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ORIGINAL PAPER

The impact of COVID-19 for the Ecuadorian mining industry in 2020: risks and opportunities

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Abstract
On 11 March 2020, COVID-19, which started in Wuhan (China), was declared a pandemic. Since then, casualties have been increasing and have not ceased. This study aimed to evaluate the impact of COVID-19 on the Ecuadorian mining industry and to identify the capacities and weaknesses caused by the sanitary crisis. For this purpose, the study was structured in four stages: (a) bibliographic review of organizations at the international level; (b) collection of local data (surveys and interviews); (c) multi-criteria analysis, and (d) selection of social and economic indicators that can be replicated in Ecuador's mining sector. International data indicated notable progress in the social, health, and safety areas but less in the labor-economic aspect. Surveys and interviews showed the different impacts of COVID-19 in Ecuador's mining sector, and multi-criteria analysis along with social and economic indicators served as a reference for recommendations to improve the weaknesses detected and reinforcing the strengths of the sector. The Ecuadorian scenario is different from the one abroad; companies presented more social and economic information and less about health and safety than international companies.

Keywords Ecuadorian mining · COVID-19 pandemic · Social and economic indicators

Introduction

COVID-19 is an infectious disease caused by the SARS-CoV-2 virus originally reported in Wuhan (China) in December 2019. The virus has infected over 668 million people, including over 6.73 million deaths globally (Orús 2023). This infectious disease has spread rapidly to other countries and continents (Chen et al. 2020). The scale and trajectory of the transmission made the World Health Organization (WHO) declare a pandemic on 11 March 2020. By mid-April, countries worldwide were affected by the virus. The COVID-19 pandemic has caused a notable increase in global economic policy uncertainty and unprecedented stock market response (Sharif et al. 2020).

The COVID-19 pandemic had wreaked havoc on extractive economies globally; back then, the market prices for oil and some metals had undergone steep declines due to a collapse in demand (Gharib et al. 2021; Yu et al. 2021). Security protocols and physical distancing caused significant disruption to the mines' operations, affecting their productivity and profitability (Hall 2021; Marimuthu et al. 2022). As a result, the share price for some major mining companies declined considerably (Bernauer and Slowey 2020; Laing 2020). Furthermore, the demand reduction caused dramatic falls in the prices of a range of metals and minerals across March and June 2020 (Laing 2020). According to the Federal Reserve Economic Data (FRED), the prices of gold, silver, and copper reached their lowest point in the international markets (FRED 2022a, b) . The price falls were more dramatic for aluminum and copper, as the slumps mirrored the declines in the share prices of many of the large multinational mining companies (Laing 2020). In contrast, commodities like gold and silver were found to be less volatile (Ali et al. 2020; YCHARTS 2022). In July and August 2020, most mining companies returned to their normal levels of activity in compliance with the selected biosafety and hygiene requirements (Gałaś et al. 2021).

The mining industry has been affected in various ways, depending on the type of mining and operation and the

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country (Laing 2020; Lone and Ahmad 2020). The restrictions imposed by governments to contain or delay the spread of COVID-19 brought several difficulties to the mining sector (Benites and Bebbington 2020; Perks and Schneck 2021). Mining companies were affected by restrictions to favor social distancing. Mine's projects slowed down or temporarily closed (Castro 2020; Gałaś et al. 2021; Giese 2022). In Italy which was badly hit by the virus, the Alta Zinc project temporarily closed down its activities in March; otherwise, most mines continued their operations (James 2020). The USA continued its mining operations since mining was qualified as an essential activity for producing critical materials and maintaining the associated supply chains (Javad 2021).

In Latin America, mining is a pivotal contributor to the national economy (RMI 2020). Colombia exempted mining activity from quarantine measures; mining companies could decide whether to slow down or stop operations (IGF 2020). Moreover, Ecuador (according to the Executive Decree 1017 issued on March 2020) established that activities related to strategic sectors may continue working during the health emergency (Castro 2020).

Ecuador's mining sector is segregated into artisanal and small-scale mining (ASM) and large-scale mining (LSM). The ASM sector comprises approximately 11,500 miners, of which at least 1500 are women. ASM represents 1% of Ecuador's 2018 GDP contributing 900 million dollars annually (NAP 2020).

In addition, in Ecuador, there are projects focused on developing legal and responsible mining through strategic processes that allow attracting potential investments aimed at economic and social reactivation; these types of projects are known as "strategic" mining projects. There are currently 5 strategic mining projects in the country, the best known of which are the Fruta del Norte Project and the Mirador Project and 6 mining projects in pre-operational stages known as second-tier generation projects (CBE 2020; SWI 2021). During the first months of the pandemic, the ASM operated with 50% of its personnel because of mobility constraints caused by restrictions of the government and the National Emergency Operations Committee (COE, acronym in Spanish) (CBE 2020, 2021b).

This limitation also had an economic impact on the women who carry out the "jancheo," name given in Ecuador to the mining waste collecting process in ASM (Ministerio del Ambiente y Agua 2020). As a result of the lack of economic resources during the first months of the pandemic, these women have constant difficulties in accessing other jobs in their localities (NAP 2020).

Between 2017 and 2019, USD 779 million in mining products were exported to countries such as the United Arab Emirates, Switzerland, Hong Kong, India, Italy, the USA, China, Mexico, Peru, Taiwan, Chile, and Spain; in the third quarter of 2019, mining contributed 61% to foreign direct investment (ARCOM 2020). In the fourth trimester of 2019, with the beginning of strategic mining projects *Mirador* and *Fruta del Norte*, the mining industry was projected as an essential source of income and a fundamental pillar for the growth of the country's economy, expecting a contribution of 4.5 in the GDP for 2021 (CBE 2020).

Based on data from the Central Bank of Ecuador (CBE, acronym in Spanish), by the end of 2020, the annual growth rate of exports of non-oil primary products was 12%, highlighting a 182% growth of mine production due to the start of the two LSM projects (CBE 2021b). The oil sector report for the second quarter of 2020 unveils the unprecedented impact of COVID-19 since the oil price shocked. Exports according to the Ministry of Energy and Non-Renewable Natural Resources (MERNNR) were lower in volume (7.3%), value (29.7%), and price (24.2%) than the previous quarter and the second quarter of 2019.

The aims of the research were to (a) assess the impact of the colossal COVID-19 crisis for the Ecuadorian mining industry and (b) identify the capacities and weaknesses of the mining sector to overcome the difficulties caused by the health crisis. This information can be used to improve emerging cooperation strategies between mining businesses, communities, and local government.

Methodology

This study was structured in four stages: (a) bibliographic review of organizations at the international level; (b) collection of local data (surveys and interviews); (c) multi-criteria analysis; and (d) selection of social and economic indicators that can be replicated in Ecuador's mining sector.

Bibliographic review

The bibliographic review comprised two phases, (1) data compilation from leading international organizations both industry and NGOs and (2) analysis, interpretation, and visualization to identify the most relevant information in response to the crisis caused by COVID-19 in Ecuador's and the world's mining sector according to 5 categories: general information, health and safety, labor, the economic, and social aspect.

Data collection

The study incorporated both quantitative and qualitative data collection procedures. The quantitative data provided descriptive information about the mining companies' investments, incomes, and production during the pandemic. The qualitative data supplied information about opinions, behavior, and perceptions of mining entrepreneurs, workers, and

the community on the impact of COVID-19 on the mining industry. The participants were local leaders, the community in general, engineers, and personnel from small- and large-scale companies. The period of the data collected was from January to March 2020. Surveys were conducted via Google Forms and interviews via Zoom and WhatsApp.

Surveys

For this research, 117 surveys with multiple-choice questions were conducted via Google Forms. The data came from a specific group of people, directly and indirectly, related to the Ecuadorian mining sector. Respondents answered questions about business and social perception of mining and the impact of pandemic in order to get their positive and negative views of mining in times of COVID-19.

Interviews

Sixteen individual in-depth interviews were conducted with open-ended questions. Participants provided their knowledge or perceptions about the present and future situation of the mining sector in Ecuador. The interviewees included managers of mining companies, mining engineers, service providers to mining companies, local politicians, and members of the local council. In addition, the Chair of the Association of Artisanal Miners for Ecuador was also interviewed.

The questions inquired how COVID-19 has affected the country's mining sector, the response of the mining sector to the pandemic, and the positive and negative effects of the pandemic in the country's mining sector.

Multi-criteria analysis (MCDA)

This research incorporated MCDA as the analytical assessment tool used to assess the most relevant factors for the conceptualization and evaluation of alternatives based on multiple economic and social criteria.

The actors selected possible solutions; the least significant alternatives were eliminated. This procedure was repeated until the best alternative emerged.

It provided top-rated ranking relationships of alternatives that express the individual preference of each actor concerning the set of criteria through two ranks modes, weak and robust ranking. In this case, the multi-criteria analysis was evaluated by three actors: mining companies, mining institutions and organizations, and community in general. The indicators were ranked from 0 to 1, and the alternatives used percentages representing actors' interest.

Social and economic indicators

Impact evaluation indicators (qualitative and quantitative) were obtained from the literature review and selected to develop information-gathering tools representing today's mining sector main disadvantages, virtues, problems, and uncertainties. These indicators were used as a reference to propose recommendations for the weaknesses detected and to reinforce the strengths of the national mining sector.

Results

Bibliographic review

For this review, the official pages of the Economic Commission for Latin America and the Caribbean (CEPAL) in 2020 were used. This source allowed to know how other countries face the current crisis and what measures are being applied in the mining sector (CEPAL 2020).

According to the analysis of the International Council on Mining and Metals (ICMM) and the review of website publications of the contingency plans implemented inside and outside the company to deal with the COVID-19 crisis, Figs. 1, 2, and 3 presented the number of information found on different topics. Figure 1 showed that companies presented significant information in health, safety, and social aspects and less information on economic and labor aspects.

Regarding the data from mining projects in Ecuador, the information was obtained from strategic projects and second-tier mining projects, which are the most important after strategic projects. During the health crisis decree, the focus became investment in health and community support

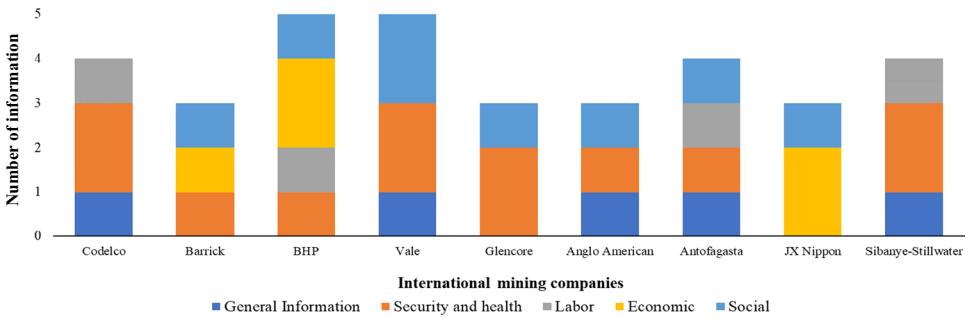

Fig. 1 Analysis of information provided by mining companies to ICMM

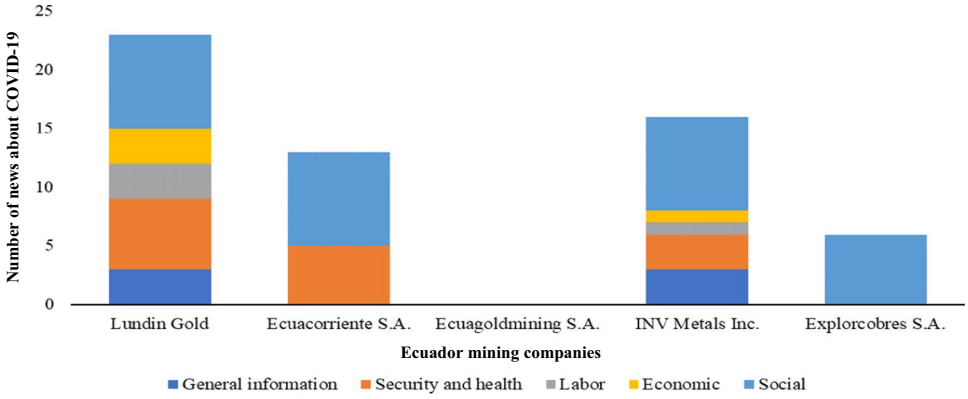

Fig. 2 Analysis of information provided by strategic mining companies in Ecuador

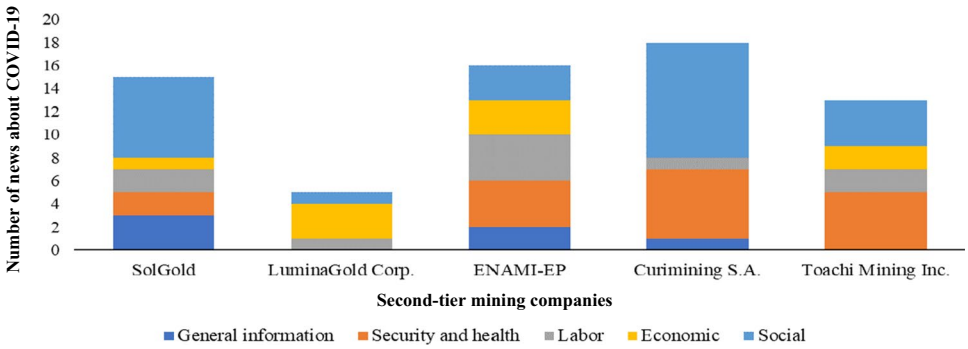

Fig. 3 Analysis of information provided by second-generation mining companies in Ecuador

to deal with the crisis. There is no data on cases of COVID-19 in ASM; the bulletins of the Vice Ministry of Mines only report cases of COVID-19 in the two LSM operating companies, Lundin Gold and EcuaCorriente (MERNNR 2021).

Figure 2 showed that strategic companies provide more information on social aspects and less on health and safety aspects for the company and the community. Moreover, there was not much information on labor, economic, and general information. In the case of Ecuagoldmining S.A., the company did not submit any information related to COVID-19.

In addition, Fig. 3 indicated that second-tier mining companies provided more information on social aspects and less information on health and safety. The companies presented less information on economic, labor, and general information.

Surveys

A total of 117 people involved in the country's mining sector were surveyed. According to the survey, 60% were aged between 20 and 30 years old, 18% were under 20 years old, and the rest were over 30 years old. Most of the respondents are from the cities of Machala and Guayaquil. Predominantly, these respondents work for public and independent institutions, and the remainder work in the private sector.

The results showed 90% believe that mining is necessary, mainly because of its contribution to the country's economy. However, most of the respondents were not aware of the contributions and measures taken by mining companies to respond to the effects of the pandemic. Communication with communities was considered to be between fair and poor (69%). Respondents indicated that companies have economic responsibility in the first place, followed by environmental responsibility and, in less proportion, social responsibility.

Figure 4 presents some of the outcomes from the survey. When asked about positive effects of the mining sector in response to the pandemic, social growth and contribution to health and education were highlighted by more than half of the respondents. In lower percentages, they pointed to employment and entrepreneurship, community support, safety procedures, and environmental liability. Also less than 20% mentioned support for local businesses and digital transformation as positive points.

Negative aspects noted were local socio-economic impact, redundancies, reduction in salaries, increasing COVID-19 cases, and decreasing economic activities dependent on the mining sector. Expectations involve environmental responsibility, community involvement, and other aspects for the employee's well-being and community.

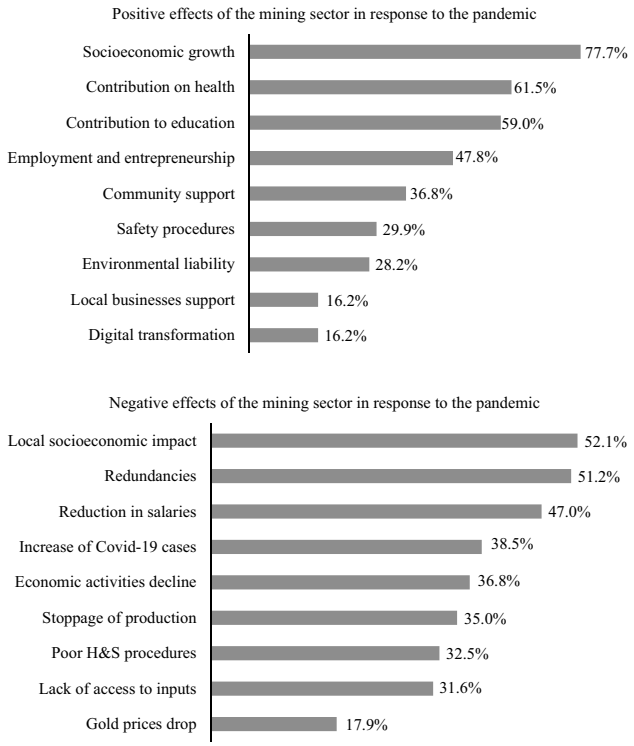

Fig. 4 Survey's outcomes

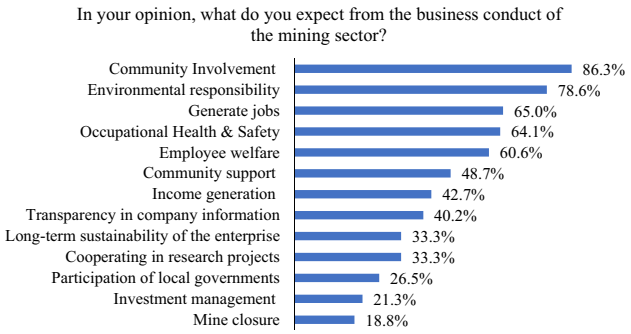

Fig. 5 Expectations of company behavior in the mining sector

Interviews

The authors of the present study interviewed 16 professionals from 11 Ecuadorian mining companies, all with less than 250 workers. Among those interviewed were the president of the Association of Mining Engineers (AIME), managers and former managers of companies directly related to mining activities, and the delegate of the autonomous decentralized municipal government of the region. The companies have mining concessions in Azuay, Bolivar, El Oro, Guayas, Imbabura, Pichincha, and Zamora provinces, and the most common metallic production material was gold. In March, at the beginning of the pandemic, almost all these companies had less than 50 people working in each mining project with more office hours than field hours. The different economic and social impacts were recorded in the interviews.

Suspension of operations was the most significant economic impact on all the mining companies, most of them for less than 60 days due to governmental regulations and preventive measures against COVID-19. A 50% to 80% decrease in the level of production and exploration was evidenced. In general, there were no problems with the restart of activities. Additionally, there were supply problems and budget reductions as a consequence of the pandemic. In the social sphere, problems encountered in the communities related to the mining project included sanitary problems and the demand for economic support from the government.

Regarding the social impacts within the companies, 12 of the 16 interviewees reported a reduction in personnel due to the pandemic. Forty-one percent indicated that the percentage of reduction was between 10 and 20%. Administrative measures were implemented, and protocols were updated in response to the pandemic. Sixty-nine percent of respondents indicated that teleworking and early vacation were implemented measures. About 88% indicated that biosecurity prevention protocols were updated. All the companies implemented their protocols in response to the health emergency.

The interviewees reported that their companies donated medical supplies, personal protective equipment, and even provided food. In the future, companies are planning to be prepared to take action against the impacts on the work environment and suspension of jobs, among other difficulties caused by this pandemic.

Concerning companies' behavior in the mining sector (Fig. 5), significant community involvement, environmental responsibility, job creation, occupational health and safety conditions, and workers' well-being were expected. This assumption showed the community's critical need for the mining sector planning oriented towards social and environmental development, which contrasted with the survey's records about companies' operations management with economic, social, and environmental responsibility. Responses indicated that companies act mainly with economic responsibility (64.7%) and with less environmental responsibility (22.4%) and social responsibility (12.9%).

Multi-criteria analysis (MCDA) with social and economic indicators

In order to carry out this analysis, actors were first selected from the surveys and interviews. Three types of actors were chosen in general; each type of actor had its derivatives, as shown below. The actors were mining companies (EM), community in general (CG), and associations and companies related to the Mining Sector (IM).

- EM. Mining companies (13 surveys and 1 interview)
  - A1. Medium-sized mining companies, between 200 and 250 workers (3 surveys)
  - A2. Small mining companies, with up to 120 workers (10 surveys and 1 interview)
- CG. Community in general (115 surveys and 1 interview)
  - B1. Representatives of municipalities (3 surveys and 1 interview)
  - B2. Local leaders (9 surveys)
  - B3. Community (103 surveys)
- IM. Associations and companies related to the mining sector (3 interviews and 1 survey)
  - C1. National Association of Mining Engineers (1 interview)
  - C2. Explosives company (1 interview)
  - C3. Logistic solutions company (1 interview)
  - C4. Service delivery company (1 survey)

Once all actors were defined, they had to evaluate 6 indicators (I1–6) based on the interest that each one of them represents for society and the mining sector. The actors assigned scores ranging from 0 to 1, where 0 is very low and 1 is very high.

Table 1 shows the average responses for each alternative according to the 3 actors. The indicators refer to social opinion on how the impact of mining is reflected in the social and economic spheres. Indicators that presented a score of more than 0.5 were selected. The social indicators evaluated were:

- I1. Communication of companies with the community
- I2. Application of health and safety programs
- I3. Labor well-being of the employees
- I4. Job stability
- I5. Community support from companies
- I6. Supply of PPE supplies

According to Table 1, associations and companies related to the mining sector (EM) and associations and companies related to the mining sector (IM) presented interest in the I2 indicator that talks about the implementation of health and safety. In contrast, community (CG) presented interest in the indicators I1 and I3 about communication with society and labor well-being for employees.

Once the best-weighted indicators were obtained, solutions were proposed for them. Six possible solutions (S1–6) were defined, as follows:

- S1. Reinforcement of biosafety protocols for mining companies with the support of COE from municipal GADs.
- S2. Job stability through the application of favorable employment policies and the effort to conserve the workforce.
- S3. The government prioritizes the development of the mining sector to diversify the economy, taking advantage of the boom in the price of gold, production, and export.
- S4. Communicational strategy towards the community reflects community support, environmental management, profits to the state, and the labor well-being that mining companies have generated.
- S5. High level of adaptation of the mining sector to gain acceptance in the community and demonstrate that the sector is essential for the country's economy.
- S6. Transparency in the information provided publicly by companies to generate trust in the social sphere.

Table 1 Multi-criteria analysis of social indicators by those derived from the types of actors

Actors		Social indicators					
		I1	I2	I3	I4	I5	I6
EM	A1	0.00	0.75	0.50	0.25	0.50	0.00
	A2	0.10	0.70	0.45	0.30	0.35	0.45
	Average	**0.05**	**0.73***	**0.48**	**0.27**	**0.43**	**0.23**
CG	B1	0.42	0.40	0.52	0.50	0.54	0.30
	B2	0.70	0.60	0.54	0.35	0.50	0.40
	B3	0.69	0.42	0.73	0.44	0.48	0.32
	Average	**0.60***	**0.47**	**0.60***	**0.43**	**0.51**	**0.34**
IM	C1	0.50	1.00	0.75	0.50	0.75	0.25
	C2	0.25	0.75	0.50	0.50	0.00	0.00
	C3	0.75	0.75	0.25	0.50	0.00	0.25
	Average	**0.50**	**0.83***	**0.50**	**0.50**	**0.25**	**0.17**

*Selected indicators that presented a score of more than 0.5

Bolded values indicate the average value per actor for each alternative

Table 2 showed the actors' interest in the possible solutions (S1–6). The results were obtained as percentages (taking into account the weighting of 1 as 100%). The selected results were those that presented a value greater than or equal to 50%.The actors showed considerable interest in solutions S1, S2, S3, and S4. Therefore, the fundamental objective in the mining sector is the reactivation and constant development of its mines and projects, as it is an opportunity to become a strategic sector and contribute to the social and economic development of Ecuador.

Discussion: risks and opportunities

The present study's results provide several vital pieces of evidence to improve the collaboration with communities and local government and focus the efforts on ensuring workplaces, well-being, and labor safety, maintaining basic services and the supply chain.

One of the major limitations detected in this study was the lack of information on the websites of the mining companies, which limited the transparency of information. Thus, social networks were also consulted to measure better the actions taken during the pandemic. In the first days of the pandemic, only one LSM company generated a communication campaign together with the main stakeholders to disseminate the actions taken against the pandemic, including access to its website with information, newsletters, social networks, and meetings with stakeholders.

From a social point of view, a percentage of the country's population still does not consider mining necessary. People in the mining sector were surveyed, but many were unaware of how pandemic was handled internally. For example, 38% did not know of any contribution that mining had made during the pandemic, 57% did not know if people had lost their jobs, and 55% did not know if strategies had been developed to deal with the health crisis. One of the leading causes, also pointed out by stakeholders, was the poor communication between the mining companies and communities. Moreover, expectations were high towards more involvement with the local community and transparency in the information provided by the company.

From the perspective of the persons interviewed, negative aspects such as the decline in economic activity, production stoppage, poor health, and safety protocols, among others, are highlighted.

Nevertheless, the respondents also pointed out positive aspects. There were contributions to the health sector, education, community support and supportive local businesses, and environmental responsibility in response to the pandemic. From the business perspective, both positive and negative aspects of the pandemic have emerged. The positive aspects were the new health and safety standards, which were implemented. All companies had to implement protocols in order to be able to operate. Eighty-eight percent mentioned that biosecurity measures were implemented.

In the small mining sector, some companies in Ecuador stopped for 60 to 90 days and then continued operating. Administrative measure taken was considered positive by the interviewees. A 69% reported remote working and going on early vacation. However, 19% of the respondents indicated a temporal suspension of work and 6% salary reductions that were not beneficial. Other problems cited were the shortage of transport services for road access, sanitary problems, and lack of economic support from the government.

It is important to highlight that the mining sector was one of the least affected in Ecuador, evidenced by increased GDP and exports. In comparison, the data for 2020 shows negative annual variations in oil exports (−42.7%), shrimp (−1.2%), flowers (−6.9%), and canned fish (−2.0%). The projection in Latin America was an increase in GDP from −6.8 in 2020 to 5.2 in 2021 and a decrease in the mining product contribution to GDP. Also an unemployment rate of 11% (CEPAL 2021) was forecasted. However, in Ecuador, a GDP recovery of 2.8% was observed (CBE 2021a), and the increase in the price of gold and mineral exports has contributed to this economic recovery, since the unemployment rate decreased from 5.5% in 2020 to 5.3% the first semester of 2021.

Ecuador's presidential inauguration in May 2021 generated political and economic stability and allowed the mining

Table 2 Multi-criteria analysis of the selection of alternatives by the types of actors

Alternatives	EM		CG			IM				Total
	A1	A2	B1	B2	B3	C1	C2	C3	C4	
S1	100%	92%	50%	67%	50%	100%	100%	100%	50%	78.78%*
S2	63%	78%	75%	89%	64%	100%	100%	100%	50%	79.88%*
S3	100%	100%	75%	78%	70%	100%	25%	25%	0%	63.66%*
S4	-	80%	25%	11%	20%	100%	100%	100%	-	62.28%*
S5	-	-	50%	56%	40%	-	-	-	-	16.22%
S6	-	20%	-	33%	-	-	-	100%	-	17.00%

*Selected indicators that presented a value greater than or equal to 50%

sector to position itself, but it was not accompanied by a communication plan to make visible the actions and strategies of the sector in response to the pandemic. Therefore, decree 151 related to environmentally and socially responsible mining established at the beginning of the government did not have sufficient support and has not been executed (Benalcázar 2022; Lasso 2021).

Studies in other countries show that, as in Ecuador, COVID-19 has had both positive and adverse impacts (Benites and Bebbington 2020; Perks and Schneck 2021; Tesfaye and Jacot 2020).

In African countries such as Ethiopia, Kenya, and Burkina Faso, there has been evidence of a drastic reduction of personnel in mines. In a study conducted in 22 countries on the impact of COVID-19 on the mining sector (Perks and Schneck 2021), it was indicated that COVID-19 has indeed affected the capacity to work in mines, mentioning that one of the most detrimental measures for the sector were the government restrictions that forced them to leave their jobs and prevented access to mining sites.

The scenario occurred in the country is similar to other countries in the region and other continents. It is a fact that COVID-19 has affected the industry and its repercussions depended on how the situation was handled by local governments and the flow of the world economy.

Conclusions

This paper focuses on the economic and social effects in the mining sector of COVID-19 and offers a local perspective on the impact and opportunities in Ecuador. We believe that compiling this information can streamline efforts for future, more effective bibliographic inquiries. The compilation and monitoring of the first 6 months of the pandemic are relevant information for the transparency and visibility of the mining sector and, above all, to denote its importance in the country's economic recovery.

Based on the results obtained when a crisis of the similar character but not a virus comes, future actions should be focused on improving the ability of mining companies to collaborate with communities and local government and strive on ensuring workplaces, well-being, and labor safety, maintaining critical services and the supply chain.

In general, the Ecuadorian mining sector does not provide access to correct and transparent data due to severe social, environmental, and political conflicts affecting the development of policies in favor of responsible mining. Hence, the mining sector's communication to the communities has direct impact on the visibility, acceptance, and positioning of the mining sector. In this regard, mining companies must improve communication plans with local stakeholders.

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Author contribution All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by Paola Romero-Crespo, Kenny Escobar-Segovia, Samantha Jimenez-Oyola, and Daniel Garcés'León. The first draft of the manuscript was written by Daniel Elizalde-Pardo and edited by Daniela Paz-Barzola. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Declarations

Conflict of interest The authors declare no competing interests.

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