technologies on their mining activities in order to become an organized and efficient sector, specialization of their workers, high engagement with governments towards creating training and education programs, and finally the government role that is twofold significant: firstly to create specialized legislation covering SMAs of mining sector and secondly regulating their activities, including environmental issues, which is inexistent nowadays.

CONCLUSIONS AND FURTHER RESEARCH

The above experiences listed in this paper provide a broad review of good practices developed by small-medium and artisanal mining companies in different

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mining regions worldwide. Related literature was analysed covering a set of projects and cases of successful application to mining SMAs towards sustainability pursuit.

The work involved identifying key aspects and initiatives developed in several relevant countries, which should be considered for guiding mining SMAs in Brazil towards sustainability. This research focused on the three main barriers faced by SMAs cited in the current literature, namely community engagement, lack of technology and lack of environmental practices. In addition, a set of good practices developed for the literature cases consulted were listed.

As a result, based on the few studies devoted to the mining sector SMAs in Brazil, were identified the main barriers faced by mining SMAs in Brazil, as well as the key stakeholders, addressing their importance to engage in sustainability practices. A range of challenges associated to mining in Brazil were identified, namely a disorganized and unsupported industrial sector, lack of technical knowledge, poor conditions to operate, among others.

One significant contribution of this research is the listing of good practices and initiatives foreseen to overcome the challenges identified, which were derived from the lessons learned from the studies analysed. These good practices included improvement or upgraded technology for these companies, financial support from the government as well as engagement between SMAs and government and SMAs and the local community, improvement of technological infrastructure, training for miners and development of safety and health actions to both, local community and workers in the mines.

As such this research may support better informed decision-making processes in SMAs of the mining sector in Brazil, knowing the main barriers that other similar sectors faced in different countries and how they were positively faced.

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