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Establish cluster zoning of Artisanal and small scale miningin Arero woreda, Borena Zone, Ethiopia

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Abstract

Nowadays, in Ethiopia, there are a number of artisanal and small scale mining/ ASM/ associations that are located all over the country that mine different types of minerals in a very traditional way of mining methods. This traditional method of mining hinders the productiveness of ASMs with full potential, especially ASM associations that are located in Arero woreda. These ASM associations are extremely subjected to such kinds of problems. To make ASMs more productive than ever, the most essential mining equipment and processing technologies should be available with the required amount and specification. But making available all equipment and machines to each individual ASM association is a challenging issue in most developing countries, like Ethiopia. So, to compromise on such a kind of issue, clustering all ASM associations into a group based on their geographic location, proximity to each other, and the type of mineral they mine, and after that, the government or any stakeholder that is involved in the mining sector can make available the required mining equipment and processing technologies to the clustered zone of ASM associations to a centralized area which is accessible to all ASM clustered associations. The main objective of this study is focused on how to cluster and zoning all ASMs located in Arero woreda and supply the required mining equipment and processing technologies to make ASMs more productive.

Keywords: ASM, Associations, Clustering and Zoning, Mining Equipment and processing Technologies.

Introduction

Artisanal and small-scale mining /ASM/: formal or informal mining operations with predominantly simplified forms of exploration, extraction, processing, and transportation. ASM is typically low capital intensive and labor intensive[1]. ASM can include men and women working on an individual basis as well as those working in family groups, in partnerships, or as members of cooperatives or other types of legal associations and enterprises involving hundreds or even thousands of miners[2]. Globally, ASMs are one of the most important income sources for people who live at low income levels. Especially in developing countries, like Ethiopia, where such a kind of mining activity is one of the most common practices among the people who live in rural parts of the country.

Those people's mining practices are extremely traditional and wasteful, but with so many challenges, the ASMs are attempting to mine the required mineral with great diligence.ASM can play a crucial role in poverty alleviation and rural development. In Ethiopia, there are a number of ASMs that mine precious metals like gold, industrial minerals like tantalum, copper and gemstones like opal, emerald, sapphire, aquamarine, amazonite, and other semiprecious type of gemstone[3]. Ethiopian communities engaged in gold mining are estimated to number 300,000–350,000 ASM activities in all regions of the country[4].

ASMs are dispersed in different localities, which make it challenging to monitor, train, and make available essential mining equipment and machines and access the ASM miners easily for any support and other tasks. The main objective of this work is to recommend a solution for how to solve those problems through the clusterization of ASMs that mine the same type of minerals for communal mining equipment, machine and technology usage, communal training center, and any other support for ASMs based on the location of their mining sites in clustered zones.

Ethiopian ASM current Status: In the last nine months of 2021, ASM contributed about 99.8%, compared to 0.2%, and directly employs around 1.5 million people as a source of livelihood and supports a further 7.5 million people in all regions, with the highest in Tigary, Gambela, Oromia, Benishangul Gumuz, Afar, Amahar, and South Ethiopian Peoples. It plays a crucial role in reactivating the national economy by mining gold (placer and primary), tantalum, gemstones, construction and industrial minerals. It also plays an important role in discovering new mineral deposits and in curbing rural-to-urban migration.

With increases in government ASM support, the revenue generation increased from less than $100 million in 1996 to $650 million in 2005[5]. These indicate the ASM sub sector has great economic potential in the development of the country's economy if they are supported by developing the ASM Cluster zone-support scheme. Despite this, many ASM mine sites face significant challenges, such as a lack of best-practice mining

and processing technology, limited financial access to acquire technology, limited training to increase productivity, weak systems to reduce environmental impact, and limited access to marketing.

To maximize the ASM benefit, the government must pursue complete formalization of ASM by using the new concept "Cluster and Manage." Technology-equipment hire, rent, lend approach, support link product to industry, and export (market-promotion approach), and sustainably provide technology-training with the aim of gradually transforming ASM into artisanal special small-scale miners/ ASSMs/.

Location of the study area: Arero is one of the woreda in the Oromia region of Ethiopia, part of the Borena Zone, with a geographic coordinate location of 4° 39' 59.99" N and Longitude: 39° 00' 0.00" E. It is bordered on the southwest by Dire, on the west by Yabelo, on the north by Bule Hora, on the northeast by the Guji Zone, on the east by the Somali Region, and on the south by Moyale. The Dawa River, the only river in this woreda, separates Arero from Odo Shakiso and Liben.

Materials and Methods

The research was mainly conducted by using qualitative data and some additional quantitative data with the involvement of different stakeholders that are involved in the ASM sectors of governmental and non-governmental organizations. The required data for the research was gathered through interviews with local residents, artisanal and small-scale /ASM/ associations, government, non - governmental officers, and experts, which were supported by semi-structured questionnaire forms designed to generate the required data.

Different types of Published articles focused on artisanal mining and unpublished paper works of case studies and reports on artisanal mining from governmental and non-governmental offices were used as a source of data. Direct field observations of the mining sites of the ASM association were also another means of collecting data sources. Collection of geospatial data from the Ethiopian Geospatial Institute and collection of geographic coordinate locations from ASM association mining sites are also part of the data collection methods.

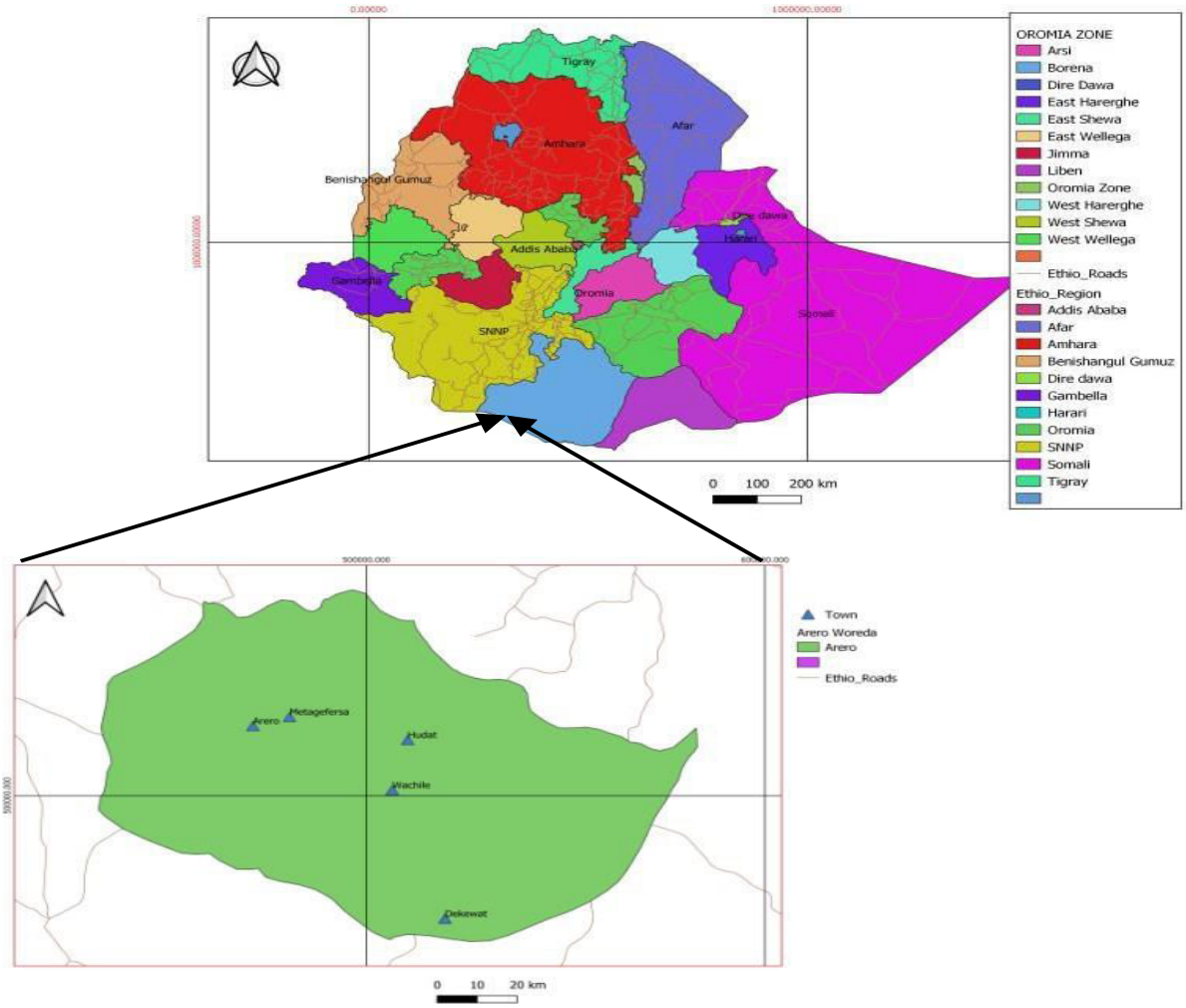


Figure-1: Location map of study area.

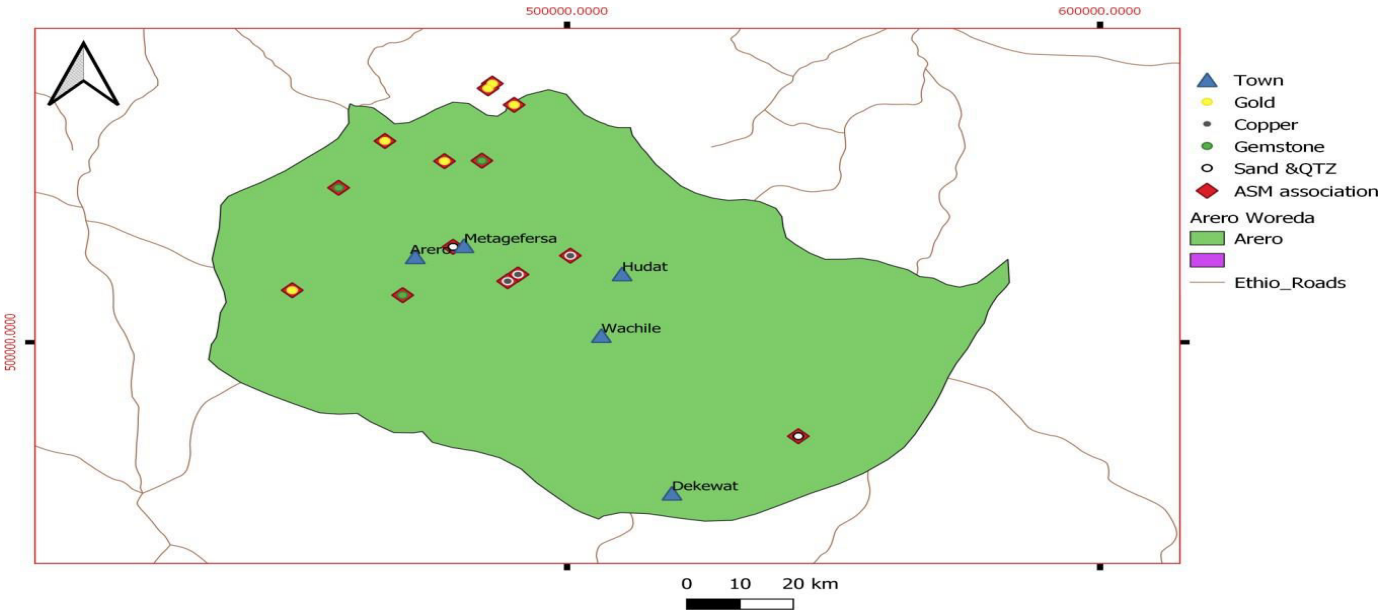


Figure-2: Map showing location of ASM associations and corresponding minerals theymine.

In addition to this, further discussions were held with the regional, zonal, and woreda level mining officers on the issue of how to solve different problems that are associated with ASMs. After collection of the required data, the locational topographic map of the study area, the topographic locational map of ASM associations, and the cluster zoning of ASM associations are done by using geospatial open software QuantumGIS/Q-GIS

Results and discussion

ASM associations in Arero woreda: In Arero woreda, there are 14 ASM associations that mine gold, copper, gemstones, and other types of industrial minerals and rocks like quartz and sand. Of those associations, six ASM associations are mining gold, and three of them are artisanal and special small-scale miners/ ASSMs/ gold mining associations. Most of the associations mine primary gold deposits, with some of the placer gold deposits. And the rest of the ASM associations are mining gemstones, copper malachite, sand, and quartz. But most of the ASM associations are currently focused on primary and placer gold mining activities due to the relative linkage of gold market chains. All gold miming ASMs they don't use mercury or any other chemicals for the beneficiation process. They use only river water and traditional processing equipment's, like Batiya for the beneficiation process. As a result, the gold produced by the Arero woreda ASM association is free of impurities due to additives used during the beneficiation process, and the mining and beneficiation system is relatively environmental friendly.

The main differences between ASSM and ASM are: in the case of Artisanal and special small scale miners/ ASSMs/, some essential mining equipment's and processing technologies are available, like Excavators, table shaking, Suluce box etc. But in the case artisanal and small scale miners/ ASMs/, all the mining equipment's and processing technologies are very traditional , like wood oriented pulley system for carrying primary gold hosted ore bodies from deep holes, Shovels and picks for digging and excavating purpose and Batia for the purpose beneficiation.

Current mining equipment's: Artisanal and small-scale mining is a largely informal economic sector that includes workers around the globe who use their hands, basic tools such as picks and shovels, and low-tech equipment such as bulldozers and more mechanized equipment to extract from the earth vital metals[6].

In Arero woreda ASM associations, the mining equipment they use for the extraction of gold and other types of economic minerals is very traditional that exposing the ASMs to wastage and problems with health and safety issues. The most common ones with their local names are: Picks/Doma, Digino, Shovel/Akafa, wood pulley system, and Batiya for the beneficiation process. And also, there are some ASM associations that use scaveters, grinding and crushing machines, and small-scale beneficiation equipment like suluce boxes and table shaking with a form of rental per hour payment system for the crushers and grinding machines. But renting those mining machines is very expensive and makes the ASM associations subjected to more expenses, since they rent the crushers and excavating machines with a method of payment per hour, whether their mining operation is productive or not. With that time bound, the miners will pay for the duration of the machine's stay at the mining site.

Table-1: List of ASM associations in Arero woreda.

Name of Association	License Type	Region	Zone	Woreda	Kebele	Specific location	Area coverage HK	Mineral type	Easting	Northing	M	F
Abdi Dhadacha	ASSM	Oromia	Borena	Arero	Madari	Alge	0.947	Gold	476994	548776	28	2
Abdi Dargago	ASSM	Oromia	Borena	Arero	Hirmaye	Qolansa	0.9	Gold	485970	569660	36	26
Gumi Misoma	ASSM	Oromia	Borena	Arero	Hirmaye	Qori	1.1	Gold	448420	513990	45	9
Qoriqufa	ASM	Oromia	Borena	Arero	Hirmaye	Qori	1	Gold	485167	568386	34	6
Qarsa Dhadacha	ASM	Oromia	Borena	Arero	Oroto	Qarsa Dhadacha	0.92	Cu**	490782	518239	25	7
Dhaka Baricha	ASM	Oromia	Borena	Arero	Oroto	Dhaka Barocha	0.77	Cu**	488842	516427	30	10
Bule Dabobeti	ASM	Oromia	Borena	Arero	Hirmaye	Elaoda	1.78	Gem stone#	484009	548905	42	7
Qarsa Qeramsa	ASM	Oromia	Borena	Arero	Oroto	Qarsa Qeramsa	1.0563	Cu**	500616	523312	26	16
Hawi Gudinatif	ASM	Oromia	Borena	Arero	Dhildhile	Rasa	5000*	Gem stone	457120	541600	35	8
Umi Badhasa	ASM	Oromia	Borena	Arero	Haro Dimtu	Dallonna	1.06699	Gem stone^{Q}	469152	512662	43	12
Mansa Dureti	ASM	Oromia	Borena	Arero	Haro Dimtu	Garaela Duritibira	0.97	Sand	478605	525690	22	17
Huje Duroma	ASM	Oromia	Borena	Arero	Hirmaye	Bore	0.8	Gold	490060	563939	34	6
Siltacho Qufa	ASM	Oromia	Borena	Arero	Hirmaye	Siltacho	1.5208	Gold	465822	554205	33	7
Waldaqobo	ASM	Oromia	Borena	Arero	Karaguata	Qobo	1.81	Quartz	543389	474665	52	25

Where: M=Male, F=Female, * M^2, Cu**= Malachite, #= Emerald, Q=Garnet.

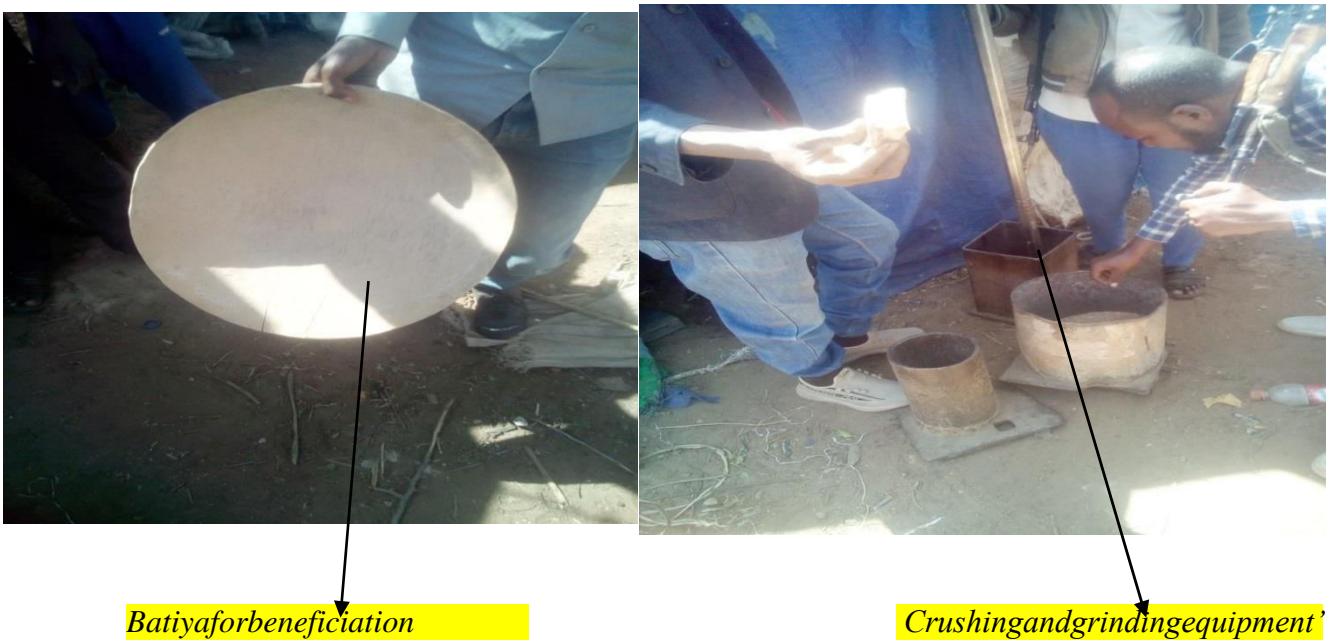


Figure-3: Traditional mining equipment's currently in use.

Essential mining equipment's and processing methods: The most common types of mining equipment and machines that are used for the purpose of comminution (jaw crusher and gyratory crusher as primary crushers and cone crusher as secondary crusher) and for grinding purposes (ball mill, AG/SAG mill, and road mill) are used, but the ball mill is the most commonly used type of grinding machine. For beneficiation, gravity concentration methods like suluce box, table shaking, and spirals are the most common ones) and also magnetic concentration methods and flotation methods are used, but in the ASM sector, gravity concentration methods are widely used due to their low capital cost[7].

To make the ASM sector more productive and effective with the wise use of resources and an appropriate method of mining, more advanced crushing and grinding machines and beneficiation methods should be available. But making available all essential mining equipment and machines to all ASM associations is difficult in developing countries, like Ethiopia. Due to this fact, to make available essential mining equipment and machines, all ASM must be formalized and clustered with a group of ASM associations in a legal way. After clustering all ASM associations based on their location, proximity to each other and type of mineral they mine, centralized mining equipment/machine and processing technologies, centralized training centers, centralized marketing centers, and centralized health and safety awareness creation centers should be established at a specific location which is accessible to all ASM clustered zoning associations.

Centralized mining machines and processing technologies: As it is known, mining equipment and related technologies are very expensive and are not affordable by each individual ASM association. Instead, it can be tolerated by centralizing the most appropriate and mandatory mining equipment and technologies by clustering and zoning a group of ASM associations that are located in close proximity to each other and the geographic location in which they are located. Centralized mining machines and processing centers are one strategy to enable and solve problems that are hindering the production rate of ASMs due to the lack of modern machines and processing plants. It is important to provide an alternative access point for equipment and technology and to promote mining operations.

The first processing centers were established in Ghana, Venezuela, and Zimbabwe by governments and other project donors. As well as providing processing facilities, the centers have played a role in providing information about environmental management[8]. Unfortunately, they have faced a number of issues, based in large part on a lack of prior research on their target beneficiaries. A centralized processing center in Bolgatanga, Ghana, for example, was underutilized because it was too far away from the mining area and the equipment wasn't tailored to local geological conditions[9]. Centralized mining equipment and processing centers are most effective in countries with localized gold deposits, but not as effective where gold is widely dispersed and miners have to transport ore far beyond the mine[10].

Centralized training center: Globally, most ASMs are located in avery dispersed manner and mined with a traditional way of mining methods, that makes most extracted precious metals, base metals, industrial minerals, and gemstones un-economical and exposed to unwise use of resources[11]. Likewise, in Ethiopia, there are a number of ASM associations that are distributed in different locations, which makes it difficult to create awareness, provide training on mining methods, provide training on health and safety issues, and any other issues that concern ASMs. For this reason, establishing a centralized zone of training center, which is accessible to all ASM associations based on their clustered zone of ASMs at a specific location, is mandatory to solve problems related to training and other issues.

Centralized marketing place: Most ASM associations found in Ethiopia are encountered with a lot of difficulties related to the availability of marketing centers. ASMs which are found in Arero woreda are selling their products by going to a very far distance from their mining sites, like Shakiso, which is 150 km away from Arero town. This makes them vulnerable to theft and other related security issues. To avoid such kinds of problems that happen due to a lack of a centralized marketing center that is situated near to all ASM associations, establishing cluster zoning of all ASMs in a group based on their location of mining sites and proximity to each other, a communal marketing center should be established that can be accibel for all clustered zones of ASMs.

ASM cluster zoning and designation: Africa is endowed with different metallic and non-metallic minerals, which increase job opportunities, foreign income, local income, support for mineral substitution, and diversification of local mineral products, and can reactivate the national economy[12]. It can play a crucial role in assisting the home's growing economic development plan. Creating a cluster zone and managing it can reduce the adverse effects on a range of negative consequences, including the environment, human rights, labor standards, occupational health and safety, and gender. It can also transform the endowed different metallic and nonmetallic minerals into production, reducing poverty-driven economies' impacts on increasing and sustained revenue (local and foreigners') household income and contribution to local economies.

Introduce integrated single-window support in mine central sites, dubbed "ASM Cluster Zones," including processing, mining, and marketing (PMM) assistance, and link product-to-market-industry-export by utilizing an integrated technology-training-market support package, with the goal of gradually transforming ASM into small-scale miners. To benefit from those mineral resources, the government must put effort into systematic and integrated resource management, technology-training-market access, financial support, integration with industrial mining companies, as well as the donor and research

community, in order to develop a well-integrated Mining-Value Addition and Mining-Processing-Marketing (2M_P) system with a target on Mining to Market (MTM) system in all minerals.

ASM Cluster zone designation and management concept is one of the mining markets that are currently developed in most ASM Mining supported countries like Africa, South Asian, and South American countries, which have recorded high ASM revenue from ASM Zone significant and sustainable mineral development[13]. The aim of the ASM Cluster zone designation and management is to jointly administrate the natural resources of a mine by ASM operators by providing continuous support, collectively as an industry, as an integrated mining, processing, value addition, and marketing package for miners by creating a cluster zone at the mine site. Supporting the ASM in potential economically viable mine sites or clustering them can help to transform the informal ASM activities into a formal economic system, reduce illegal activities, improve and promote mining's contribution to the national economy, increase mineral diversification and sustainable development, reduce poverty, and increase revenue.

The establishment and designation of "ASM zones" initiative in Ethiopia has many advantages for both the government and miners[14]. The government can manage ASM activity by establishing a proper planning, administration, and management structure that is more rewarding and works in more economic aspects than the often focused on police and other types of control on costly environmental remediation, allowing it to preserve an economic sector that is one of the few viable sources of income in rural areas. Establishment of an ASM Cluster Zone helps governments expect to enable better supervision and administration of ASM and to prevent conflicts with large-scale mining (LSM), as their mineral rights often overlap and reduce workable land for ASM.

The cluster zone facilitates mining, value addition, and mining, processing, and marketing (2M_P), technology-training, market access, and financial integration of governments, industrial mining companies, as well as the donor and research community, and others with a focus on mining to market (MTM) system in all minerals by creating a potential cluster zone by the government[15]. The support can reactivate the national economy and sustain systematic and integrated resource management, create a data base, and attract stakeholders to support ASM.

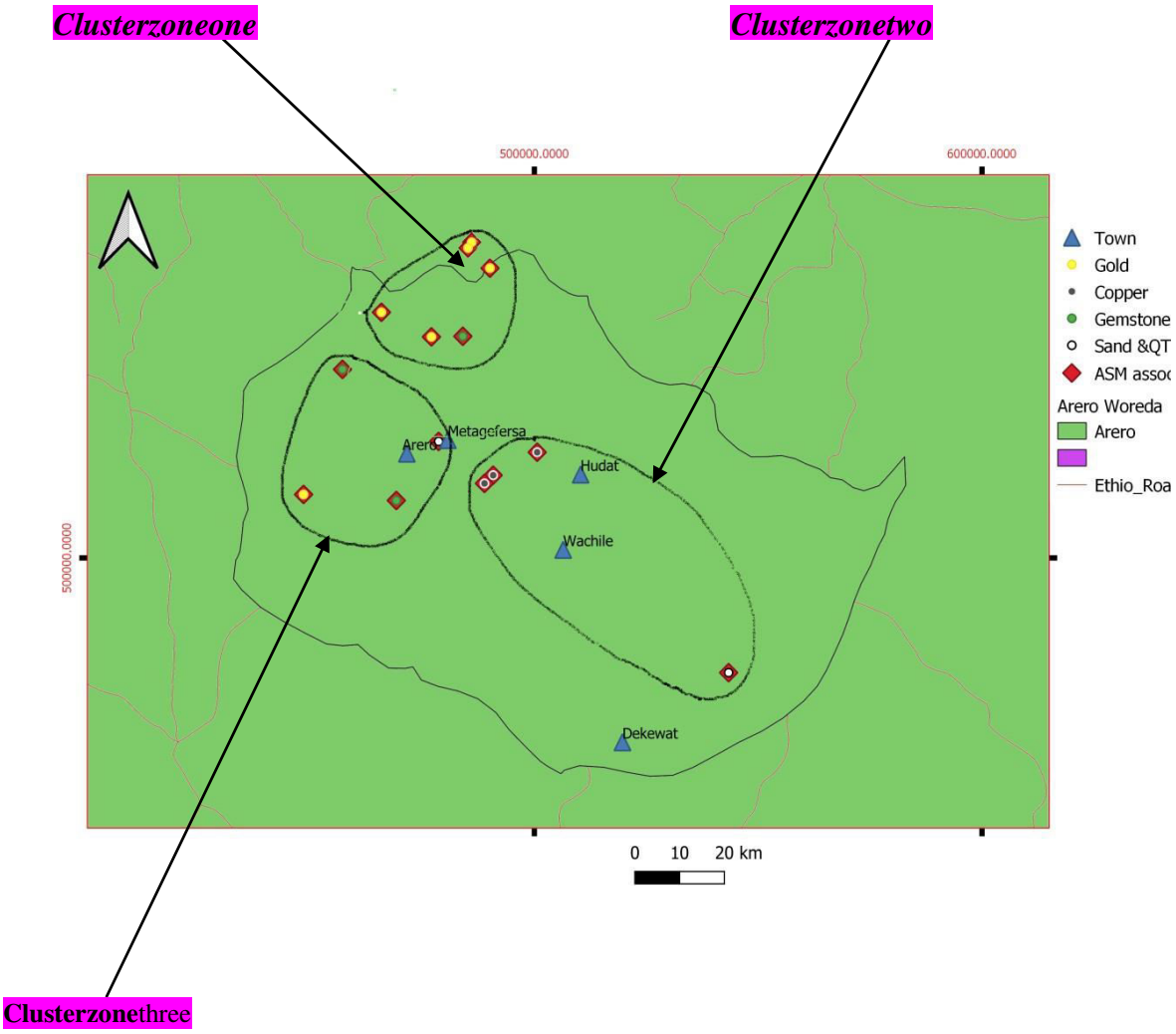
ASM cluster zoning in Arero Woreda: In Arero woreda, there are 14 ASM associations that mine primary gold, and some others mine gemstones and industrial minerals. However, ASM associations of this woreda are dispersed and separated by significant distances. Most of the gold miner associations use traditional mining equipment's with a lot of energy and time loss. To make those associations more productive with optimal energy and time loss, more advanced mining machines and processing technologies must be available to ASMs.

In order to make those essential mineral processing machines available in an economical and cost-effective way, clustering 14 ASM associations into three basic clustered zones based on their geographic location, proximity to each other, and to some extent with the type of mineral they mine, which means all ASM associations that mine gold, clustering in to one group, all ASM associations that mine gemstones, clustering in to one group, and all ASM associations that mine copper, clustering in to one group, and the rest, ASM associations that mine sand and quartz, clustering in to one group is an appropriate way of clustering the dispersed ASM associations in different geographic locations and the means to solve ASM problems regarding the essential mining equipment and processing technologies.

After clusterization, the government or any stakeholder that is involved in the mining sector can deliver the required mining equipment and machines, or the clustered ASM associations may have the potential to buy those mining equipment and machines if the government or any financial institute can arrange loans that can be paid back over time in a year of production. Here, the method of clustering will be more effective if it is based on the type of mineral they mine, since the mining equipment and machines required for gold, copper, and gemstone mining purposes are more or less different from each other with some limitations. But in the case of this study, clustering all ASM associations based on the type of mineral they mine has some limitations since some associations are very scattered and far apart from each other. For this reason, clustering with their geographic location and distance from each other and with some extent, based on type of mineral production is a good approach of clustering and zoning.

Conclusion

In Arero woreda, there are a lot of mineral resources that are still not well exploited by ASMs, since almost all ASMs are mine by traditional mining equipment and processing technologies. To make those ASMs more productive with their full potential and to develop wise use of resources, establishing three cluster zones of ASMs, and making available communal mining machines and processing technologies, communal training centers on mining methods, health and safety issues, and communal marketing centers, which are accibel to all ASM clustered zones, is critical to solving problems that are hindering the productiveness of ASMs which are located in Arero woreda. And it is the key to upgrading those ASMs into special small-scale mining companies that make them productive with their full potential. As we know, ASM is one of the main income sources for most people, especially those that live in developing countries of rural areas. So, making empowered those ASMs by essential mining machines and processing technologies with formalized and clustered zoning of ASM associations is the way to improve the lifestyles of those people who live with this mining activity, and it is the best approach to increase the contribution of the mining sector to the GDP of the country.



Figures-4: Map showing Cluster zoning of ASM associations in Arero woreda.

Recommendation*:* In Arero woreda, there are 14 ASM associations that mine gold, copper, gemstones, and other types of industrial minerals and construction materials. But all ASM associations mine with very traditional mining equipment. So, to make those ASM associations more productive and effective, the government or any stakeholder that is involved in the mining sector should establish cluster zoning of ASM associations based on their locational mining sites and type of mineral they mine, and make available the required mining machines and processing technologies to all clustered zones as a form of financial funding or as a form of loan with a long period of payback to the government or any financial debit association. Not only have that, but Arero woreda faces significant challenges to infrastructural development, including accibel road, potable water, and the health sector, among others.

So, the Ethiopian government should develop those infrastructural facilities to make clusterization of ASMs more effective.

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