Impacts of Artisanal Gold Mining on Miners and the Environment in the Asgede Tsimbila Woreda of Northern Tigray, Ethiopia.

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Abstract:
Artisanal gold mining frequently entails a multitude of obstacles, encompassing substandard environmental, health, and safety practices, the proliferation of infectious diseases, and the potential for security issues that may adversely affect neighboring populations. The present study is to evaluate the effects of artisanal gold mining and its related activities on both miners and the surrounding surroundings. Artisanal gold miners engage in subterranean excavation and use shafts to access subsurface deposits. They proceed to extract, transport, and pulverize the ore, subsequently subjecting it to the panning process to isolate gold particles. The primary cause of land degradation can be attributed to surface mining activities. Air pollution arises because of the release of dust and other particulate matter into the atmosphere, as well as the emission of chemicals from industrial processes and the improper disposal of waste into the surrounding environment. In Asage Timbila, the processes of mercury amalgamation and amalgam breakdown are frequently undertaken by women, exposing them to direct contact with mercury. This phenomenon often occurs inside domestic settings, when women are commonly confined to their familial residences. A variety of technological advancements, including cleaner gold processing technologies and alternative methods, have been developed to assist miners in minimizing or eliminating their reliance on mercury. However, miners often lack awareness of these alternative technologies and face challenges in adopting them.

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Introduction:

Artisanal Gold Mining (AGM) is an economic endeavour that predominantly relies on rudimentary traditional mining methods and physical exertion. In recent times, there has been a significant rise in criticism towards artisanal gold mining, primarily driven by concerns over its detrimental social and environmental impacts. Presently, the global AGM activity has facilitated direct employment for over 15 million individuals, with an additional 100 million individuals benefiting from indirect employment opportunities [1]. Artisanal gold mining operations are predominantly characterised by a lack of regulation, informality, and transience. The purposeful use of mercury pollution throughout the world has been mostly attributed to the use of mercury in small-scale artisanal gold mining (ASGM). In the majority of instances, a significant portion of the mercury used in the processing of gold ore is released into the

atmosphere or discharged into the surrounding environment and adjacent water bodies, so allowing for its potential uptake by various organisms [2]. The Annual General Meeting (AGM) is also linked to substantial environmental deterioration, encompassing the contamination of air, land, and water with poisonous substances, the devastation of plant and animal life, geological instability resulting in landslides, floods, erosion, and tremors, degradation of the landscape, as well as the presence of radiation hazards.

Artisanal small-scale gold mining in Ethiopia predominantly comprises a multitude of individuals and micro firms engaged in informal activities, primarily focused on the extraction of placer gold and gemstones. Gold extraction in Tigray, as well as various other regions of Ethiopia, has predominantly been carried out from placer deposits. The AsgedeTsimbila and Lalay Adiabo regions are characterised by significant levels of both seasonal and permanent mining activity conducted by artisanal gold miners. There exists a notable proportion of children and women who engage in mining endeavours. The artisanal gold mining activities within the research region exhibit a lack of organisation and consistency. The consequences of mining operations pose significant challenges to both the well-being of mine workers and the ecological integrity of the surrounding surroundings. Hence, it is imperative to assess the ramifications of artisanal gold mining and its associated activities on both the mine sites and the surrounding ecosystems.

Location of the study area:

The present study was carried out in the Tigray area of Ethiopia, focusing on the woredas (administrative divisions) of Asgede Tsimbla and LaelayAdiabo. These particular woredas are renowned for their significant artisanal gold production, as depicted in Figure 1. The study area exhibits two distinct seasonal weather patterns: the wet season, occurring from June to September, with an annual rainfall ranging between 500 and 750 mm, and the dry season, spanning from October to May, with sporadic rainfall in the remaining months. The mean yearly temperature fluctuates within the range of 20 to 25°C, while the height varies between 770 and 2300 metres above sea level (m.a.s.l.).

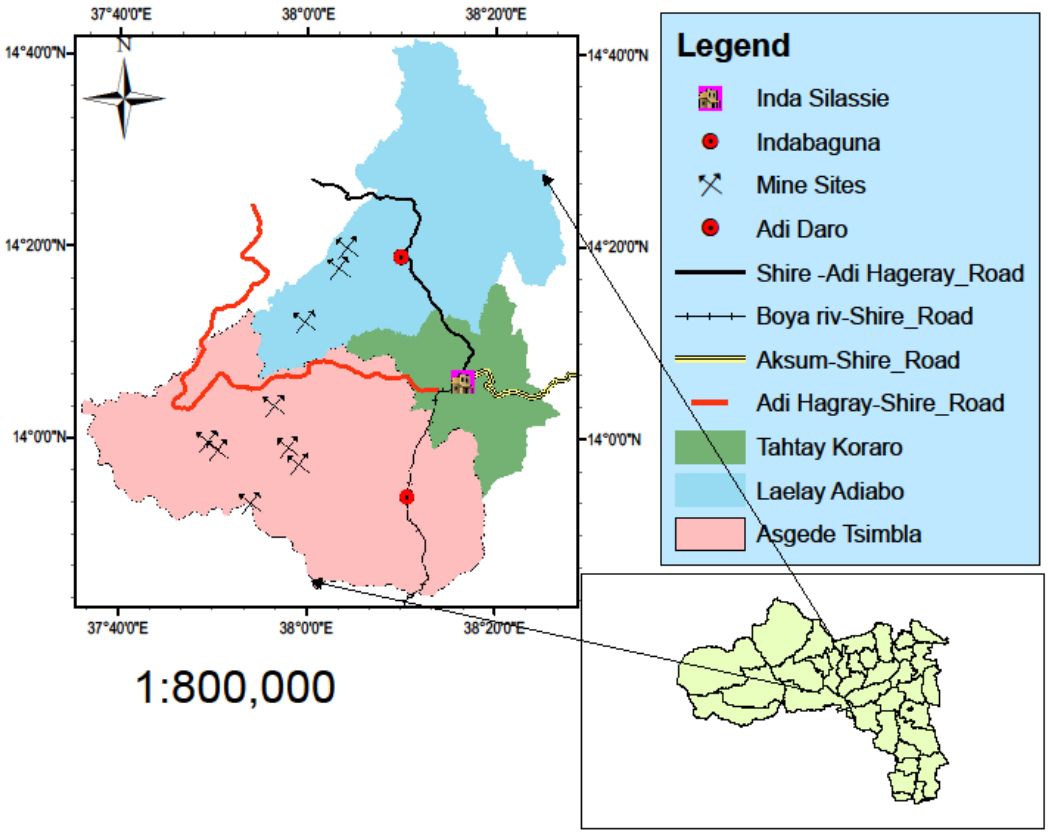

Figure 1: Location map of the study area [1]

Geology of the study area

The Precambrian basement rocks can be categorised into four main groups. Firstly, there is the lower Tsaliet Group, which is primarily composed of metavolcanic and volcanic rocks that formed approximately 850 million years ago [3]. Secondly, there are the metasedimentary rocks that make up the Upper Tambien Group, with an age range of 835-740 million years [4, 5]. Thirdly, there is the Didikama formation, which is predominantly composed of dolomite. Lastly, there are the younger diamictites and the intrusion of intrusive plutons, including sytectonic and postctonic granitoids, with ages ranging from 800 to 520 Ma, caused alterations in the Precambrian rocks and served as a heat source for hydrothermal fluids. This thermal activity led to the mineralization of basic metals and gold in the local area [6-9]. The geological composition of the research area is primarily characterised by the presence of agglomerated Meta, philite, and graphite shale, as well as mafic and ultramafic rocks. Additionally, quartz shale and sericite feldspar, metasediments, granite, granitoids, and intrusive volcanic formations are also prevalent within the region. Figure 2 provides a clear representation of the geological characteristics of the study area.

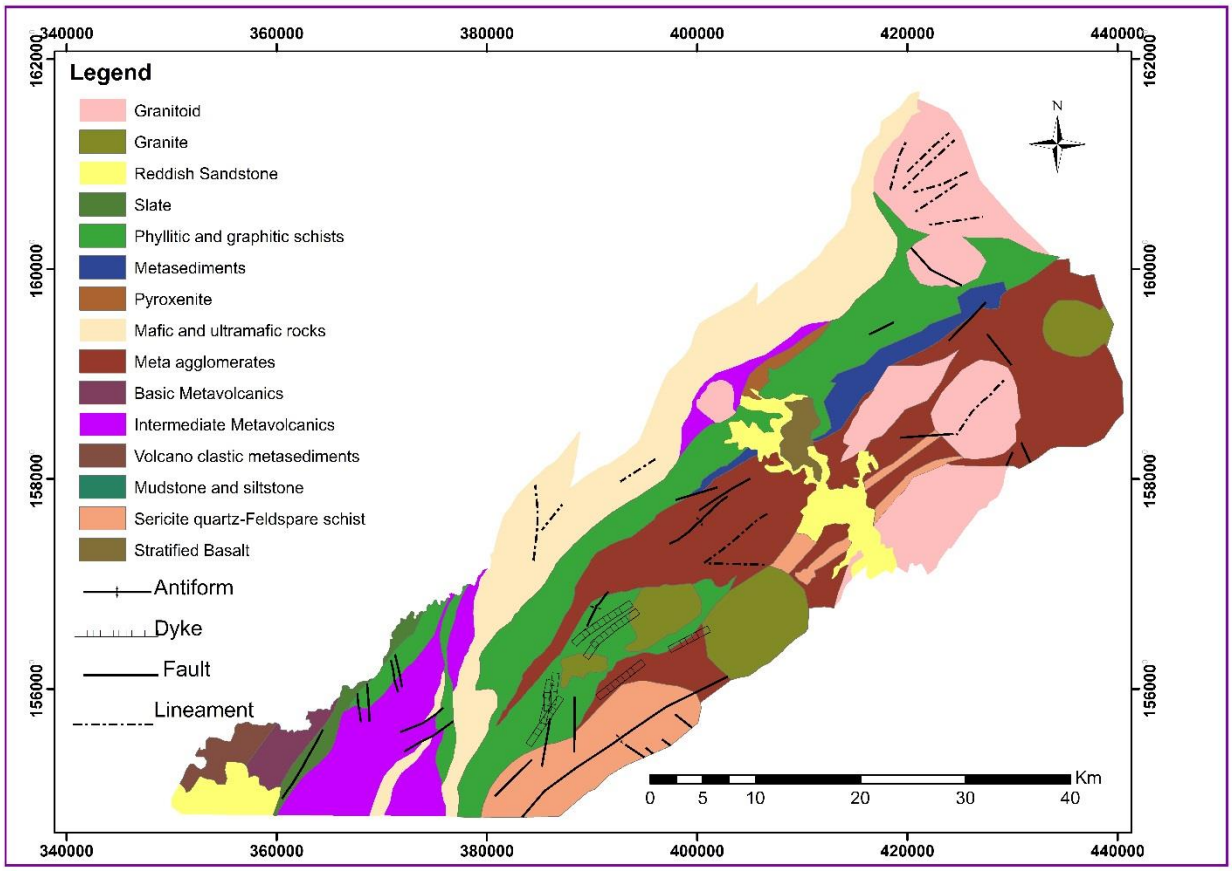

Figure 2: Geological map of the study area (modified from n.rao.et.al 2019)

Methodology:

This study examined current publications, books, articles, and pertinent regulations related to artisanal gold mining and related enterprises to acquire data. The study focused on qualitative research, however, a minor amount of quantitative research was used for data collection and analysis. Interviews, observations, and literature reviews were used to gather data on people's opinions on artisanal gold extraction and its environmental impacts. Interviews with locals, traditional gold miners, the government, and specialists provided the necessary data. Semi-structured questions guided interviews. Processing, analysis, and interpretation followed field data collecting. The study used observation and interview data to understand the extraction method, processing procedures, equipment, and risks to artisanal gold extraction in the study region. GPS was used to map artisanal mining areas and photograph them.

Result and Discussion

The majority of artisanal gold mining activities are attributed to the extraction of alluvial gold, which originates from hard rock gold ore deposits because of erosion and weathering processes. In contrast, a significant amount of primary gold (tsinsi) was extracted through excavation at an average depth of 35 metres beneath the surface of compacted rocky terrain. Approximately 85.94% of miners concur that the primary factor contributing to the loss of life in artisanal gold mining (AGM) is the utilisation of artisanal gold extraction techniques and associated processing equipment. Consequently, the individuals in question were subjected to various challenges, resulting in significant repercussions on the surrounding ecosystem, as examined and

deliberated upon.

AGM mining and processing methods

At AsgedeTsimbla and LaelayAdiabo, artisanal gold extraction methods include deep mining, surface mining, and surface mining. Tilket mining was used in May-Silay to gather deep alluvial deposits along river banks and ancient river channels and primary gold, notably quartz veins, from depths of up to 35 metres. The data is shown in Figure 3. Deposits are no deeper than 2 metres. Clearing the vegetation and excavating to the gold layer began. Traditional mining methods and equipment were used for excavation. Excavators use shovels, picks, hammers, axes, and chisels. Grinding is done using metal mortars (mogue) and pestles (mewketi). Mesh is utilised for the purpose of sizing. The act of panning is primarily conducted with plastic pans, commonly referred to as Dola pans, although wooden or metal pans are sometimes utilised. The user's text, "[1 & 10]," does not provide enough information to be rewritten in an academic manner. Mercury and cyanide are frequently employed in artisanal gold mining as prevalent methods for achieving the ultimate gold recovery outcome. Mercury was employed in the amalgamation process as a cost-effective method for the retrieval of minute gold particles from sediment [11, 12, 13].

Figure 3: Deep mining techniques with sloping depth up to 35meters in the location May-Silay(Photo).

Effect of Artisanal Gold Miningon Miners

The mine workers subjected to some of the worst forms of working conditions, leading to injury, exposure to toxic chemicals, and even death during all stages of mining. Artisanal Gold miners dig shafts and work underground, pull up, carry and crush the ore, and pan it for gold. Consequently, injuries, eye and other skin attack by dirty and chemical solution (water) are common in Adim-Mehameday, Adi-Nigsti, Meli, and Rahwa. About 85.94% of the miners selected for interview agreed that the techniques of Artisanal gold mining and processing equipment on use were the major cause dangers up to life loss in AGM.

When they tried to extract ore from deep shafts with competent host rock are firing light oil were used for burn and weaken the hard rock so as to mine the ore easily shown in Figure 4. But they were facing problems related to respiratory system due to the effect of poor ventilation system inside the mines. They might, also collide with the walls of shaft due poor lightening.

Figure 4: (a). Light oil used for firing the host rock, (b) deep shafts with competent host rock (Photo)

Miner also sustained injuries from falling rocks and sharp tools, and have fallen into shafts. They worked with very unstable and troublesome formation within depths about 35 meters shown in Figure 5. Consequently, they risk grave injury when working in unstable shafts, which sometimes collapse or prone to slope failure.

Figure 5: (a) rock fall and initial stage of caving, (b) caving inside the host rock (Photo)

The transportation of ore over long distances through a shaft, as well as the process of crushing the ore using the heavy traditional tools known as "Mewketi" and "Mogue," posed significant risks to the lives of miners. A significant number of artisanal miners experience considerable discomfort in their cranial region, cervical region, upper extremities, or lumbar region, and face the potential of sustaining chronic spinal damage due to the arduous task of bearing substantial loads and engaging in repetitive vertical movements within the mining pits.

Based on the data collected from interviews and observations, it was found that in the majority of the surveyed areas, around 93.75% of respondents identified the lack of water availability, insufficient awareness, and outdated mining technology as the primary challenges. In addition, miners would transport milled ore across considerable distances to locations where water resources were accessible. Another concern that arose was the increased cost of transportation and its impact on public health.

In Adimehameday and Meli sites, significant health concerns were observed, including exposure to dust leading to silicosis, exposure to mercury and other toxins, adverse effects resulting from poor ventilation such as heat and lack of oxygen, as well as the consequences of overexertion, unsuitable workspaces, and inappropriate equipment. The prolonged transit of materials both within and outside of mine excavations has resulted in excessive physical strain on miners, as reported by the respondents and observed throughout the study. The use and processing techniques employed constituted the primary source of challenges encountered by miners. The objective is to enhance gold processing practisesin order to reduce the utilisation of hazardous mining and processing techniques. Gravity concentration methods are widely employed in the extraction of gold due to their prevalence and reliance on the relative density of gold in comparison to other minerals. Various gravity concentration processes often employed in mineral processing include panning, sluicing, utilisation of shaking tables, and deployment of spiral concentrators.

The Environmental Implications of Artisanal Gold Mining

The environmental impacts associated with AGM (artisanal and small-scale gold mining) are comparatively greater in magnitude as compared to alternative mining methods. One of the challenges associated with the AGM (Airborne Gaseous Emissions) is the substantial concentration of polluters within a specific geographical area, resulting in notable localised effects. Controlling, monitoring, and enforcing environmental infractions posed significant challenges attributed to resource scarcity, informality, and the sector's inherent inaccessibility. The Annual General Meeting (AGM) has been found to have adverse effects on both the physical and social environment across the various phases of mining, as depicted in Figure 6. The AGM company caused significant environmental harm as a result of its inadequate environmental, health, and safety practises. The primary environmental issues identified in the Asged-Tsimbla and LaelayAdiabo regions include river damage in alluvial areas, river siltation, erosion damage, deforestation, inadequate closure practises, landscape degradation, incorrect disposal of solid waste, and mercury pollution.

Figure 6: Impact of Artisinal gold mining in the Asged-Tsimbla woreda (Photo)

Multiple factors caused the study area's significant environmental consequences. Both surface and Tilket mining cause soil degradation and air, water, and noise pollution in the AGM villages in Asged-Tsibla and Lalay-Adiabo. The major cause of land deterioration is surface mining. Dust and other particles, chemicals from production, and waste disposal have caused air pollution. Artisanal mining caused silt issues.

According to a research [14], 95% of mercury used in AGM (absorbent glass mat) gets released into the environment. AGM practises affect the world by transporting mercury air pollution [15]. Dredging and sluicing in mining causes soil degradation and river siltation. River siltation increases suspended sediment, which blocks light transmission and reduces nutrient availability [16]. Mercury and lead can leak into groundwater systems during high rains [17]. Mercury and Lead particles affect nearby animals like humans [18]. Chemicals and suspended particles pollute water. Due to chemical contamination and mining waste, many communities' water supplies are expected to be poor. Water quality assessments on major streams and source locations are needed to detect pollutants beyond WHO standards. The main causes of the problem are a lack of knowledge about best practises, inadequate training, poor technological systems, human oversight issues, ineffective regulation enforcement, fiscal constraints, limited accessibility, and a lack of awareness about advanced procedures.

Health Impacts due to Mercury Exposure

Mercury's health impacts may appear gradually. An extensive review of scientific literature found that Artisanal and Small-Scale Gold Mining (AGM) communities are prone to neurological and renal complications, as well as immunotoxic and autoimmune effects from mercury exposure [19]. When amalgamating gold with mercury and using heat to separate the gold, miners are exposed to mercury, a highly toxic substance. Mercury's negative effects are gradual. Concerns exist about include all vulnerable children and women at the Annual General Meeting (AGM) in Asgede-Tsimbla and Lalay-Adiabo. Miners call Mercury an excellent gold recovery acid since they don't know its exact name. They also know little about Mercury's effects on humans and the environment. According to interviewees, mercury has been illegally used in Adi-Nigsti, Adi-Mahameday, Hitsats, and May-Hanse. Mercury exposure usually causes cognitive impairment, developmental delays, epileptic episodes, and visual and hearing abnormalities. Mercury exposure is more harmful to the

cardiovascular and central nervous systems [20]. Mercury poisoning has severe health effects on youngsters. Excessive exposure might cause coma or death [21]. Mercury exposure increases pregnancy abnormalities and miscarriages in women [22]. Many women report menstrual cycle issues [23]. Mercury poses major health risks, yet many artisanal miners are unaware of this. Without medical expertise, diagnosing the illness might be difficult. The amalgamation process exposes women in artisanal gold mining to mercury, increasing their health risks [24]. Mercury exposure is harmful to both genders, although societal factors often increase women's exposure. Thus, such exposure has greater physical effects on women. Women in Ethiopia and other countries do mercury amalgamation and decomposition, exposing them to mercury. This happens in home settings because women are usually restricted to their families. Direct open-air burning can separate mercury from mercury-gold amalgam in homes or small structures near the mining site. Mercury vapours increase in these restricted spaces, exposing people to this dangerous chemical. Combination is sometimes done using stoves and kitchen equipment, which women, the main food producers, manage.

Mercury reduction has been the main focus of AGM health and environmental mitigation. AGM practises have improved, largely by moving mining away from residential areas and villages. Children and others are exposed to less lead due to these modifications. Miners are also instructed to wash their hands and clothes before returning to their villages after processing.

Regulating Artisanal Gold Mining

In the majority of global regions, governmental mining policies predominantly prioritise large-scale mining operations. The government exhibits a degree of tolerance towards the majority of artisanal mining activities, even extending to those conducted beyond the confines of officially designated mining locations. The strategy is primarily characterised by a non-interference stance and a disregard for the prevalent issues of poverty, child labour, and mercury usage in artisanal mining.

As per the statements provided by local chiefs, the majority of artisanal mining sites are situated beyond the officially recognised boundaries, posing challenges for regular monitoring and supervision efforts. The regulatory and supportive measures for the sector were not effectively implemented. Consequently, the task of augmenting miners' earnings, mitigating environmental repercussions, and tackling health and safety concerns proved to be challenging. Solely relying on technically oriented techniques is insufficient in addressing environmental challenges. The successful implementation of technical solutions necessitates a comprehensive understanding of the cultural, social, economic, and organisational milieu in which the miners operate. The resolution of environmental issues necessitates the implementation of technically sound solutions that are culturally appropriate. Furthermore, a comprehensive approach is essential for the successful implementation of these changes.

Conclusion

The mining and processing techniques used in the artisanal gold mining (AGM) districts of AsgedeTsibla and Laelay Adiabo include deep, surface, and shallow mining operations. The annual general meetings (AGMs) held in both locations were fully manual and relied on equipment that needed a large amount of effort. Artisanal miners' mining and gold processing techniques and instruments were distinguished by a lack of safety precautions, inefficiency, and devotion to traditional practises. The use of these traditional practises resulted in dramatically lower crop yields, as well as increased health risks and negative environmental implications. The mine workers were subjected to very hazardous working conditions, including insufficient ventilation and lighting systems, as well as incidents of ground failure. Mercury exposure provides a major danger to both genders, with women being

especially vulnerable owing to a variety of sociocultural factors. As a result, women tend to suffer more severe health repercussions as a result of such exposure. Females commonly execute the operations of mercury amalgamation and amalgam breakdown, exposing them to direct contact with mercury. This issue is common in domestic settings, as women are frequently restricted to their familial houses. The process of extracting mercury from the mercury-gold amalgam by using direct open-air burning may also be witnessed within residential settings or modest structures positioned near to the mining site. Within these restricted spaces, this approach can result in considerable quantities of mercury vapour exposure. Mercury contamination demands more governmental monitoring and enforcement at both the national and local levels. The adoption of a mining licencing system has the potential to improve environmental management by legalising their operations. The application of mining rules and regulations at the Woredas and higher levels of government should be prioritised by the appropriate authorities. Stringent steps to enforce rules and regulations relating to the usage of protective equipment such as hand gloves, mercury retorts, and tailings ponds would also greatly help to resolving the issue at hand.

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