

Research Article

The Establishment, Designation, and Management of an Artisanal and Small-Scale Gold Mining Cluster Zone: Case Study of the Odo Shakiso District, Oromia, Ethiopia

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Abstract

Artisanal and small-scale mining (ASM) encompasses informal or formal operational mining activities that primarily use traditional tools and simple methods and techniques for resources of earth extraction, transportation and processing. ASM generally, requires minimal operational capital investment and is typically characterized by low capital, intensive labor worker and comprises an individual's working as private or in family groups, as well as in partnerships, or as members of cooperatives in legal associations and enterprises. Ethiopia is one of a developing country, endowed with different mineral resources, where ASM was the most common practice among the people who live in rural parts of the country next to agriculture. Despite the ASM methods being traditional, mining activity practices were wasteful nature and abounding with so many obstacles and miners were making effort to continue their work of extract minerals primarily focuses on mining precious metals like gold, platinum, tantalum, lithium, copper, gemstones and semiprecious gemstones like opal, emerald, sapphire, aquamarine, amazonite, and other semiprecious type of gemstone, industrial minerals like clay, crushed stone, diatomite, gypsum, salt, sand, silica sand. A huge number of ASM's in Ethiopia still face significant obstacles/challenges including a lack of the best mining and processing practices, low degree of capitalization and mechanization, limited financial access, lack of training on capacity building to increase production and productivity, inadequate environmental impact reduction measures, and limited access to marketing opportunities. Ethiopia is now implementing several initiatives/ measures which support the growth of ASM industry sector to revitalize the ASM with its main goal. To fully benefit from ASM, the government must work on ASM formalization through the novel idea of cluster and manage. To gradually transform/turn ASM into ASSM support them by suiting conditions on how to get equipments through rent approach, link with technology manufacturing industry and additionally provide training on sustainable mining and processing technology in the process of ASM transformation.

Keywords

ASM, Association, Odo Shakiso, Cluster Zone, Formalization, Processing Center, Earth Resources, Technology, ASM Transformation Strategy

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1. Introduction

1.1. Background

Artisanal and small-scale mining (ASM) encompasses informal or formal operational mining activities that primarily use traditional tools and simple methods and techniques for resources of earth extraction, transportation, and processing [3]. ASM generally requires minimal operational capital investment and is typically characterized by low capital, intensive labor, and worker and comprises an individual's working as private or in family groups, as well as in partnerships or as members of cooperatives in legal associations and enterprises [18, 23]. ASM is among the most significant sources of income for low-income communities in developing countries worldwide [23]. Ethiopia is one of the developing country endowed with different mineral resources, where ASM was the most common practice among the people who live in rural parts of the country next to agriculture [15, 19].

Despite the ASM methods being traditional, mining activity practices were wasteful by nature and abounding with so many obstacles, and miners were making efforts to continue their work of extracting minerals. ASM can be very important for rural community development in poverty alleviation and reduction [6]. In our country, Ethiopia, it is known that there are numerous ASMs that are working in various parts of the country, both in association and individually, primarily focused on mining precious metals like gold, platinum, tantalum, lithium, copper, gemstones, and semiprecious gemstones like opal, emerald, sapphire, aquamarine, and amazonite, and other semiprecious types of gemstones, industrial minerals like clay, crushed stone, diatomite, gypsum, salt, sand, and silica sand, [12, 13]. The number of people involved in ASM is difficult to determine because of the informal nature of the sector, lack of official statistics, and other factors. Also, according to producers, gender, production volume, production quality, and quantity, the quantities of ASM numbers in the country are not exactly known [14, 20]. However, some data collected at the regional government offices show that the number of artisanal and small-scale miners of gold and opal in the major producing areas alone, including legal and illegal mining, was estimated at 1.26 million communities [11, 16, 36].

Because ASMs are scattered/disseminated across several mining site locations, it has become a big obstacle to providing training and necessary mining tools as well as to monitor

and readily accessing ASMs for support and other duties. The main objective of this study is to gather the necessary information on the current status of ASM's and to identify the technology that complies with the deposit type they mine, to organize ASM in a cluster zone, and suggest a solution on how to solve ASM's problem through the ASM cluster zone based on the location of mining sites according to commodity type by providing shared mining technology and machineries shared training, and any other assistance for ASM's in Odo Shakiso woreda.

1.2. Ethiopian ASM Profile: Status and Challenges

In addition to being a major employer, the ASM has made a substantial contribution to the nation's revenue. The amount of gold Ethiopian ASM contributes increased from 735 kg in 2009 to 8,386 kg in 2013. The amount of 13,406.75 kg of gold was produced by six (6) ASM Associations in the Odo Shakiso woreda (Figure 1). This indicates ASM is able to produce many tons of gold from seven regions, worth millions and covering 50-70% of revenue and local consumption with an erratic nature [11, 36]. ASM directly employs approximately 1.5 million people as a source of income for their livelihood and provides support to an additional 7.5 million people across seven regions such as Oromia, Benishangul Gumuz, Tigray, Gambela, Amhara, Afar, and South Ethiopian Peoples [16]. ASM is essential in stimulating other economic sectors through the mining of gold, tantalum, gemstones, construction, and industrial minerals [15].

ASM has a significant impact on reducing rural-to-urban migration and exploring new mineral deposits. An ASM sector requires incentivization, and an incentivized ASM increases overall contribution to the national economy, increases revenue collection, and creates jobs and attractive large-scale investment in this sector [11, 21]. According to the World Bank Group 2014 report [31], ASM's contribution to the worldwide national economy as a whole reached 65%. This shows the enhancement of government support for ASM, aimed at income-generating. Thus, these demonstrate that the subsector has a great deal of significant economic potential to enhance the national economy if the promotion and expansion of the ASM cluster zone support plan is created [32].

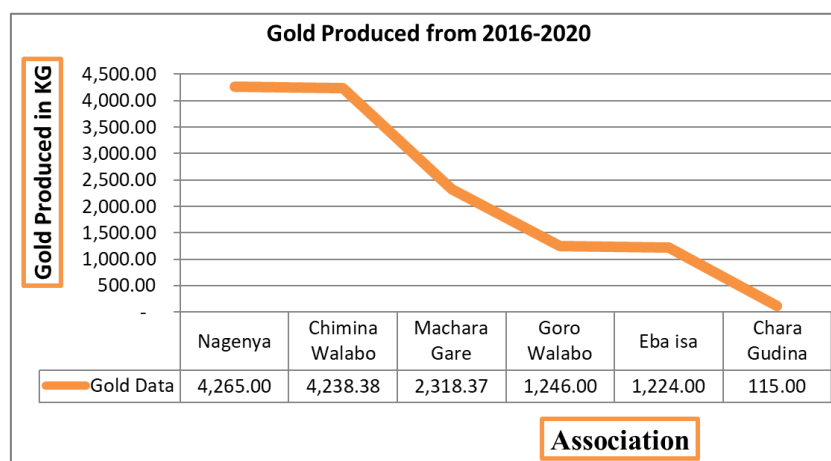


Figure 1. The gold produced by ASM associations in the Odo Shakiso woreda.

Despite this, a huge number of ASM's in Ethiopia still face significant obstacles/challenges, including a lack of the best mining and processing practices, a low degree of capitalization and mechanization, limited financial access, a lack of training on capacity building to increase production and productivity, inadequate environmental impact reduction measures, and limited access to marketing opportunities. Aforementioned are generally underestimated in their contribution to the economy [33, 36]. Inappropriate technology use, poor information, low levels of environmental protection awareness, and a low capital base perpetuate this challenges trap [34]. Other major challenges are that the majority of ASM activities (production and marketing) are informal, and gaps in the legal framework and regulations enforcement need significant improvement regarding ASM [2].

Ethiopia is now implementing several initiatives/ measures that support the growth of the ASM industry sector to revitalize the ASM with its main goal [35]. To fully benefit from ASM, the government must work on ASM formalization through the novel idea of cluster and manage. To gradually transform/turn ASM into ASSM, support them by suiting conditions on how to get equipment through rent approach, link with the technology manufacturing industry and additionally provide training on sustainable mining and processing technology in the process of ASM transformation. Therefore, the government ought to adopt and implement a coordinated strategy approach to reduce the main challenges of the ASM sector through delivering:

- 1) Strengthened ASM Governance: these in aspects of good governance need to be strengthened, namely law and regulation, structural management, and geosciences data by legalization and formalizing, which attract investment in this sector as part of the formal economy.
- 2) Formalizing and Transformation: This incorporates promoting access to capital, markets access to technology, and access to skilled labor. In turn, this will increase the efficiency, productivity, and competitiveness of local mineral producers at the ASM level and in-

crease and enhance value addition and optimize profits by facilitating access to local processing facilities and market, while developing supplier relationships and diversifying business operations.

- 3) Promote Sustainable Mining: Foster an environmentally and socially responsible ASM sector that complies with appropriate environmental, community, health, and safety standards.
- 4) Intervention of main issues: Promote two important issues that crosscut in each objective of ASM, namely, women's fair participation and beneficiation in ASM and utilization of indigenous knowledge.

2. Materials and Methods

2.1. Location and Accessibility of the Study Area

Odo Shakiso is one of the woredas in the Guji Zone, Oromia regional state of Ethiopia, located in the southern part of the country, with a geographic coordinate of 5° 35'N and Longitude: 38° 55'E (Figure 2), which has potential economic mineral resources. Odo Shakiso is bordered on the south by the Dawa River, which separates it from Arero; on the west by Bule Hora; on the northeast by Uruga; on the north by Bore; on the northeast by the Adolana Wadera; and on the east by Liben. Odo Shakiso is accessed from the Addis Ababa via Addis Ababa- Modjo – Ziway – Shashemene – Hawasa – Adola - Shakiso or Addis Ababa – Modjo – Adama – Asela – Shashemene – Hawasa – Adola - Shakiso asphalt road. Within the study area, there are a number of gravel roads and dry weather roads. The towns in Odo Shakiso include Shakiso and Megado. Shakiso is a town that has a latitude and of 5° 45'N and a longitude 38° 55'E and an elevation of 1758 meters above sea level. Both, the two largest mines, the Lega Dembi gold mine and Kenticha tantalum mine are close to Shakiso. Gold mining has been practiced as placer and primary mining and continues to be an important industry in this woreda. Also, planting coffee and enset was an important cash crop in this

woreda. The lithologic rock units observed in the study area are weathered bedrock, mainly quartz schist, graphitic schist,

mica schist.

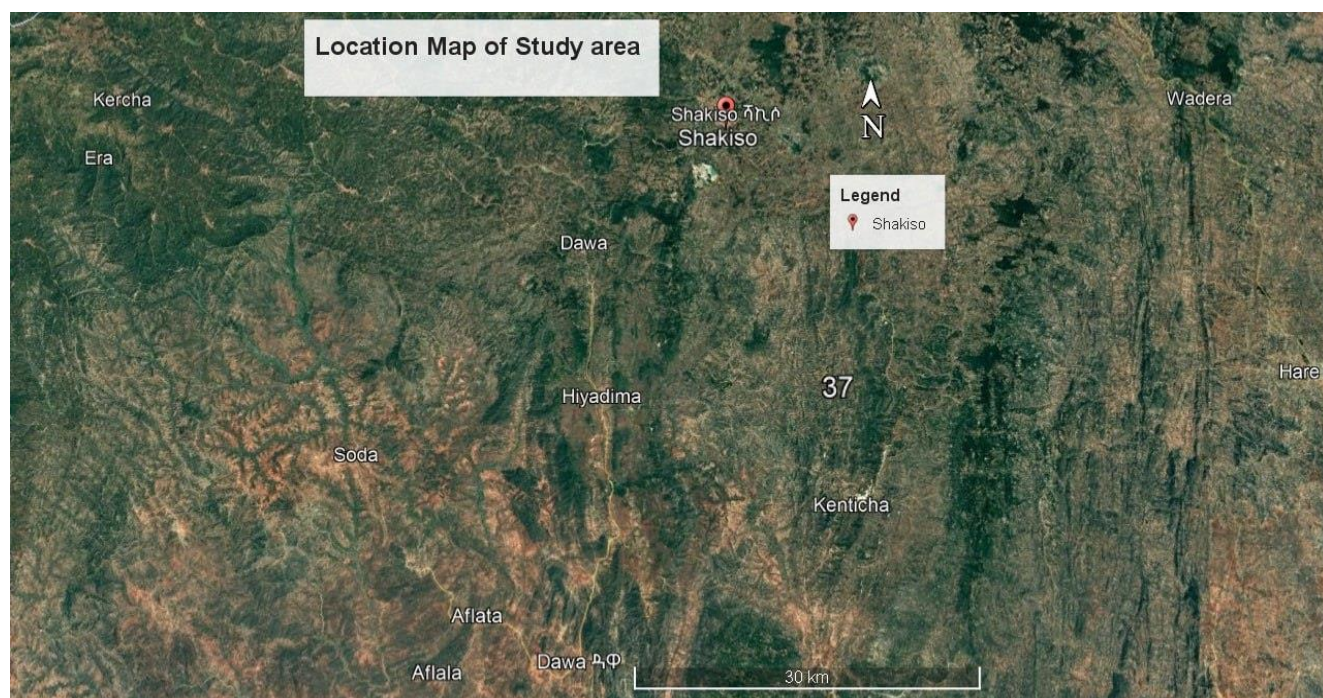
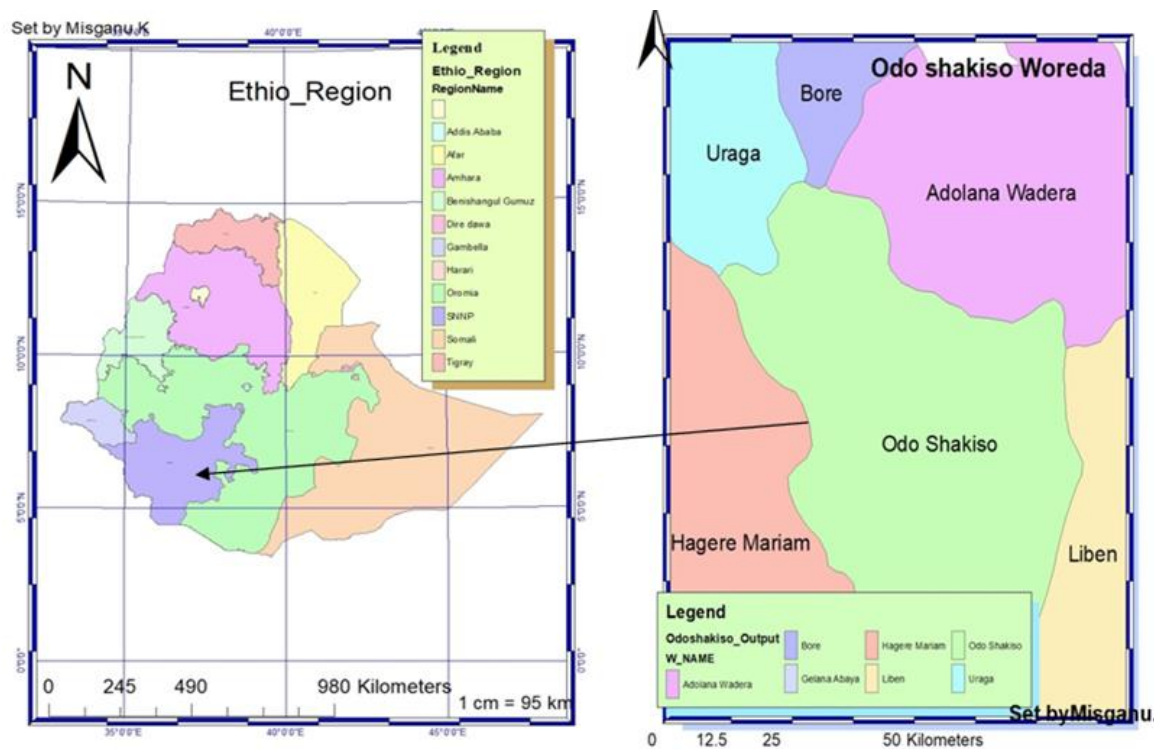


Figure 2. Location map of study area.

2.2. Data Collection Techniques

During data collection, multiple techniques, involved to obtain

the data, including interviews, discussions, and questionnaires targeted at various groups, such as leaders of ASM associations, members of artisanal and small-scale mining communities, and both governmental and non-governmental officers and experts.

Structured questionnaires were intended, created and developed to ensure the gathering of high-quality data.

The research drew on a variety of sources, including published articles focused on artisanal mining, unpublished reports from governmental agencies, as well as license documents and geological maps of the study area. Additionally, data were collected through direct field observations of mining sites operated by ASGM associations. Additionally, geographic coordinate location of observed mining sites was also recorded as part of the data collection process. During field visits, interviews were organized and well structured around key important topics, including production quantity, volume, and price fluctuations; equipment and technologies currently in use; future technology requirements/demand; training needs for ASGM operators; and major challenges and problems faced in production.

3. Results and Discussion

These papers result a discussion that provides insight into

the ASM Cluster zone designation and management concept in Odo Shakiso woreda, Guji zone, Oromiya region, Ethiopia, behind it, its use, its advantage for miners, the government, the impact on resource management, and others. Details are presented as follows.

3.1. ASM Association's Status in Odo Shakiso Woreda

In Odo Shakiso woreda, there are 118 associations in the form of ASM and ASSM that mine placer and primary gold deposits and other types of industrial minerals. And also, there are many traditional gold producers in Odo Shakiso woreda. Of those associations, one association is mining stone, 100 are artisanal and special small-scale miners (ASSMs) gold mining associations, while the left is artisanal and small-scale miners (ASM) who engage in traditional gold production (Figure 3).

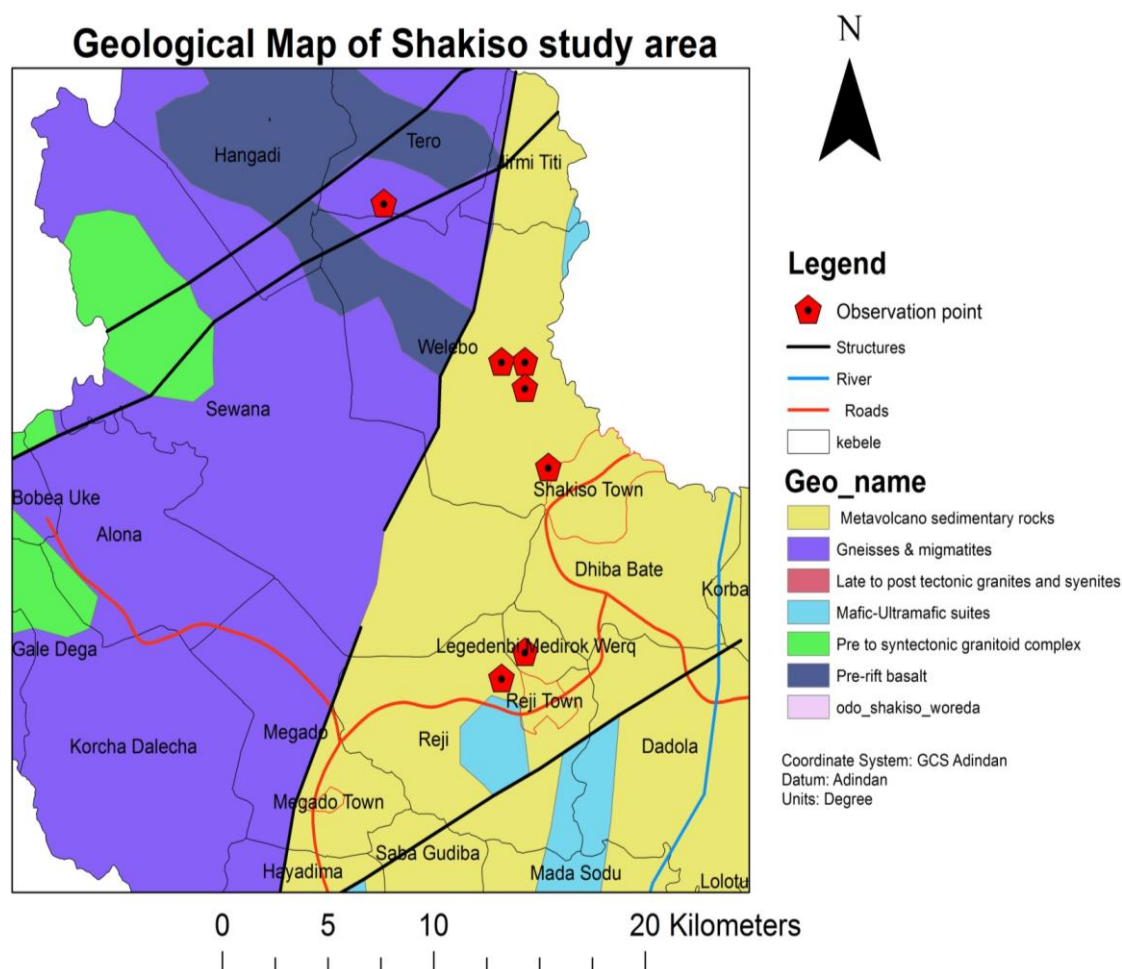


Figure 3. Geological map showing ASM sites observation location and lithological rock unit within the area.

However, most ASM of this woreda were using traditional mining equipment, which consumes a lot of energy and time, while ASSM are using more mechanized equipment (Figure 4). To make them more productive, effectively availing of more advanced mining machines and processing technologies is a must. In order to provide necessary mining and processing technologies for ASM in an economical and cost-effective

way, clustering them into two basic cluster zones based on their location and according to their proximity. This is an appropriate way of clustering the dispersed ASM in different mine sites and means to solve ASM problems regarding the lack of mining and processing equipment and technologies (Figure 7).



Figure 4. Pulley system using by Odo Shakiso artisanal miners.

After the cluster zone is designed and equipment is implemented by the government or with involved stakeholders, ASM gets access to provided mining and processing equipment and technologies. In other ways, ASMs may have the potential to buy those mining and processing equipment and technologies if they get the support and access from the government or financial institutions. The clustering method is more effective when ASMs are clustered based on their types of minerals they produce. This is because the mining and processing equipment required for this purpose is unique in its characteristics. In the case of this study, clustering all ASM based on the type of mineral they mine has more advantages since ASM associa-

tions mine sites are close to each other. For this reason, clustering those ASMs according to their proximity to each other is a good cluster zoning approach in this area.

Most of the ASM associations are focusing on primary and placer gold mining activities. This is due to the relative linkage of gold market chains available in the woreda formally and informally. In the beneficiation process, ASM gold miners use river water and local processing equipment provided by private persons (Figure 5). As a result, the gold produced by the Odo Shakiso woreda ASM association is free of chemicals, and the beneficiation process is relatively environmentally friendly.



Grinding machine



Sluice box



Shaking Table



Batea on the water prepared for processing and other equipments



Carpet within sluice box with cached concentrate



Excavator using by ASSGM associations



Figure 5. Mining and processing equipments using by miners in the shakiso woreda.

In the Odo Shakiso woreda, there is a main bold difference between ASSM and ASM: essential mining and processing equipment and technologies like excavators, table shaking, sluice boxes, etc. are available with artisanal and special small-scale miners (ASSM), while all available equipment with artisanal and small-scale miners (ASM) is very simple and traditional, such as pulleys made of wood, shovels, and bateas made of wood. Artisanal and small-scale miners (ASM) use pulleys made of wood for carrying primary gold mined from deep holes and bateas for the panning purpose in the case of the beneficiation process (Figures 4 & 5).

3.2. Mining and Processing Tools Applied by ASGM

Artisanal and small-scale mining is a large mining sub-sector that stimulates the economic sector. Globally, artisanal and small-scale mining workers use simple and basic tools such as picks and shovels and semi-mechanized, low-tech equipment for mining and processing [27, 29]. In this woreda, ASM associations use very traditional mining and processing equipment for the extraction of placer and primary gold. This exposes ASMs to economic mineral wastage and health and safety issues. The most commonly used equipment for the purpose of mining and processing in the Odo Shakiso woreda includes picks, shovels, wood-made pulleys, and bateas (Figure 5). On the other hand, some ASM associations use excavators, grinding and crushing machines (ball mills), and beneficiation equipment like sluice boxes and shaking tables (Figure 5). Most artisanal and small-scale miners (ASMs) and artisanal and special small-scale miners (ASSMs) use rental equipment in the form of a per-hour payment system or division system for the machine they rent for the duration of the machine's stay at the mining site. But renting that mining and processing equipment is very expensive and requires huge money and exposes the ASM to more expenses.

ASM pays their payment even if their mining operation is productive or not (Figure 5). The most common types of mining equipment and machines that are used for the purpose of comminution/crushing are primary crushers like jaw and gyratory crushers and secondary crushers like cone crushers and the grinding purpose equipment such as ball mills, AG/SAG mills, and rod mills [28]. In the ASM sector, common gravity concentration methods like sluice boxes, shaking tables, and spirals are widely used due to their low capital cost [31]. Also, sometimes magnetic concentration methods and flotation methods are used (Figure 5).

To wisely use and manage resources, it is necessary to arm ASMs with appropriate methods and more advanced mining and beneficiation technologies for more effective productivity efficiency [36]. But providing this necessary equipment for all individual ASM associations is difficult in developing countries, like our country, Ethiopia. For this fact to provide necessary mining and processing equipment, all ASM must be

legalized and formalized to organize those into cluster zones according to the mineral types they produce based on their mine site location and depending on their proximity to each other [19]. Then the ASM associations that form cluster zones can get mining equipment and processing technologies, capacity-building training, marketing places, and health and safety awareness from established centers at specific locations that are accessible to all ASM clustered zoning associations [34, 36].

3.3. ASM Cluster Zone Designation and Management

Ethiopia is endowed with different mineral resources, in which most of the minerals are mined by artisanal miners. These manners increase job opportunities in rural parts of the country, boost foreign income, and support local income by stimulating the national economy [11, 36, 15].

The artisanal and small-scale mining sector (ASM) has become a high priority for Ethiopia's homegrown economic stimulation. Currently, significant reforms are underway to modernize and transform artisanal and small-scale mining (ASM) into a sustainable livelihood for artisanal and small-scale mining communities, including encouraging ASM to mining operation policy and proclamation, marketing, responsible access to technology, access to financial funds, training, and inclusive small enterprises to engage safely and legally in the mining sector and collaborate productively with large-scale mining enterprises [1, 35]. To optimize this plan, ASM cluster zone designation and management concept in selected potential mineral deposits areas should be acted on as one option of a prototype with expansion in the future. Establishing an ASM cluster zone is vital in creating a sustainable ASM mining operation as it enhances the link between miners and the land they work on, promotes planning that may be accompanied by an extended mine life, and it can be used to obtain funding from formal financial institutions, and therefore may encourage operation within a regulatory framework. The establishing, designation, and management of the "ASM zone" initiative in Odo Shakiso is a newly developed concept, and it has many advantages for both the government and miners. ASM cluster zone is a systematical method which assists the legalization and formalization of ASM with providing single window services at one center in mines sites such as mining and processing technologies, marketing center, (MPM), link to market-industry, capacity building training support package with aim of gradually transforming small scale miners [23]. ASM cluster zone designation and management concept are one method of the natural resource administration system that is mined by ASM, and so far, this concept is being implemented and established in most ASM practicing countries in Africa, like DR Congo, South Asian countries, and South American countries such as Colombia and Indonesia [3, 4], and the concept of delineating

“ASM zone” was being tried in Ghana, Mozambique, Suriname, Tanzania, and Zambia [6-8].

The aim of the ASM cluster zone designation and management in Odo Shakiso woreda is to administrate the natural resource mined by ASM through providing continuous support collectively as industries of integrated mining, processing, value addition, and marketing packages for miners by creating a cluster zone in/near mine sites. Supporting the ASM in potential economically viable mine sites or grouping them into clusters can facilitate transforming the informal ASM activities into a formal economic system, which reduces illegal activities in the ASM sector, improves and promotes the contribution of mining to the national economy, increases mineral diversification and sustainable development, reduces poverty, reduces social and environmental impacts, and increases local and national revenues. Supporting ASM by developing clusters also creates conducive conditions for integrated support of mining-processing-training-value addition-marketing for ASM operations as a collective, as one industry [9, 34, 36].

Creating an ASM cluster zone and managing it effectively can reduce the adverse negative environmental impact consequences, occupational health and safety, and related human rights, labor standards, and gender. Also, it will assist in the transformation of mineral production-based poverty reduction by increasing local revenue and contribute to local economies increment [2, 5].

The government can manage the ASM activity after grouping it into an ASM cluster zone through a proper planning, administration, and management that is more rewarding and more economic than often focusing on policies and other interventions or costly environmental remediation, so as it can preserve an economic sector that represents one of the few viable sources of income in rural areas [24]. The first and

initial step to determine how to classify and categorize ASM into smaller subtype groups is establishing, designating, and managing these groups to make sure that these groups are identified, treated, and managed accordingly [9, 18]. It can help to decide whether there are some subtypes of ASM that need to be treated differently from others and support a decision hinging upon whether a government judges that it can feasibly administer a system of licensing and regulation.

To benefit from mineral resources, the government must put effort into the ASM sector to introduce integrated and systematic resource management, modern technology, access to training, markets, and financial support, and integration work with research institutions, NGOs, and manufacturing industries. This will develop a well-integrated mining-processing-value addition-marketing system to use and manage minerals systematically [5, 21]. The ASMs can benefit from single-window support of mining-processing-marketing provided by the state. However, the delineation, establishment, and administration require a great deal of governmental effort as well as the tight coordination with industrial mining companies and involvement of other interested stakeholders. Besides, ASM zones do not come for free, meaning a strong and constant commitment of financial and human resources is required for setting up and running them. The establishment and designation of “ASM zone” in Odo Shakiso necessitate/entail an initial emphasis on the legalization and formalization of the ASM sector, as well as its incorporation into local and regional economic development and land-use plans and strategies, particularly those aimed at poverty alleviation, and additionally, reviewing and evaluating mining policies, in order to incorporate a poverty reduction component into artisanal and small-scale mining (ASM) strategies [10, 24].

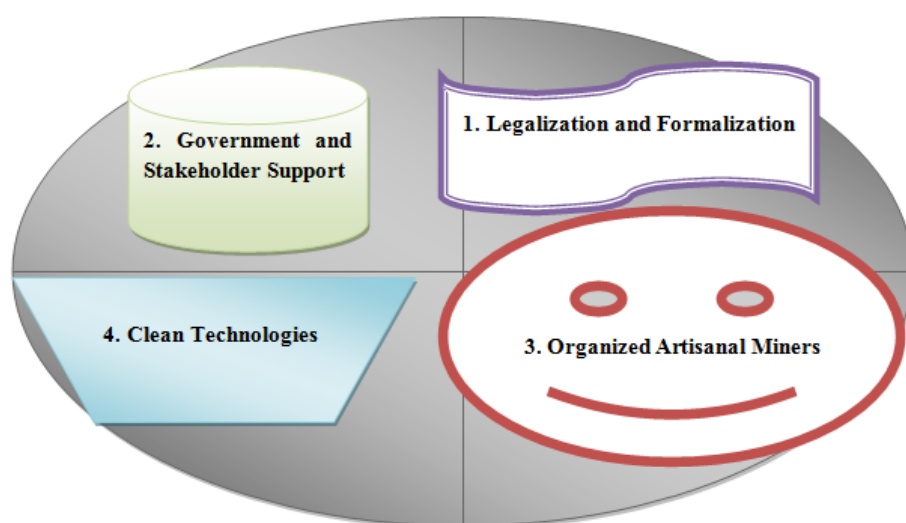


Figure 6. Principal primary key things included into organization of artisanal and small-scale mining (ASM) strategies.

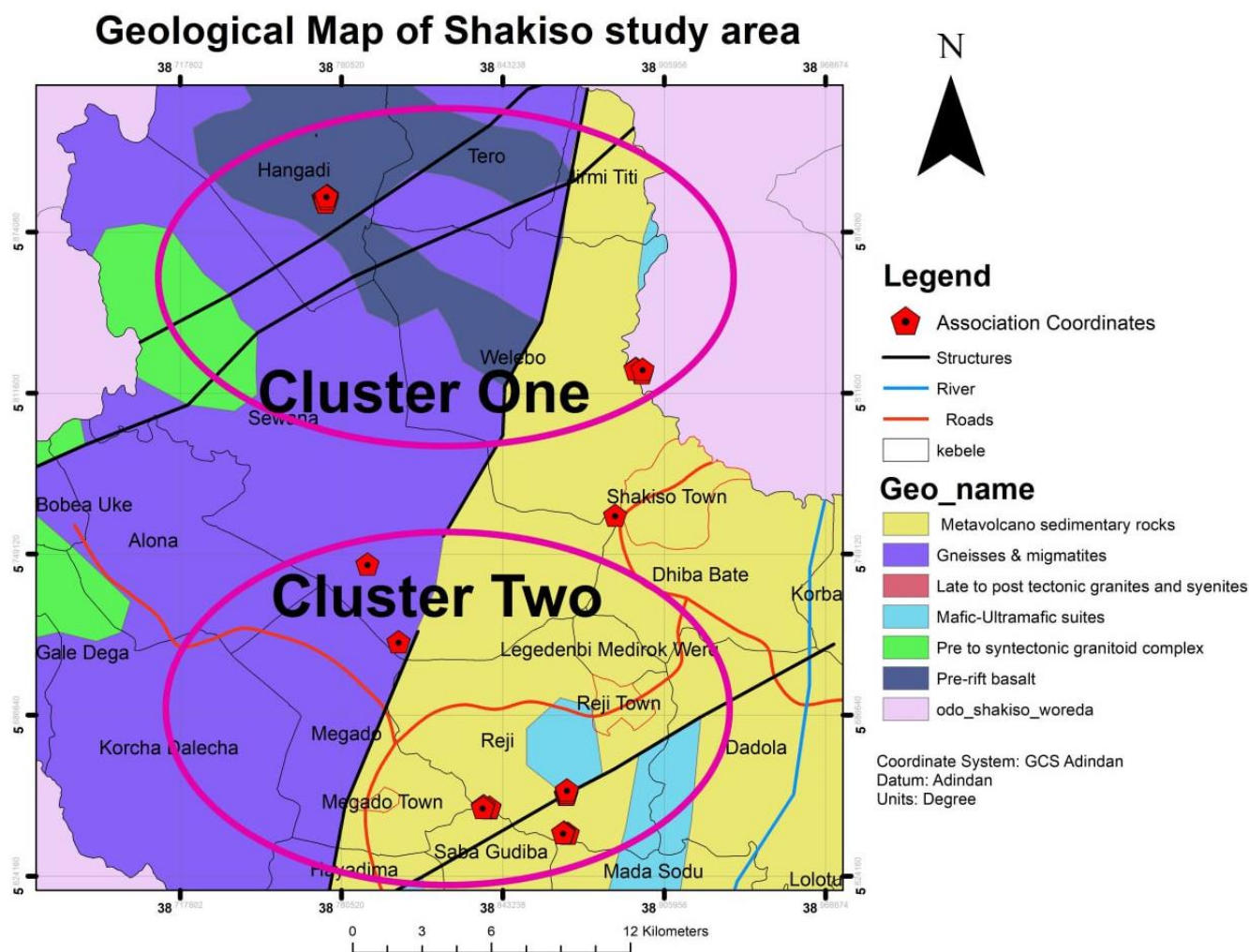


Figure 7. Suggested ASM cluster zone block (block 1 & block 2) in Odo Shakiso Woreda.

In order to begin the designation, establishment, and management of the ASM cluster zone in Odo Shakiso, the designation and implementation phases are suggested/recommended as illustrated in the following flow chart (Figure 8).

In ASM cluster zone establishment, the designation phase helps to make better-informed decisions by providing it with a view of the realities on the ground. The important sequencing of research activity in the designation phase includes defining scoping study, government capacity assessment, ASM industry sector assessment, ASM impact assessment, and further ongoing research. This phase provides an overview of the ASM sector and informs whether further research is required and designed. It includes gathering basic information on ASM and the techniques and technology that ASM operations use and the economic characteristics of ASM, numbers of miners, types of ore, ore demand and marketability, market center, training gaps, and others, like building a database on ASM and integrating with cadasters, determining the impacts of ASM operations, the government's capacity to manage ASM mining operations, and the ongoing research depending on the government needs to gather information and review its own

capacity.

The implementation phases include activities such as the identification and delineation of the "ASM zone and the estimation of resources for the economical ASM zone. Identification and delineation processes are gathering basic data on resources; manpower, technology, and the number of ASM; delineating and mapping potential mineral resource areas; checking for other reserved land areas such as natural parks, protected lands, agriculture, forestry, fishery, and tourism, etc.; and the availability of such kinds of information is important while estimating resources for economical ASM zones that focus on the determination of mineral deposit tonnage and grade for ASM operations. The implementation phase plan will realize the economic potential of ASM integrated as part of the government's economic and poverty-reduction plans, facilitate the introduction of a supply chain initiative in the ASM sector, support ASM operations on better practices that benefit operators, train ASM workers how to employ techniques that benefit them, such as occupational health and safety standards, support ASM operations on new equipment intervention and inputs that are provided as part of government assistance for ASM, and consider market failures that

happen in the ASM sector that can be fixed by assisting ASM operations. ASM stakeholders, such as communities near mines, should notify on ASM zone implementation and an-

ticipated changes in ASM operations through education, training, and other programs.

Designation Phase	• Gathering basic geological information and data • Assessment of Government and Industry mining sector • Identify potential mineral deposit Zone • Identify quantity of miners • Identify production volume • Identify miners Mining and processing potential • Identify Mining and processing techniques • Identify problems like Environment, Market) • Analyze this basic information, ASM mining and processing problems, Country benefit, commodity and industry linkage • Current market demand and supply
Implementation Phase	Phase I • Support licensing, regulation, monitoring and enforcement • Allocate land, likening, re-licensing and permitting • Legalize, formalization and supporting • Support on Environmental mitigation measures, Health and safety; and Improving gender standard/inclusiveness Phase II • Facilitate or encourage ASM participation in supply chain initiatives • Create a government-sponsored purchasing scheme • Create Services and technical assistance to ASM operations and to ASM workers • Build Transport infrastructure provision • Provision of geological data, geological expertise and exploration service • Provision of or subsidy of the sale of equipment • Supporting clean mining and processing operations sponsored by government/NGOs • Market center development • Socio-economic benefits and sustainable development ○ Skills development ○ Capital investment ○ Taxation, governance and development policy ○ Upstream economic development
Management Phase	• Supervision and Support of ASM • Dialog with ASM and local communities • Delivery of ongoing on job training measures • Support and assistance in mine plan and mine closure plan • Provision of extensional services like sanitary, health and education facilities • Provision of mining and mineral processing and/or tailings facilities

Figure 8. ASM Cluster Zone Designation Phase flow chart in Odo Shakiso worda.

Therefore, it is better to introduce the ASM cluster zone designation and management for ASM transformation in Odo Shakiso worda. This ASM transformation step concluded as illustrated by the following diagram. Integrated ASM transformation requires creating ASM cluster zone development in mineral potential areas with proper mining and processing equipment and technology. ASM can be supported directly by introducing modern technology and financial funding (rent-lend-purchase-supply equipment) ASM associations and cooperatives engaged in the mining activity with the aim of transforming ASM into a company. Start underground mining activity in the ASM license area (where there is existing potential), since surface resources are depleting, by creating modern mining and processing techniques, building a modern primary market and training center, modern bene-

faction center services, and controlling the illegal market. However, this may require proclamation and policy amendment.

And also, ASM can be supported directly by creating investment working environments in active ASM mine sites on ASM through share collaboration cooperatives and companies/governments with the aim of ASM entering into shares with existing resources, and the company/government will support technology, finance, experience, and market links of the company share. This ASM-Company link must create a conducive working environment. With modern equipment and better market access, the ASMs can produce in high quality, increase productivity, reduce environmental impacts, and in the long run can transform from ASM to small-scale company.

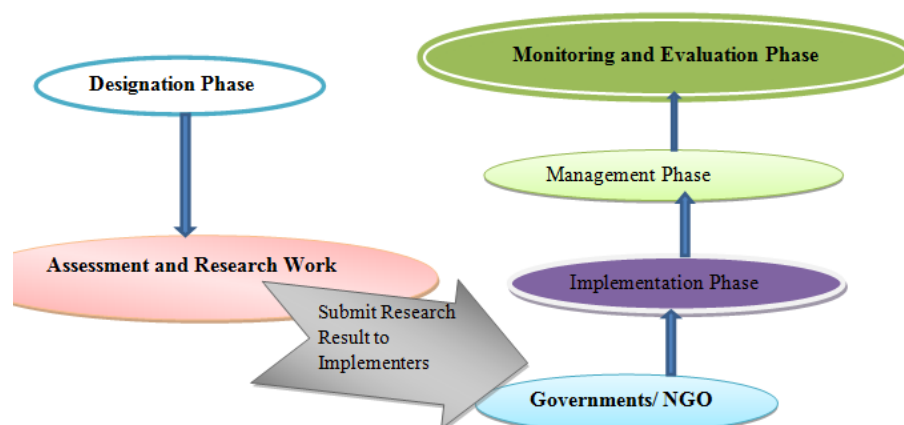


Figure 9. The Concept of ASM Transformation Steps in the Odo Shakiso Woreda.

3.4. Purpose of ASM Clustering

3.4.1. Creating Centralized Mining and Processing Machines and Technologies

Mining and processing equipment and technologies are very expensive and not affordable to provide for each ASM association individually. However, it can be tolerated by providing the most appropriate mining and processing equipment and technologies at one centralized cluster zone according to the types of their production. The lack of modern and appropriate mining and processing equipment is a problem that is hindering the production and productivity of ASM. Therefore, forming a centralized mining and processing cluster zone for ASM based on their location and proximity to each other is a strategic system that enables and solves problems that hinder the production and productivity of ASM. So, it is crucial and mandatory to provide and promote mining and processing equipment and technologies and offer alternative access routes for mining and processing operations [34, 36].

The concepts of processing centers were first established and applied in Venezuela and successfully implemented and applied by the government, NGOs, and private companies in Zimbabwe, as well as in Burkina Faso, Ghana, Mali, and Tanzania, Peru, and Suriname [30, 34, 36]. These processing facilities played a significant role in providing information on environmental management, drilling and blasting services, ore transportation, and technical support in areas such as mine planning, mining method selection, mine safety and pollution control, information on legal issues, geology and metallurgy, and the selection and purchase of technical equipment [17]. One center organized mining and processing equipment was more effective where deposits are localized. However, it is not very effective; the mineral is widely dispersed and requires far transportation from mine sites [34, 36].

3.4.2. Provide Centralized Training Center

Most ASMs work in a dispersed manner and follow tradi-

tional mining methods. This condition exposes them to unwise use of resources [25]. When we come to saw in our country, a number of ASM are works scattered in different locations in different parts of the country. In turn, this manner makes it difficult to provide capacity building and awareness for ASMs, provide training in mining and beneficiation for ASMs, and address health and safety issues for ASMs on their work [36]. Therefore, for the reason mentioned above, establishing a centralized cluster zone training center is mandatory to solve problems related to training and other issues [26].

3.4.3. Facilitate Creation of Centralized Marketing Place

Most Ethiopian ASMs are experienced and faced with a lot of difficulties in availability in the marketing place. ASMs found in Odo Shakiso woreda are selling their products to nearby market centers opened at the shakiso Reji, Dolovia, and Benti Korbo areas (Figure 9). Selling their products to nearby market places has benefits for ASMs in that they are not exposed to other problems like theft and other related security issues. To avoid a lack of marketing center problems similarly in other areas, situate to establish an ASMs cluster zone near to their mining sites.



Figure 10. Gold buyer @Dolovia mining site.

3.5. ASM Cluster Zone Management Strategies

Once the ASM cluster zone is established and founded, it needs the government and stakeholder support to improve management and sustainability of the ASM operation. Support ASM operations with better equipment and technical assistance to improve productivity and their practices in mining and processing operations and access to financial services. Supervision of the ASM is necessary to implement an efficiency and pollution-reduction system that saves time, energy, and water as well as reduces negative environmental impacts and on how they follow clean processing techniques. Develop and improve ASM practices by adopting sustainable mining and processing, value addition, and markets; facilitate or encourage ASM participation in mining operation dialogue; provide extensional services and technical assistance to ASM operations; and provide services to ASM workers and infrastructure like roads and electricity, which assist ASM operations by connecting them to transport networks and lowering the costs of transportation. Providing comprehensive education for the ASM community, like awareness creation and capacity building on the administration of a small mining business, mine based exploration techniques, adequate mining

and mineral processing techniques, environmental issues related to mining and beneficiation and occupational health and safety, mine closure planning, and waste management systems, and in addition to mining, how to start the practice of another business-like agriculture, shopping, etc. [18, 36].

The management strategies of established ASM cluster zone phases illustrated as the following provide a practical way for governments and stakeholders who are involved in the ASM mining sector on how to identify, delineate, establish, and manage ASM zones, which are amenable for the development of ASM mining operations. The work presents guidance for governments on managing artisanal and small-scale mining (ASM) in the simple frame of developing and implementing a management strategy for ASM, which focuses/concentrates on the ASM zone and offers guidance on assessing, identifying, evaluating, creating, establishing, and managing these types of zones [22]. ASM cluster zones ought to follow an industry approach, which means the ASM operations are not regarded individually but collectively, as an industry. The process of identifying, delineating, establishing, and managing “ASM zones” is seen as a phased process and will be explained by the following steps:

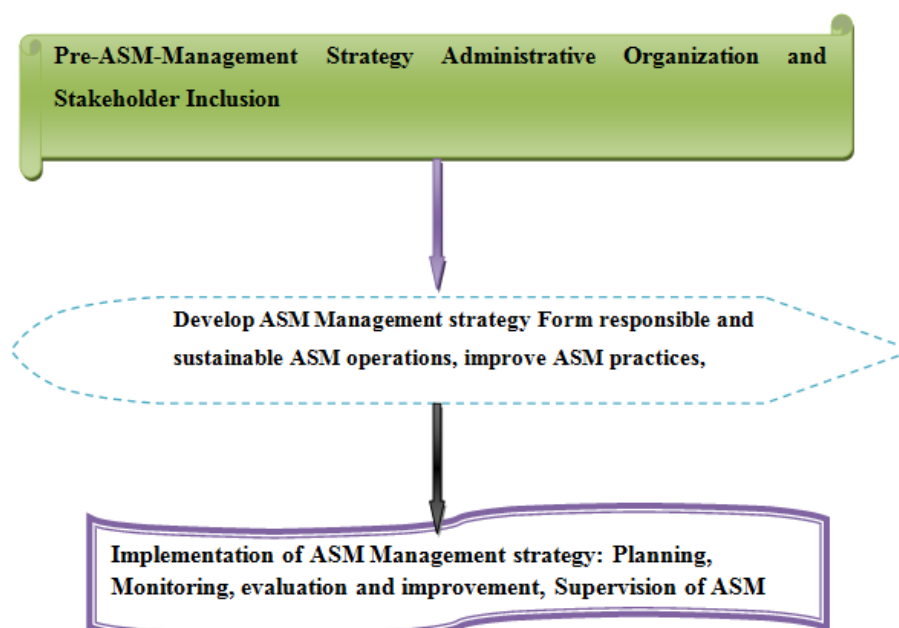


Figure 11. ASM Cluster Zone Management strategy diagram.

4. Conclusion and Recommendation

In Odo Shakiso Woreda, there are a lot of mineral resources that are still not well exploited, and there are many miners that mine gold and other types of minerals in this woreda. But woreda's mineral resources are not only exploited by ASMs, because almost all ASMs are mined by traditional mining

equipment and processing technologies and focus more on precious minerals. Supporting Ethiopia's ASM is a key for the country's resource utilization, revenue generation, job creation, and poverty reduction, mainly for most people who live in developing rural areas. The formalized and legalized artisanal miners will benefit through technical, financial, and market access and training on mining and beneficiation of minerals. The government has responsibilities to regulate the

ASM sector to mitigate negative consequences, just as they have obligations to harness that economic potential for sustainable development and will administer the mining-beneficiation-marketing.

To make ASMs more productive and to increase their production, establish two ASM cluster zones and provide mining and processing technologies, train miners on mining and beneficiation processes, and address environmental, health, and safety issues for capacity building increment, and expand the marketing center in ASM cluster zones. This is a critical way of solving problems that are hindering the production and productivity of ASMs that exist in this woreda and a key for ASM transformation. These require effective effort work of the government and stakeholder involvement in the mining sector, mining, and processing machines and technologies through forming and establishing clustered zones. In addition to this, providing financial access as a form of loan from financial institutions is best. Not only is this, but also developing infrastructure facilities and extensional services such as roads, potable water, and the health sector is more effective for ASM in this woreda.

Therefore, empowering those ASMs by providing mining and processing machines and technologies and legalizing and formalizing ASM into cluster zoning is the way to improve the production and productivity of ASMs. This will result in improvement of ASM community lifestyle that survives and leads his life by mining activity and is the best approach to increase the contribution of the mining sector to the country's GDP.

Abbreviations

ASM	Artisanal and Small-scale Mining
ASSM	Artisanal and Special Small-scale Miners
GDP	Growth Development Production
NGOs	Nongovernmental Organizations
MPM	Mining and Processing Technologies, Marketing Center

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Conflicts of Interest

The authors declare no conflicts of interest.

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