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Mining cooperatives in Brazil: an overview

W. Alves*, P. Ferreira, M. Araújo

ALGORITMI Research Centre, University of Minho, School of Engineering, Campus de Azurém, Guimarães 4800-058, Portugal

Abstract

In the current literature, cooperatives are commonly linked to a network of contracts or coalition. This is particularly the case of producer owned cooperatives that operate in small business scale such as farmers or diggers which are members of the cooperative. Mining cooperatives wield significant influence over the mining sector. These organizations have been getting increasing importance as powerful actors to support diggers through initiatives and policies to improve small-scale mining activities. In spite of the importance of cooperatives to the local communities and small companies, scientific literature concerning their organization, benefits and barriers are still scarce. The objective of this research was to examine the actual scenario of mining cooperatives in Brazil analyzing how mining cooperatives could be used as a sustainable strategic network into the mining sector in Brazil.

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Keywords: mining cooperatives, sustainability, Brazil

1. Introduction

Over the past decades, the mineral exploitation has experienced significant growth, contributing to economic development in many countries, especially the developing ones, given to the promises to generate wealth and jobs. This growth embrace mining activities in several sustainability concerns. These concerns may include not only environmental impacts such as atmospheric and water pollution, greenhouse emission through land degradation and disforestation, but also social issues which include high social costs, such as loss of regional culture, noise, health impacts, conflicts over land use, loss in the air quality, among other.

* Corresponding author. Tel.: +351 937 895 028.
E-mail address: wellingtonbn@gmail.com

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Regarding the discussion of cooperatives in the mining sector, in the current literature cooperatives are commonly linked to a network of contracts or coalition. This is particularly the case of producer owned cooperatives that operate in small business scale such as farmers which are members of the cooperative [1,2]. Mining cooperatives wield significant influence over the mining sector. These organizations have been getting increasing importance as powerful actors to support diggers (small artisanal miners) through initiatives and policies to improve small-scale mining activities towards sustainability [3,4].

Moving on to the Brazilian case, historically the mineral exploitation has contributed to establishment of the national territory. Nowadays, in digging' activities (*garimpos*, performed by diggers - *garimpeiros*) the status of cooperation with adoption of collective actions still persists, in spite of the effectiveness of this cooperation being difficult to achieve [3,5]. The creation of mining cooperatives presumes the alliance between individual interests, in order to achieve collective benefits for all the ones involved in the activity [7]. The alliance into cooperatives could be a key element to improve sustainability in the Brazilian mining sector.

In spite of the relevant importance of cooperatives to the small mining activities and also to local communities, related scientific literature concerning their organization, benefits and barriers are still scarce. The objective of this research is to examine the actual scenario of mining cooperatives in Brazil analyzing how mining cooperatives could be used as a sustainable strategic network into the mining sector in Brazil.

The remainder of this paper consists in 5 sections as follows. Section 2 begins with a brief introduction about cooperatives, including mining cooperatives. In section 3 an overview of mining cooperatives in Brazil is presented. Section 4 outlines the research methodology used in this work, followed by the empirical analysis described in section 5. In section 6, a summary of findings and policies implications are presented.

2. The importance of mining cooperatives

Mining cooperatives are defined as associations created by miners which aim to support the exploitation, industrialization and commercialization of mining products. These organizations also seek to contribute for encouraging small-mining producers, through humans and ethics values, to promote social inclusion, better miners' income distribution and poverty reduction [5],[11]. They have become a powerful representation voice to communities and also to different economic sectors in many developing countries, generally supporting small producers through a collective approach [12].

The mining cooperatives could have a great positive impact to diggers, namely in supporting them through social and economic benefits [8-9]. For instance, the creation of cooperatives through small producers has been developing alliances between companies supplying their products and creating benefits to both, communities and companies. Mining cooperatives can then assist developing countries not only in the economic field, but in threefold: creating jobs, developing strategic networks between small producers and enterprises and also increasing social development [10].

Mining cooperatives have an important repercussion in local scale and could be key actors in extractive industries, providing a vital role to many communities in the economic field. This raises questions with regards to how successfully can the barriers be surpassed when diggers are integrated into mining cooperatives and how this inclusion can enhance social inclusion. In order to illustrate some benefits achieved through cooperatives in the mining sector, Table 1 summarizes a few examples of problems which individual diggers and related community face and the possible contribute of the cooperative approach to solve them.

Table 1: Individual diggers *versus* cooperatives.

Individual diggers' problems	**Cooperatives' benefits**
Individual work – no risk sharing	Collective work - sharing profits
Illegal work	Possibility to legalize the work
Difficulties to sell mining products	Development of a network between cooperatives and companies
Lack of safety to work	Development of safety programs
Lack of training	Investment in training
Few contributions to local community	Generating royalties to municipality
Lack of support of public entities	Governmental support

In spite of the key role of mining cooperatives, the debate about them is still limited. This paper intends to contribute for further discussion, widening the debates by combining two main objectives driving the creation of mining cooperatives. Firstly, the socio-economic benefits to diggers derived from the legal formalization of the diggers' work, supporting them and the surrounding counterparts. Secondly, the discussion of the role of mining cooperatives as a strategic sustainable network within the mining sector.

3. Overview of mining cooperatives in Brazil

Brazil is a large, unevenly developed country with different cooperative traditions and historically mineral exploitation, which has contributed to the formation of the national territory. The cooperatives in Brazil have been a great instrument in many contexts such as encouraging frontier development by smaller producers, encouraging market production, enhancing technological development and improving economies of scale [13][5].

Meanwhile, the legal formalization of the existence of small-mineral producers and diggers is a big challenge faced by the Brazilian mining sector. The majority of "*garimpeiros"* work illegally, and mineral cooperatives pose as an alternative instrument to support them towards legal formalization, training, and also contributing to increase their productivity.

Assuming minerals cooperatives as drivers to overcome challenges posed to individual diggers, the Brazilian government regulated and agreed on the creation of mineral cooperatives to operate in areas of 50-1000 ha. This regulation has been encouraging small mining producers to take part of cooperatives, claiming the importance of organization to increase the performance of small-mining activities [6].

4. Research methodology

In this research, a qualitative approach was adopted in order to collect information about the importance of mineral cooperatives to Brazilian mining sector, their contribution to the overall objective of sustainable development and the benefits brought and barriers faced by those cooperatives.

The main steps developed in this research are detailed as follows. In order to capture the importance of cooperatives to the mining sector, this research began with a literature review identifying potential studies which could support a better understanding about mineral cooperatives. However, after searching numerous journals associated with this topic, few works were found, demonstrating lack of research in this field, or a gap in the literature.

A case study was adopted as research strategy aiming to study within its contextual scenario, the specific phenomenon of the mineral cooperatives in Brazil. This research focuses on the state of Paraiba in Brazil, chosen due to its natural characteristics and the willingness of different stakeholders to cooperate in the research. Paraiba has seven mining cooperatives operating, all of them were invited to take part in this research and five of them accepted.

In-depth semi-structured interviews were devised to address sustainability in the cooperatives, covering social, economic and environmental concerns. As such, the interviews were focused on five specific aspects namely (1) general information about the cooperatives (2) cooperatives and stakeholder's communication, (3) communication

relationship (4) environmental and social impacts and (5) barriers faced. The interviews were held with the president and/or manager or their representative of the cooperatives[†], they took place in each one of the cooperatives and lasted from 40 to 80 minutes.

The interviews were then analysed, and a picture of this set of mineral cooperatives was obtained aiming to assess the importance of those cooperatives to the economic and social development of the local communities in the Paraiba state. Furthermore, the main operating barriers faced by the mineral cooperatives were also identified and described.

5. Empirical analysis

The sample consists of five mining cooperatives that agreed to participate in the study. The characterization covers the profile of the respondents, the minerals exploited and some quantitative information on the cooperatives operation. Table 2 shows a sum up of the cooperatives technical record.

All cooperatives consulted in this research work with the non-metallic sector. According to National Department of Research Mineral (DNPM), the mineral production in Brazil account for a total of 72 minerals substances, including 23 metallic, 45 non-metallic and 4 energetics [14]. In 2015, the non-metallic sector represented a total of 2.53% of the Brazilian industrial GDP (Gross Domestic Product) [15]. In the non-metallic sector, minerals such as kaolin, quartzite, feldspar and ornamental rocks are particularly relevant to the Brazilian minerals reserves. For instance, ornamental rocks represented in 2013 a total of 8.5% of the international market and ranked the fifth place in the global market. The quartzite and feldspar are the main non-metallic minerals exploited and the region addressed in this research, which is considered a geological province for these minerals and as such strategic for the sector and for the economy of the country [14]

Table 2: Technical record of participating cooperatives.

Geographical area		Paraíba state - Brazil	
Total of cooperatives in the state		07	
Participating		05	
Research addressed to		Cooperatives as a sustainable strategy network	
Sector		Mining sector	
Activities		Non-metallic sector	
Cooperativities size:		Small- mining activities	
	Operation (years)	Cooperatives members	Mineral exploited
Cooperative A	9	19	Feldspar-Mica
Cooperative B	7	108	Quartzite
Cooperative C	9	13	Feldspar-Mica
Cooperative D	5	30	Kaolin-Mica
Cooperative E	8	178	Quartzite-Kaolin
	$\overline{X}$=7.6	$\overline{X}$=69.9	

The participating cooperatives are operating according to the Brazilian legislation and also to the DNPM (National Department of Research Mineral) rules, which regulates mining activities, in this case small-mining activities (areas 50-1000 ha). An interesting characteristic of the participating cooperatives is that they are relatively young enterprises

[1] Although the interviews carried out were focused on management board or presidents of cooperatives, in some cases as in cooperatives E and D some cooperatives members participated once they asked to participate.

(< 10 years), which explains some challenges (described in the section 6) they face as well as the still timid contribution they have to the Brazilian mining sector.

Some of the cooperatives comprise a small number of members, while others have a large number of members, as in cooperatives B and E, as illustrated in Table 2. In these last cases, for practical reasons not all members can be participating in the management board and as such representative democratic management is in place as the management board is elected by cooperatives members. However, the low academic level of cooperatives member and the lack knowledge constraints of the management board which frequently is composed with higher educational levels. In fact, cooperatives members see themselves more as employees than as members of the cooperatives.

The profile of the interviewees is presented in Table 3, which shows that most of the interviews had a low education profile on the mining sector as well as low formal education and are working for the cooperative for at least 5 years. The majority of interviewed are part of the cooperatives since its establishment, and according to them, the investment in training by cooperatives is still scarce or does not exist. Moreover, the participation of the interviewed in other organizations such as, universities or syndicates is limited, with only two of them collaborating with in a university and a syndicate. It is also important to highlight that according to DNMP, lack of knowledge in mining fields and specialized staffs are important challenges to be overcome by small-mining activities.

Table 3: Profile of the respondents (n=5).

	Present position at cooperative	**Years of work at cooperative**	**Educational background**	**Associated with some organization**
Cooperative A	President	9	N/B[a]	No
Cooperative B	President representative	4	Mining technical	Yes
Cooperative C	Management board member	6	N/B	No
Cooperative D	President	5	N/B	No
Cooperative E	Management board member	5	N/B	Yes
		$\bar{X}$=5.8		

[a] No background, meaning no formal educational

As illustrated in the Table 4, most of the interviewed were not aware of the cooperative principles and most cooperatives do not operate according to these principles. The use of cooperatives principles by these organizations have a great role supporting on cooperatives members to improve his skills, offering technical assistance and training.

Table 4: Cooperatives principles used.

	Cooperatives principles						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Cooperative A	✓	X	X	X	X	✓	X
Cooperative B	✓	X	X	X	✓	X	✓
Cooperative C	✓	X	✓	X	X	X	X
Cooperative D	✓	X	X	X	X	X	X
Cooperative E	✓	✓	X	X	✓	✓	✓

1-Voluntary and open membership 2- Democratic member control 3- Member economic participation 4- Autonomy and independence 5- Education, training and information and independence 6- Co-operation among co-operatives 7- Concern for community

5.1. Community relationship and social impacts

As outlined before, one of the motives to create mining cooperatives is to establish a better organizational structure for diggers.

Cooperatives are directly linked to local communities, as these activities often involve families living close to these premises. Also, mines are frequently located in remote geographic areas with limited infrastructures, thus the improvement of social inclusion through the emergence of social infrastructures represents a key outcome of cooperatives' activities. Table 5 indicates the distance between the cooperatives included in this research and the nearest community, demonstrating that this distance is less than 10 km for all of them and as such its local community impacts are likely to be relevant.

Table 5: Distance of mining cooperatives and community.

	Distance from nearest community (*km*)
Cooperative A	6
Cooperative B	2
Cooperative C	3
Cooperative D	10
Cooperative E	6
	$\overline{X}$=5.4

In spite of the interviewees recognition of the importance of involvement with the local community, when asked about the community engagement into cooperatives' activities, the majority of them indicated that the cooperative have not developed actions to pursue that engagement. Some of the interviewees argued that, the nearest community have not reported any disturbance. However, during the field research and through direct contact with a few local cooperatives' members (diggers) complains on negative aspects such as noise, dust and some health problems were identified.

Actions targeting the minimization of impacts generated were also addressed during the interview. For instance, support to schools at local community, development of health and safety strategies and establishment of professional training courses were given as examples of possible actions. However, the interviewees argued that neither of these actions are developed by the cooperatives; they claimed that it is difficult for cooperatives to make these efforts, due to both the lack of resources and to the organization culture itself.

Another topic pointed out during the interviews related to the community was the existence of Social Licence (SL). Over the past decade this SL concept has become embedded and accepted within the core mining industry as an attribute of success to community engagement. The SL is supported on the locally-impacted communities' perception of value towards company's activities. The interviewees were asked about the SL existence or if they had some information about SL meaning. In spite of the importance of SL to ensure and demonstrate community engagement, all participating cooperatives reported that SL was not implemented. Moreover, they were not aware of its meaning and importance.

5.2. Environmental impacts

Despite of the development of policies towards social and economic issues in the mining sector, the environmental impacts generated by mining activities are still the major threat and concern. On regarding to mining cooperatives, although undertaking small scale activities, environmental impacts still persist directly related to water, air and land use. Environmental issues include dust emission, noise, land occupation, energy and water use, the latter being intensively used in mining activates.

To address these issues the interviews aimed at understanding three main aspects linked to environmental impacts originated by those cooperatives. More specifically, (1) cooperatives' perception about their impacts, (2) actions

developed by cooperatives towards environmental impact reduction and (3) key players able to support cooperatives in environmental concerns.

Environmental impacts remain an extremely confused and complex issue for mining cooperatives. For the majority of them these activities only have positive impacts, more precisely only social benefits such as jobs creation and wage growth. As such, environmental issues are not perceived, or at least considered by the interviewees.

As stated in section 02, cooperative activities bring both economic and social benefits, and the participating cooperatives were aware about them. However, the land use, dust emission, and a large amount of energy and water used in mining activities and contributing to several environmental impacts, environmental impacts seem to be fully ignored by the interviewees. These results corroborate the idea that negative concerns and in particular environmental issues remain poorly addressed in these mining cooperatives, which tend to value mainly social and economic benefits.

Table 6 presents a set of actions towards minimization of environmental impacts, derived from the literature review. Interviewees were asked about its implementation on their own organization but most of them admitted that none of these actions or just a few of them were in place. Most cooperatives argued that it is difficult to develop some of these actions, due to their lack of skills and monetary support. Even recycling, resource reduction and water consumption reduction during processing, which were actions implemented already by some of the largest cooperatives, were assumed as difficult to be put in practice. Monetary, governmental, administrative support schemes and specialized staff were indicated as key aspect which were considered essential for supporting those cooperatives on reducing their negative environmental impacts and even to comply with the legal requirement of environmental recovery after mining closure.

Table 6: Actions for environmental impacts reduction.

	ACTIONS						
	Recycling	Resources reduction	Water consumption (reduction)	Solid Waste (minimization)	Liquids effluents (minimization)	Renewable energy sources (use)	Energy efficiency (mechanisms available)
Cooperative A	X	X	X	X	X	X	X
Cooperative B	✓	✓	✓	✓	X	X	X
Cooperative C	X	X	X	X	X	X	X
Cooperative D	X	X	X	✓	X	X	X
Cooperative E	✓	X	X	X	X	X	X

6. Summary of findings and policies implications

In this research, sustainability in mining cooperatives was discussed along its three dimensions namely, social, economic and environmental, while taking into account the importance of these cooperatives to the Brazilian mining sector. An empirical study to analyse mining cooperatives in Brazil was conducted addressing in particular the case of non-metallic mining cooperatives in the Paraíba state. The possible benefits of the cooperative activities were summarized and its contribution towards sustainability was analysed. Furthermore, the main barriers to ensure sustainable practices in cooperatives were pointed out.

Cooperatives have been important instruments in twofold: to support diggers on improving their activities and to support small-mining activities to overcome their major challenge, namely their legal formalization.

The use of the cooperatives principles represents the key aspects ruing this business model; when properly considered they can support attaining sustainability objectives within mining activities. Notwithstanding, findings in this research indicate that the participating cooperatives are not working in line with all those principles, and have

several difficulties to put them into practice which rises concerns on their effective contribution towards a sustainable development at local and global levels.

The obtained results in this research showed that initiatives for sustainability in mining cooperatives are still scarce in the Brazilian mining sector. Interviewees were asked about their understanding of the sustainability meaning and also if it was considered in their activities; they were also asked about disclosure or mechanisms to report sustainability. All argued that these issues are not taken into account and they also showed difficulties in understanding the sustainability meaning and its importance.

The results showed that strategies and actions towards sustainability need to be disseminated and integrated into the cooperatives business model in Brazil. Positive outcomes from the incorporation of sustainability concerns on mining cooperatives activities can be expected if adequately linking sustainability with economic benefits to cooperatives members, social development of the region and stakeholders as well as environmental impacts reduction.

In line with previous studies published by OCB (Brazilian Cooperatives Organization), the empirical findings of this research identified a list of problems faced by the participating cooperatives, namely (1) difficulties to follow the cooperatives principles, (2) reduced understating of cooperation principles by all as some of the members see the cooperatives as an employer company and expect regular wages and do not understand sharing of profits concept, (3) difficulties on the legal formalization of the business activities at the Public Administration Institutions, (4) lack of skills to manage the cooperative, (5) reduced governmental support (6) shortage of working capital and (7) lack of training of specialized staff.

To sum up this section, the results indicate that in the long term, to overcome these barriers an important first step for cooperatives would be to operate more efficiently in what concerns the use of both natural and human resources. As cooperatives push into remote geographical areas, depending on the raw materials availability, they are also changing the lives of those people living there. Therefore, mining cooperatives will tend to contribute as a strategic network to improve the sustainability of the Brazilian mining sector.

The need to build a good relationship with communities and the environment has been realized in several countries where mining takes place. The seek for building this relation is posing a challenge to the Brazilian mining sector, even if not yet fully perceived; meanwhile, further discussions in this direction pose relevant field for future research.

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References

[1] J. de Haan, S. Geenen, Extr. Ind. Soc. 3 (3) (2016) 823–831.

[2] D. Bocangel, “Small-scale mining in Bolivia: national study mining minerals and sustainable development,” 2001.

[3] G. Duff, D. Garnett, P. Jacklyn, J. Landsberg, J. Ludwig, J. Morrison, P. Novelly, D. Walker, P. Whitehead, Landsc. Ecol. 24 (8) (2009) 1135–1143

[4] T. Mazzarol, E. M. Limnios, S. Reboud, J. Co-op. Organ. Manag. 1 (1) (2013) 27–40.

[5] A.F. Freitas, A. dos S. Macedo, Rev. Bras. Gestão e Desenvolv. Reg. 12 (1) (2015) 107–131.

[6] O.C.B., “Diagnóstico do Ramo Mineral - Desafios para o Setor,”. (2016) 69.

[7] O.C.B., “Panorama do Cooperativismo Brasileiro,” Brasília. (2016).

[8] A. Dale, F. Duguid, M.G. Lamarca, P. Hough, P. Tyson, R. Foon, R. Newell, Y. Herbert, “Co-operatives and Sustainability: An investigation into the relationship,” Co-operatives Sustain. Rep. (2013) 1–76.

[9] International Co-operative Alliance (ICA), “Co-operative identity, values and principles” ICA, 2017. [Online]. Available: http://ica.coop/en/whats-co-op/co-operative-identity-values-principles.

[10] International Co-operative Alliance (ICA), “Co-operative sector announces global turnover of 2 . 2 trillion USD for top 300 coops , and employment figures of at least 250 million worldwide”. 32 (2) (2015) 3–4.

[11] A.F. da S. Rodrigues, “Cooperativismo Mineral no Brasil: o caminho das pedra, passo a passo". (2008) 131.

[12] K. Francescone, “Cooperative miners and the politics of abandonment in Bolivia,” Extr. Ind. Soc. 2 (4) (2015) 746–755.

[13] S.L. Stattman A.P.J. Mol, Geoforum. 54 (2014) 282–294.

[14] D.N.P.M., “Departamento Nacional de Produção Mineral. Anuário Mineral Brasileiro: Principais substâncias metálicas,” 2016.

[15] Ministry of Mines and Energy, “Anuário estatístico do setor de transformação de não metálicos,” Brasília, 2017.