Artisanal and Small-Scale Gold Mining

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The aim of this work is to explain the concepts of sustainability with respect to small artisanal gold mining. For this, a qualitative approach with a descriptive scope was used, for which the bibliographic review technique was conducted. In this sense, articles, theses, books and institutional documents, and any contribution related to the research topic were taken into consideration. Likewise, this documentation contributed to the delimiting aspects that allowed a contrast between the proposed definitions and small artisanal mining in the Northeast Antioquia region in Colombia. Based on the reviewed sources, different needs were recognized in artisanal small-scale gold mining in Northeast Antioquia that still need action. In conclusion, through the exposition of sustainability theories, three common factors were identified within the various positions that were raised—the environmental, economic, and sociocultural dimensions.

artisanal mining | small-scale gold mining | sustainability in mining | gold mining

1. Introduction

For industry, applying the concept of sustainability can be a complex task, owing to the broad scope of the term, the dynamism with which it varies over time, and the influence of the culture of the society. These aspects have given rise to conflicts between the different currents that have adopted the term since it emerged as world public policy in 1992 [1]. In this sense, the economic and environmental spheres are the two dimensions of sustainability that have presented the greatest conflict, even in the decades before the nineties [1].

An example of the above is the definition provided by Giovannoni and Fabietti [2], who ensured that sustainability, from the business point of view, refers to the ability of a corporation to last over time in terms of profitability, productivity, and financial and management performance of the environmental and social assets that make up its capital. In short, business sustainability is the business of staying in business.

Thus, it can be seen that the industrial perspective first welcomes the economic dimension, while the environmental and social aspects remain secondary and move away from the first motivation that promoted sustainability: the capacity of the environment to meet current and future needs.

The following question then arises: what happens when there is no corporation? Or, more importantly, when there are rudimentary or informal industrial processes, are the environmental and social dimensions considered? In this order of ideas, artisanal and small-scale gold mining emerges as the main topic of this research, an activity characterized by its rudimentary processes, its tendency towards informality, and its high presence in rural areas [3]. In this type of mining, a large part of the population lacks the technical knowledge to properly exploit the resources [3].

Regarding the environmental issue, by employing rudimentary processes, artisanal and small-scale gold mining stands out worldwide for its use of mercury for the treatment of gold minerals, whether from alluvial deposits or veins. This results in significant emissions into the atmosphere and discharge into bodies of water and soil. Precisely, these last two mean the favoring of mercury methylation, which is a process that generates bioavailability in people's diet [4].

On the other hand, in Latin America, small artisanal gold mining is characterized as a subsistence method for many people. This culture has not only produced environmental effects but also favored social problems, ranging from territorial disputes over access to deposits to the forced labor of children [5].

In Colombia, this type of mining has been fundamental throughout its history, as most of its gold production comes from small artisanal mining [6]. However, despite the government's efforts to prohibit the commercialization and use of mercury and to initiate mining formalization processes, there is still much work to be done if it is to enter the path of sustainability, especially in the social and environmental dimensions, since issues such as child labor or the contamination of soils and water bodies with mercury persist.

At the regional level, the Department of Antioquia plays a fundamental role in the country's gold production, producing about 65% of the national production of gold [7]. However, at the same time, this region was classified as the place with the highest air contamination caused by mercury in the world in 2021 because most of its gold is produced through artisanal methods [8].

As for Northeast Antioquia, it is characterized by its historical gold production, dating from colonial times [9]. This region stands out for the presence of both large-scale and small artisanal mining and is made up of the following municipalities: Amalfi, Yalí, Anorí, Cisneros, Yolombó, Vegachí, Santo Domingo, San Roque, Segovia, and Remedios. These last two municipalities have the highest production with 1635.9 and 1207.8 kg, respectively, in the first quarter of 2020 [7]. Likewise, by 2011, there were 75 artisan plants (or "entables") in Segovia and 22 in Remedios, which accounts for the intense artisanal activity present in this region [10].

Although there is a government initiative to strengthen the sustainability of the mining sector in Colombia, which includes the situation of small artisanal gold mining, there is no evidence of an operational plan to contribute to the sustainability of this area [11]. Furthermore, considering that this type of mining is characterized by the use of rudimentary processes, it is very difficult to expect them to take the initiative in the implementation of sustainability plans.

Artisanal and small-scale gold mining has favored the contribution of certain Sustainable Development Goals (SDG) to the detriment of others. For example, in Northeast Antioquia, small artisanal gold mining has contributed to poverty reduction and hunger reduction (Objectives 1 and 2). However, it has also affected health and sustainable water management (Goals 3 and 6) [12]. Therefore, if measures are not taken, this type of mining will not be sustainable since it would affect the interrelation between the SDGs [12].

That said, this research aims to explain the concepts of sustainability and relate them to small artisanal gold mining. As for the scope of this research, is expected that, first, this research will become an antecedent for future projects and initiatives associated with the sustainability of the small-scale Artisanal gold mining in Northeast Antioquia, and thus, will contribute to the phenomenon of study in a context with little inquiry. Second, this article will contribute to the image and acceptance of mining in Colombia through the exposition of concepts that allow actual problems such as the approach with communities to be addressed.

2. Analysis on Results

With all of these positions exposed, it can be seen that sustainability can be applied in mining despite being an activity related to non-renewable resources, especially if it mainly focuses on the implications it has on communities and the environment [13]. Additionally, from the classification proposed by Eggert [14], it was possible to identify three dimensions: environmental sustainability, economic sustainability, and sociocultural sustainability. Therefore, the results were classified into three points:

2.1. Environmental Sustainability

In Northeast Antioquia, work has been done on sustainability without speaking of a specific plan in this regard. However, how has this happened? Taking a look at the principles proposed by The Natural Step [15], it can be seen that the first principle holds that in a sustainable society, nature should not be exposed to systematic increases in the concentration of substances on the earth's crust. Thus, through initiatives such as the one from the University of British Columbia (in conjunction with local

governments and UNIDO), in which the concentrations of mercury emitted into the environment have been reduced, it has been possible to make contributions to the sustainability of the artisanal and small-scale gold mining in Northeast Antioquia.

These actions have also contributed to the second principle proposed by The Natural Step [15], which seeks that, in a sustainable society, nature is not exposed to systematic increases in the concentration of substances produced by society. In this sense, by training the plant owners to modify the gold transformation processes, it has been possible to produce more efficiently, and the waste produced by this activity has been reduced. In this way, it has also contributed to the sustainability of artisanal and small-scale gold mining in Northeast Antioquia.

The studies proposed by Molina et al. [16] and Sánchez et al. [17] make it clear that although contributions to the sustainability of artisanal and small-scale gold mining in Northeast Antioquia and the first two principles of The Natural Step have been achieved, this is not still a sustainable activity.

Taking into account that principle number four posed by The Natural Step states that in a sustainable society, there should not be structural barriers that affect the health of people, their influence, competence, and impartiality and that if the contamination of sediments favors the bioavailability of mercury in people's diets, it is not possible to guarantee living conditions that allow the inhabitants of these municipalities to satisfy their needs and, therefore, the fourth principle of sustainability of The Natural Step cannot be achieved. Thus, if work is not continued to achieve these aspects, it will not be possible to comply with the principles of sustainability.

Regarding the third principle of The Natural Step, there is no data on the physical degradation resulting from small artisanal gold mining in Northeast Antioquia. Consequently, this is an aspect that needs special attention if it is to contribute to the construction of the sustainability of this activity.

2.2. Economic Sustainability

The use of whole ore amalgamation can be analyzed in two ways: the first has to do with the ratio of the use of mercury. The high range that has been reported implies a greater investment in the transformation process to obtain a poor amount of gold. Thus, the maximum potential of the mineral is lost and, consequently, a potentially higher profit is lost as well. In this way, it is very difficult to comply with the second principle of sustainability in mining proposed by Eggert [14], which consists of ensuring that mineral development is socially and economically efficient. In this case, the economic benefits are not maximized, and the expenses and possible income are not clear.

The second way is to focus the analysis on the word "efficient." With 30% gold recovery, it cannot be said that there is an efficient process. If the 50% of gold recovery proposed by Veiga [18] is preserved, it could be said that it is a process that recovers half of the gold present in the mineral and that the other half is discarded and would therefore generate half of the possible profits. As such, in this case, not only is there an inefficient mineral development, but the possible profits that can be obtained from the operation are not maximized, which violates the same principle of sustainability in mining mentioned in the previous paragraph.

On the other hand, the panorama has been changing since Veiga's [18] reports, and it can be said that in this aspect (in Northeast Antioquia), there has also been work on sustainability without talking about sustainability and without having a plan. Precisely, when the University of British Columbia trained and empowered the owners of the processing plants (or "entables") at the Portovelo plant in Ecuador, about 39 of them changed their processing model to the one studied in the visit [19].

Due to a lack of capital, many other businesses were unable to completely transform their model but adopted pre-amalgamation concentration methods. Therefore, with the application of these changes, not only was whole ore amalgamation stopped, but the efficiency of gold extraction also increased, profits could be maximized a little more, and it could contribute to stopping the non-compliance of principle number two proposed by Eggert [14].

It is important to note that, given the lack of an official census for artisanal mining in Northeast Antioquia, it is very difficult to know how many operations and how many projects have yet to change their gold transformation methods. Therefore, if work is not continued on in this aspect, artisanal and small-scale gold mining in Northeast Antioquia will not be sustainable.

2.3. Sociocultural Sustainability

As already observed in the previous section, concentration processes highly contribute to the sustainability of small artisanal gold mining in Northeast Antioquia. However, if a culture is imparted in this region that allows changing the quick and easy method for the method that produces a greater added value to continue, it will be possible to contribute even more to the sustainability of small artisanal gold mining.

Thus, in the same way that retorts and concentrator equipment have become part of the gold transformation culture, mercury-free processes can as well. In this way, not only does it contribute to the environmental scope of sustainability, but the percentage of gold recovery is also maximized and thus complies with principle number two of sustainability in mining, which consists of maximizing the benefits of the project.

Until now, how the situation in Northeast Antioquia can affect principles 3 and 4 of sustainability in mining proposed by Eggert [14] has not been addressed at the sociocultural level. This is mainly because the type of culture that still predominates (subsistence) today in this region does not allow for these to principles to be adequately addressed. This is confirmed by the MMSD [13], which argues that there are several difficulties in achieving the ideal of a fair and equitable distribution of costs, benefits, and risks arising from mining activity:

- The first of the difficulties lies in how to identify and evaluate these costs, benefits, and risks, considering the cultural, economic, and environmental attributes [13].
- The second is more focused on the culture, policies, and laws of companies—which may well be an artisanal gold mining project—which on many occasions, hinder the transparency with which this issue is addressed [13].

That said, does a subsistence culture allow the generation of surpluses as a result of mining development? Additionally, what is the fairway to distribute the surpluses identified in this case?

These principles could be approached with fewer obstacles once the culture of gold recovery changes since a greater profit (product of a greater recovery of gold) could generate surpluses.

3. Conclusions

Based on the first sustainability perspective presented by Giovannoni and Fabietti [2], it was possible to identify that sustainability is a very broad term, which has different proposals, principles, and approaches depending on the application scenario. Thus, with the introduction of positions by different authors such as Porritt and Eggert, it was possible to reaffirm the breadth of existing proposals. With the introduction of the different sustainability initiatives that have emerged over time, such as The Natural Step, emphasis has been placed on a variety of principles that the term sustainability implies. Finally, the Giovannoni and Fabietti definition of business sustainability shows that there are different approaches to sustainability depending on the sector.

Similarly, with the presentation of these different definitions and positions, it was possible to establish that sustainability emerged within the field of renewable resources; therefore, it was necessary to identify whether it was possible to have a sustainability approach for an activity such as mining related to the extraction of non-renewable resources and which is the sector in which this research is concentrated. Eggert's definition of sustainability in mining demonstrated that artisanal and small-scale gold mining can have an approach towards sustainability, and with the presentation of its four principles, it was

also demonstrated that this type of mining can maintain this approach's principles of sustainability even though it centers non-renewable resources. In addition, through the MMSD project and its seven questions, a tool for the evaluation and planning of sustainability in artisanal and small-scale gold mining was obtained.

Second, the presentation of the situation of small artisanal gold mining in Northeast Antioquia was a key aspect of this research because it made it possible to link theory and reality. With the exposure of mercury problems that ranked the Department of Antioquia as the most polluted by this metal in the world in 2010, the subsequent reductions in mercury emissions, the introduction of clean technologies in the gold transformation processes, and the training of personnel by the Initiatives of the University of British Columbia and various initiatives led by the Universidad Nacional de Colombia, it was possible to link numerous actions and activities conducted in reality with the theories proposed for sustainability in mining. From this link, it was found that these activities have contributed to the sustainability of small artisanal gold mining in Northeast Antioquia and that it is possible to organize a plan based on theories and principles of sustainability in mining.

Third, through the exposition of sustainability theories, three common factors could be identified within the various positions raised—the environmental, economic, and socio-cultural dimensions. With these, different needs were recognized in small artisanal gold mining in Northeast Antioquia that still require action.

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