

## Impacts of artisanal gold mining in River Nile State, Sudan



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### ABSTRACT

This paper aims to investigate the impacts of artisanal gold mining in Sudan, through descriptive analysis of survey data collected at individual levels during 2018. The survey took place in the site of traditional gold mining in River Nile State. The sample used in this study includes 153 participants working in mining sites; their ages ranged between 16 and 57 years. Some of the essential findings are that 97% of the respondents reported that they had been benefited from their work in helping their families and extended families. Some of them got married, bought a car, or even build a house and establishing their own business. Many incidences happened due to a lack of safety equipment. Respondents were agreed that stimulant pills and drugs are always available at the mining site. The use of mercury and cyanide in the process of purification was proved that it exposes people and land to the risk of health and environmental problems. We suggest that the government should make significant progress towards formalizing ASGM (Artisanal Gold Mining) sector and improving infrastructure, mineral processing technology, and equipment to support gold extraction and purification, as well as expertise to develop mineral-based manufacturing.

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### 1. Introduction

Sudanese lands contain many different minerals, and this diversity in the types of minerals is due to the diversity and different types of soils and rocks, where there are deserts lands and mountain ranges, sedimentary rocks, and flat valleys. The soil varies from sandy and clay soils, as there are seas, rivers, waterways, and lakes. Most types of soil contain gold, especially in the northern regions of Sudan. This gold is mixed with other minerals in veins, volcanic, and sedimentary rocks. In addition to other minerals such as copper, zinc, iron, and silver, as well as there are uranium, manganese, bauxite, aluminum, and cobalt. There are many minerals in the River Nile State, the area of study, the most famous of which is gold.

The gold mining operations started before three centuries (BC) by the Pharaohs, and these operations continued by the Napata Kingdom in the Nubian Desert and also by the Kushite Kingdom in

Benishangul mountains in the Blue Nile region. Studies indicate that the Pharaohs have mining operations for gold in the Nubian Desert and Karma areas. Also, the mining continued by Meroe civilization, as well as the Turkish rule in Sudan during the era of Muhammad Ali Pasha, who sent troops to invade Sudan in order to search for gold. Artisanal mining operations began strongly, and this can be considered as one of the modern social and economic phenomena. It spread out all over Sudan, especially in the north. In 2008 the activity started as a result of discoveries of heavy gold nuggets by some citizens through surface excavations of the land surface in the valleys and the desert in River Nile State. By the end of 2009, a gold rush activity starts as a large number of citizens coming from Eljazira, Kordofan, Darfur, and other different states of Sudan (Fig. 1).

This phenomenon has spread rapidly in most parts of Sudan in River Nile State in Berber area-Abu Hamad-Seddon, Ubaydi, Wadi Alhimar, Wadi Alsnkir, Wadi Ala'esahr, or Um Eltrabeesh, Elshereik, Alnejeem and Al-Kru, and also in the Red Sea State in Haya area, Gunneb, Alaoulib, Dordaib and in Bhorah, in Wadi Amoor things, Qubqaba, Tijnah, Bratek, Wadi Aldrbakan and Brkatib. And in the Blue Nile state, the artisanal gold mining sites spread in different places as in Jam, Pau, Deir, Kurmuk, Bunni mountains, Benishangul, Karaba hill, and Belqoah. In

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South Kordofan, these sites distributed in the Abu Jebeha area in several different regions such as Tirtir Hills, Wakra, Aljadeed, and Abu Nawara. In the State of North Kordofan, the artisanal gold mining sites can be found in Jabrat Asheikh in the Alsafia area (Bakr, 2018).

Several articles in the literature have been studied the impacts of artisanal gold mining in different sites in Sudan. They prove that ASGM activities have a positive effect on workers from an economic point of view as it enhances the local economy and increases individual earnings and business opportunity. While negative impacts also have their effects on workers and land from an epidemiological point of view. These negative impacts could be summarized as follows:

- Environmental degradation, land erosion, forced displacement
- Conflicts between the local population and investor (the case of Jebel Amir in Darfur), human rights abuses in mineral sites, health, and safety (Wadi and Alredaisy, 2015; Ille, 2016; Bartlett, 2016)

Due to these factors, the government could fail at investing in mining. This study aims to identify the impacts of traditional mining operations on people living in gold mining areas in addition to those working in these areas in the River Nile state, Sudan. The following section discusses the risks associated with ASGM, followed by a description of the area of this study and explains the method of data collection. The next section will be the result followed by a discussion and the final section of the conclusion.

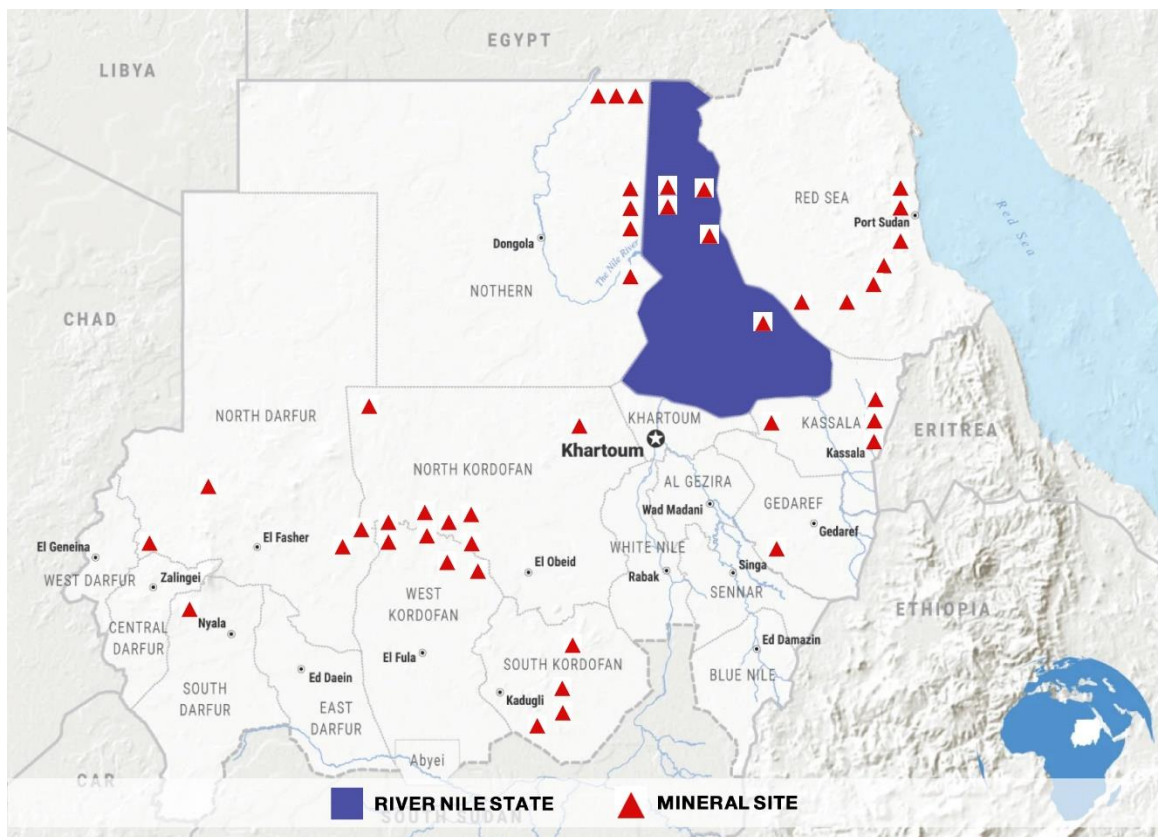


Fig. 1: Geographical distribution of Artisanal mineral sites in Sudan

## 2. Risks associated with ASGM: An overview

There is no uniform definition of Artisanal and Small Scale Gold Mining (ASGM) and no consensus on what constitutes a small-scale mining operation in the literature. The WBG (2014) defined it as a Poverty-driven activity, usually conducted in the poorest and most remote rural areas of the country by a mostly itinerant, poorly educated populace with few other job alternatives (WBG, 2014). Barreto (2011) defined it as activities that exploit mineral deposits, with geophysical and chemical characteristics, which enable simpler forms of exploration, extraction, processing, and transport (Barreto, 2011). However, the common attribute of

these definition is the activities, in which miners are severely under-capitalized, seldom operate as proper business enterprises, and lack adequate advanced technologies (UNECA, 2011).

ASGM is an important sector to the rural livelihood in promoting economic growth. Around the world, about 40 million people are directly engaged in this sector (IGF, 2017). The traditional method of extracting gold from ore is called Amalgamation. It is a process of adding mercury to gold ores. It is an easily accessible and uncomplicated procedure and financial assistance for workers (Spiegel et al., 2006). The main problem with this sector is the use of a dense mass of liquid mercury, in particular, panning processes that

separate gold from other minerals inside the amalgam.

The amalgam is then hand-squeezed into a piece of fabric to remove any excess liquid mercury that wasn't merged with gold. The miners do a decomposition process using a gasoline torch at a temperature around 460 °C, the resulting amalgam of 40-50% mercury can be separated from the gold. This process may contain about 2-5% residual mercury, and it may reach 20% in some African countries when the processes of evaporation are ineffectiveness (Veiga and Hinton, 2002). The process causes the risk of health and environment due to the cyanidation of mercury-contaminated tailings. (Guimaraes et al., 2011). Globally, about 15 million operators in 70 countries release between 1400-1600 tons of mercury each year (Gibb and O'Leary, 2014; Veiga et al., 2014). In the sites of study, this process is conducted in percolation vats, as observed in the neighboring nation in African, e.g., Mozambique, Tanzania, and Zimbabwe (Veiga et al., 2014). The estimated disease burden as a result of chronic mercury intoxication is about 2.45 million in 2015 (Steckling et al., 2017). In these cases, when the mercury-contaminated tailings are leached with cyanide, the sites will contain high levels of mercury. As a result, the environmental problem will appear. Despite awareness of mercury toxicity, it is still used unabated in the ASGM sector worldwide. The need for miners for money and the greed of small business owners, making the major environmental and health issues entirely, no concern with mercury toxicity (Chan et al., 2003). Therefore, international management code is necessary for mercury in ASGM, at least for policymakers and practitioners to sure how to address this sector appropriately and to identify mechanisms to reduce mercury waste.

### 3. Study area and method of Study

#### 3.1. The description of the study area

This study was carried out in River Nile (Nahr al Nil) State (Fig. 1), with an area of 122.123 km<sup>2</sup>; and population of 1,027,534. The State is located between Latitudes 16-22North and Longitudes 32-35 South. It consists of six localities: The capital city Ad-Damir and the other five localities are Atbara, Shendi, Al-Matamma, Berber, and Abu Hamed. The main activities of the population in this state are agriculture, trade, livestock, and small business, and the most important agricultural products are Egyptian bean and soybean, as well as the production of fruit and vegetables. Moreover, in the field of industry, the state produces cement and its related byproducts. River Nile State can be considered as one of the Sudanese historical areas. It is the cradle of ancient civilizations, the Meroitic civilization in Begrawiya, Shendi locality, and north of the city as there are Almusawarat and Al-Naqaa historical sites where there are temples of the Sun and the lion.

One of the geographical features of the state was the rocky desert hills with a height of more than 1000 m in elevation. This dessert is a part of Red Sea Hills, which composed of basement rocks and lava fields associated with Cenozoic and cinder cone complexes dating back to Devonian age. Studies show that this state has witnessed gold excavations in the past. The geological environments of the State and the rock structure of River Atbara nearby suggest the presence of gold and other minerals. The state is characterized by a semi-desert climate, the rain in autumn season ranging from 150 mm in the south of the state to 25 mm in the north yearly. The mean temperature is 47°C in the summer season and 8o C in the winter season.

The main objective of this paper is to identify the impacts of traditional mining operations on ASGM gold miners in the River Nile State, Sudan, and to provide some strategic visions that help in developing the positive aspects of mining operations in the country.

#### 3.2. Method of data collection

In this study, we have collected primary data and supplementary information about respondents' personal characteristics and the environment through questionnaires and field surveys. In particular, data and information about the economic, social, and environmental impacts of traditional mining operations in the River Nile State.

### 4. Results

Table 1 presents the respondents' characteristics, including age, marital status, place of residence, and educational level respondents' ages ranged from 16 to 57 (n=153), and averaged 26.55 years, with a median of 23 years and a mode of 21 years. Almost a third of the respondents (31.6%, n=51) were below the age of 30 years, while the majority 63 (41.2%) were in the age group (31-45 years), and the rest were over 45 years old.

The distribution of sample residence seems to be normally about all the states of Sudan with more respondents from Gezira and Kordofan state, about 25% each of the two states.

In terms of marital status, 78 respondents (51%, n=78) indicated that they were married, whereas 56 (36.6%) were single, never married. In addition, 19 (14.4%) were divorced.

Education levels are among the respondents are as follows: Overall, 43.8% of the respondents have a higher secondary school education, 34% have attended primary/middle school, 16.4% have a university education, and 5.9% of the respondents have no education. Analyses revealed that the majority of the sample (63.4%) indicated that they full-time workers and get a known percent of the product, while 26.1% of them had owned a detective device of gold and working for their own business. About 10.5 of the respondents are car owners who



offer transportation services for the population of the field area, and 4.7 are owners of gold mining and drilling equipment for exploration.

**Table 1:** Demographic and socioeconomic characteristic of respondents

Item	value	#of resp.	%
Age	From16 to 30 years	51	33.3
	From 31to 45 years	63	41.2
	Over 45 years	39	26.5
Residence	River Nile	10	6.5
	Gezira	39	25.5
	Gadaref	6	3.9
	Kasala	4	2.6
	Northern	20	13.1
	Khartoum	5	3.3
	Darfur	19	12.4
	Kordofan	41	26.8
	White Nile	7	4.6
	Red see	2	1.3
Marital status	Married	78	51
	Divorced	19	14.4
	Never married	56	36.6
Education (years)	0	9	5.9
	9	52	34
	12	67	43.8
	16	25	16.3
Occupational status	employed	97	63.4
	Detective device	33	21.6
	Car owner	16	10.5
	Mining Equipment's owner	7	4.7
Previous Profession that you left	Agriculture	65	42
	Business	52	34
	Student	25	16
	Sheep pastor	11	7
how many years you have been working in the mining	1-3 months	31	20.3
	4-6 months	33	21.6
	7-12 months	33	21.6
	More than one years	56	36.6
Revenue/month	1000-3000 SDG	35	22.9
	3000-5000 SDG	50	32.7
	5000-10000 SDG	43	28.1
	More than 10000 SDG	25	16.3
Were there any benefits?	Yes	149	97.4
	No	4	2.6
If Yes, please specify:	Get married	20	13.1
	Bought a house	35	22.9
	Bought a car	11	7.2
	Help my extended family	105	68.6

Table 2 indicates the level of satisfaction reported by respondents with the quality of different services in the mining areas. Most respondents described their satisfaction (84%) as dissatisfied and very dissatisfied with the service quality of healthcare.

**Table 2:** Response to services questions in the mining site

Item	Very satisfied	satisfied	dissatisfied	Very dissatisfied
1. How satisfied are you with the service quality of healthcare?	2(1%)	22(14.4%)	108(70.6%)	21(13.7%)
2. How satisfied are you with the quality of food?	19(12.4%)	25(16.3%)	80(52.3%)	29(19%)
3. How satisfied are you with the quality of water?	4(2.1%)	56(36.6%)	73(47.7%)	20(13.6%)
4. How satisfied are you with the communication services?	58(37.9%)	71(46.4%)	17(11.1%)	7(4.6%)
5. How satisfied are you with transportation services and roads?	49(32%)	35(22.9%)	60(39.2%)	9(5.9%)

Table 4 presents the length of period that married respondents were away from their wives. 61.5% were reported that they have been absent from wife

This finding is consistent with the respondents' satisfaction with the quality of food (71.3%), quality of water (58.2%). Communication services were satisfied or very satisfied according to 84.3% of the respondents, and 54.9% were satisfied or very satisfied with the transportation services and roads.

The respondents were asked about their employment status in the 12 months preceding the survey. The analyses reveal that 65% of the respondent reported that they were working in agriculture; another 45% reported that they were working in their own business, about 16% of the respondent are leaving education and come here to work in gold mining Compared with 7% are sheep owners. In addition, 63% of the respondents have been working for 1-12 months in the mining, while 37% have been working for more than one year in mining. About One third (32.7%) of the respondents earned 3000-5000 SDG (Sudan currency Code) per month. 28.1% were earning 5000-10000 SDG; 22.9% were earning less than 3000 SDG, and only 16% receive more than 10000 per month. The analyses show how the respondents used their revenues from work in mining. Almost 97% of the respondents reported that they had been benefited, and most of them (68.6%) used their earnings to help their extended family. Others are getting married (13.1%), bought a house (22.9%), and bought a car (7.2%).

Table 3 shows the safety improvements that have been made in the mining area and the warranting intervention measures (Fig. 2 and Fig. 3). There were 37.3% of respondents opined that there are small incidences while working, 36.6% reported that there are moderate incidences, and 9.8% reported that there too many incidences while working.

Considering the problems that were happening due to poisoning while working, 66.7% of the respondents opined that there were no problems, 33.3% said yes, there were problems. The types of poisoning while working as reported by the respondent are Cyanide poisoning (41.2%), mercury poisoning (35.3%), and poisoning with food (23.5%). 39.9%agreed that, usually, there were a protective means for incidence and poisoning, whereas 26.1% said that protective means for incidence and poisoning were provided sometimes, and 34% reported that protective means were never provided. Regarding the source of water in the study area, majority (51.9%) reported water reservoirs from the sellers, 32.8% reported Nile water, and (16.3%) ground wells.

for about 3-6 months, 23.1% opined that they have been absent for about 6-12 months, and only 15.4% have been missing for more than one year.

Furthermore, 22.9% of the participants reported that sex services were not available in the mining

areas in the artisanal mining community.



Fig. 2: Transportation of miners



Fig. 3: Sacks contains sands, gravel, and rock they may contain gold

Table 3: Response to risk and safety precaution questions in the mining site

Item	Answer			
1. Is there any incidences while working?	Too many 15(9.8%)	Moderate 56(36.6%)	small 57(37.3%)	nothing 25(16.3%)
2. Is there any poisoning while working?	Yes 51(33.3%)	No 102(66.7%)		
3. If Yes, please specify:	Cyanide poisoning 21(41.2%)	Mercury poisoning 18(35.3%)	Poisoning with food 12(23.5%)	Poisoning with water 0
4. Are there protective means for incidence and poisoning?	Usually 61(39.9%)	Sometime 40(26.1%)	Never 52(34%)	
5. Source of water	Ground wells 25(16.3%)	Nile water 50(32.8%)	Reservoirs water from the sellers 78(51.9%)	

In comparison, 28.6% agreed that sometimes this service is available, and 48.4% opined that no sex services in the mining area. Regarding wines, tobacco, and Shisha in the mining areas for the artisanal mining community, the majority of participants reported that they usually (42.5%) or sometimes (39.2%) could be found, and they are becoming increasingly popular among artisanal mining community. The participants agreed that stimulant pills and drugs are always available (39.2%) or sometimes-available (36.6%) in the mining areas.

Table 4: Availability of sex, wine, and drug in the mining site

Item	Answer		
1. How long have you been absent from your wife?	3-6 months 48(61.5%)	6-12 months 18(23.1%)	More than 12 months 12(15.4%)
2. Availability of following services:	Usually	Sometime	Never
a) Sex	35(22.9%)	44(28.6%)	74(48.4)
b) Wines, Tobacco and Shisha	65(42.5%)	60(39.2%)	24(15.7%)
c) Stimulant pills and drugs	60(39.2%)	56(36.6%)	37(24.2%)

## 5. Discussion

Sudan is experiencing a gold rush in different regions of Sudan's states, prompted many adventurers to go to those places in search of wealth, exposing themselves to mercury by using their hands and simple tools to search for gold. The situation in the gold mining regions in the state of the Nile River is not safe due to the absence of security and regulation, those with powers control the areas of abundant gold and drive the other out of it. Therefore they are unsafe, and often armed conflicts occur.

The purpose of this paper is to identify the effects of traditional mining on ASGM gold miners in the Nile State. Respondents are 153 workers, their mean age is about 27 years, and most of them are married.

The majority of miners in our study sites are Sudanese come from different states and a few small companies working there using modern equipment such as metal detectors or other small machinery. Gold is extracted by using very simple tools such as mattocks, hammers, hoes, and metal bars of different lengths and thicknesses to crush and collect the sand, gravel, and rock that they believe may contain gold after that they need to use mercury or cyanide to wash and clean it. As reported by the respondents (Table 3 and Fig. 3), although there are small or sometimes nothing incidences while working, many cases of poisoning while working is found. Furthermore, the analysis shows that workers consume unsafe water, as it is a reservoirs' water from the sellers or directly from the Nile. This may contribute to increasing the risk of exposure to water-washed and water-borne diseases such as malaria, diarrhea, and cholera.

Environmental and health problem in Sudan caused by artisanal mining in all states of the country is well documented in the literature (El Tohami, 2018; Tayrab et al., 2016; Wadi and Alredaisy, 2015; Yahaya et al., 2012). In investigating the negative health and social impacts of traditional mining operations on ASGM gold miners in the River Nile State. Our basic findings suggest that the length of the period that married respondents were away from their wives for at least 3 to 12 months, in addition to the availability of wines, tobacco, and Shisha, sex services, or abuse alcohol and stimulant pills and drugs (Table 4). Thus, we can conclude that mining sites are risky places; miners can easily get the service that is against the culture, principle, and values of the Sudanese communities. However, most of the miners reported that one of the basic benefits of their works in ASGM was the ability to help extended families and owing a house.

Sometimes accidents happen when holes or tunnel collapse, resulting in injuries and deaths to miners. The respondents argue that the protective means for incidence and poisoning are not available in the gold mining sites as usual, which indicates that no safety in the mining. Besides, the primary source of drinking or washing water is directly from the Nile or the sellers. This water problem makes the rainy

season from July to October a preferable season for mining due to the availability of water in the streams. As a result, people ignore agriculture, and there will be a decrease in cultivated areas. Our evaluation of the services in the mining site and most of the respondents believe that they are not satisfied with the quality of water foods and health care services, whereas; some of them are satisfied with the communication and transportation services (Table 2). Moreover, from our witness, there are poor sanitation conditions, with the absence of government services and regulations, we believe that people are in high health risks, in particular, they exposed to water-borne diseases.

The Artisanal Gold Mining's literature contains numerous researches suggesting that most people who have been in ASGM for the past ten years have done so because of economic reasons (Kamlongera, 2011; Hilson and Garforth, 2013). The vast majority are farmers of agriculture (Hilson and Van Bockstael, 2011; Dondeyne and Ndunguru, 2014), this coincides with our finding that a large proportion of miners are married, full-time, unskilled workers.

## 6. Conclusion

Sudan is promising in the mining field, and it may be at the forefront of producing countries, especially precious metals if extracted and exploited in a proper way using scientific and modern methods. At this time, the mining sector can be considered one of the important sectors, and it contributed deeply to the development of the national economy, especially after the secession of the South Sudan in 2011 and loss of oil revenues by declining the share of imports exports.

Although Artisanal Gold Mining has a positive economic contribution at the local level, as it generates the disposable incomes needed to improve the household's quality-of-life, The social and environmental costs can be more harmful and more severe for the households as well as governments. The third of groundwater resources, rivers, and the destruction of fertile agricultural and grazing lands are environmental impacts that result from unregulated land drilling. The human capital is affected by child labor, and lack of education opportunities, healthcare for employee and sexual and gender violence. The social capital is affected by conflict minerals, crime, violence, and forced labor in remote temporary settlements whose sole purpose is mining. The most significant environmental and health impacts of Artisanal Gold Mining are the extensive misuse of mercury in the production process. The estimated amount of missed mercury during amalgam burning is about 70kg per year, which is enough to create serious environmental and health risks. Also, the problems of consuming water in Sudan exist, unsafe water, which is used in the area of small mining, giving rise to multiple health problems. This is true since only 67% of the population has access to safe drinking water. These deficiencies in quantity and quality of water in the



mining areas make the workers at risk of water-borne diseases such as diarrhea, dysentery, typhoid, and cholera. (Smart Artisanal Gold Mining from a Sudanese Perspective). The majority of workers are unqualified and work for low wages, sometimes underage, and they are working under dangerous conditions. In terms of money, revenue sharing is skewed in favor of financiers.

## 7. Recommendations

To improve the economic contribution of ASGM, the government of Sudan needs to make significant progress towards finalizing its ASGM sector and improving infrastructure, mineral processing technology and equipment to support of mining, as well as expertise to develop mineral-based manufacturing. ASGM could contribute to economic growth, poverty reduction, development of resilient and sustainable communities. However, the government needs to ensure the proper safety precaution requirements for companies and individuals working in these activities.

### Compliance with ethical standards

### Conflict of interest

The authors declare that they have no conflict of interest.

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