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ECONOMIC IMPACTS OF ARTISANAL MINING AND ENVIRONMENTAL POLLUTANTS ON FOOD SECURITY IN SOUTHERN AFRICA: A Review

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Abstract

Introduction: Environmental pollutants, including those from mining activities, have become a significant global problem, contributing to millions of deaths and economic losses worldwide, while posing challenges in occupational, environmental, and social domains. This issue is also a public health concern that impacts food security and, consequently, people's health.

Objectives: This paper aims to analyze the economic impact of environmental pollution from mining activities on food security in the Southern Africa region.

Methodology: Published articles available in electronic databases (PubMed, SciELO, ScienceDirect, and Google Scholar) from 2013 to 2023 were reviewed. The selected publications met the inclusion criteria, and the data were analyzed and synthesized into themes of interest.

Findings: This region faces food insecurity despite its richness in natural resources. Artisanal mining is the main economic activity in some areas. The review highlighted mercury as the most used metal in artisanal mining, which has negative environmental impacts that affect agriculture and contribute to food insecurity. Gold is the primary commodity extracted in artisanal and small-scale gold mining (ASGM), significantly influencing economic wealth.

Conclusions and recommendations: Environmental pollution from artisanal mining has adversely affected agriculture and food security in Southern African communities. It is recommended to implement strategies to prevent environmental pollution in small communities where mining activities have a significant impact

Keywords: *artisanal mining, environmental pollutants, food security, economy, Southern Africa*

Introduction

Environmental pollutants have emerged as a global problem in the 21st century, with estimates suggesting that their pathways and effects are contributing to millions of deaths and economic losses worldwide (Entwistle et al., 2019). Among the relevant types of environmental pollutants are chemicals derived from mining activities around the world, which are causing health concerns in affected communities. These activities pose challenges in occupational, environmental, and social domains (Awomeso et al., 2017; Dietler et al., 2021). It is estimated that 150 million people depend on artisanal and small-scale mining (ASM) across 80 countries in the global south, with the African continent being the major contributor to this activity. In this region, global natural resources such as minerals and metals are extracted from some of the poorest countries (Cossa et al., 2022; Dietler et al., 2021; Minerals, 2018).

As artisanal and small-scale mining (ASM) activities continue to grow in many resource-endowed countries in the African region, revenues serve as a precursor to socio-economic growth, especially in mineral-rich rural communities. Despite bringing a wealth of socio-economic benefits, ASM also has particularly destructive effects on the environment, compromising its role as a key factor in sustainable livelihoods and contributing to sustainable development (Hilson & McQuilken, 2014; Ofosu et al., 2020).

Anthropogenic activities lead to environmental pollution through mining discharge and leachates into soils and aquatic environments, becoming a public health concern and affecting food security and, consequently, people's health and nutritional status (Cossa et al., 2022; Jayakumar et al., 2021; Kortei et al., 2020). Heavy metals are the most studied commodities resulting from mining discharges in water, soil, sediment, food, and air (de Souza et al., 2017; Gbogbo et al., 2018; Magwedere et al., 2013; Mambrey et al., 2020;

Mataba et al., 2016; Singo et al., 2022; Wang et al., 2017). However, there is still a lack of understanding of the impacts they may pose on food safety (Cossa et al., 2022; Dietler et al., 2021; Jayakumar et al., 2021).

Thus, it is relevant to understand how environmental pollutants are affecting food safety and how ASM activities are contributing to overall food insecurity in Southern Africa. This region is extremely rich in natural and metal resources (Azadi et al., 2022; Cossa et al., 2022; Govender et al., 2021; Jayakumar et al., 2021; Marcantonio, 2018; Saulick et al., 2017).

This paper aims to provide insights into environmental pollutants studied in economically impacted countries of Southern Africa due to artisanal mining activities, which influence food insecurity. The paper will review relevant topics studied in the region such as: (i) the economy and artisanal mining sector; (ii) environmental pollutants over the past decade; (iii) vulnerable groups exposed in mining settings; (iv) food insecurity and artisanal mining; and (v) paths and solutions for sustainability.

Methodology

A peer-reviewed literature search (Levac et al., 2010) was conducted in duplicate to identify all available articles from 2013 to 2023. Publications were selected from databases (PubMed, ScienceDirect, SciELO, and Google Scholar) based on titles and abstracts, according to the following inclusion criteria: 1) studies specifically on artisanal mining in the Southern Africa region, 2) effects on agriculture and the environment, 3) impacts on social and economic domains, and 4) effects on food security. A descriptive and thematic approach was used to characterize and synthesize the content of the included articles.

Economy and artisanal mining sector

Artisanal and small-scale mining and economic development

Worldwide, around 150 million people across 80 countries in the global south depend on ASM activities, of which 40 million are workers. In the African continent alone, 54 million people depend on this activity, with an estimated 9 million ASM operators.

Southern African countries have vast potential for mineral resources that drive socioeconomic development and contribute to Gross Domestic Product (GDP)(Mozambique, 2023; Wilson et al., 2015). This sector has shown positive performance due to increased capabilities and the liberalization of mining companies in these countries. Among the minerals explored, gold has demonstrated an increase in annual production and revenues, contributing significantly to the countries' GDP. For example, in Mozambique, gold production recorded a growth of 65.3% in 2022 compared to 2021(Mozambique, 2023).

Seccatore et al. (2014) state that in 2013, The Global Mercury Assessment (UNEP) estimated that ASM of gold released approximately 727 metric tonnes of mercury (Hg) into the environment per year, representing 37% of the global 1960 tonnes of Hg released annually by anthropogenic sources into the environment.

At the microeconomic level, Artisanal and Small-Scale Gold Mining (ASGM) brings benefits to individuals, both miners and their families, driven by the need to generate cash for daily life needs such as food, children's education, healthcare, clothing, and shelter, all important components of the Millennium Development Goals (MDGs). In Southern Africa, this activity is seen as an alternative source of income, especially given high levels of unemployment and poverty, making ASGM a primary means of survival for many participants (Wilson et al., 2015).

Although Wilson et al. (2015) present ASM as the backbone of some local economies facilitating the development of complementary, sustainable, revenue-generating activities, and serving as a source of finance for local investors to run their small businesses, it remains challenging to formalize and establish more extensive registration programs for ASGM, or for governments to encourage alternative, sustainable, and realistic livelihood options that could be easily accepted by miners.

Thus, it is relevant across the region for policies and strategies to emphasize the importance of managing and exploiting resources in a sustainable and transparent manner to raise living standards for African populations and future generations.

Challenges posed

Apart from the previously presented benefits of ASGM, in many African settings, this activity may lead to a decline in income. This is because people tend to invest time and

money in purchasing equipment without obtaining sufficient gold profits. This represents not only a risky business but also a context-dependent one, as gold-bearing rock is not evenly spread among men and women in the community. Consequently, there is no guarantee that poverty could be reduced (Wilson et al., 2015). Malone et al. (2023) point out that in ASGM settings, one important challenge is to reduce mercury use, taking into consideration the Minamata Convention. However, this requires negotiations with miners to ensure that realistic solutions align with their capabilities and strengths, prioritizing the miners' fundamental economic interests. This could be achieved by properly supporting and following up with them, rather than using an enforcement-driven approach that could push the sector further into shadow economies.

In South Africa, another documented challenge highlighted in Mhlongo et al. (2019) is the issue of abandoned mines, such as in the Sutherland goldfield. This forces people to engage in ASGM activities, leading to socio-economic issues within the communities around the abandoned mines, particularly in reversing efforts to clean up environmental hazards like abandoned mine shafts. At the individual level, the use of child labor implies reduced school attendance, which is likely to limit opportunities for future economic improvement in that community(Wilson et al., 2015).

In general, addressing the diverse economic impacts of ASGM is challenging as it involves deciding which various metrics to use, at what societal level they occur and function, and how to measure and evaluate the direct and indirect pathways of influence (Wilson et al., 2015).

Opportunities raised

According to Wilson et al. (2015), ASGM creates significant economic opportunities and benefits. For instance, women engage in this activity to raise capital for starting businesses. This allows them to transition away from gold mining work, which they perceive as endangering their health, and move back to urban centers. They are directly involved in generating income for themselves and their families. Across Africa, ASGM shares crucial economic drivers that transcend cultural, ecological, geographical, and political differences, despite potential variations among subcultures and environments.

In the policy domain, developing regulations and policies can contribute to the long-term impacts of ASGM, including poverty reduction at the community level. This presents opportunities in the Southern Africa region to establish interactions across social,

environmental, and economic domains. These interactions aid in defining and implementing appropriate policies and actions at various spatial and temporal scales (Wilson et al., 2015).

Environmental pollutants of the past decade

Over the past decade, studies in the Southern Africa region have focused on environmental pollutants, addressing exposure to biological, chemical, and physical contaminants (Bentley & Soebandrio, 2017; Gbogbo et al., 2018; Green et al., 2019; Male et al., 2013; Mataba et al., 2016; Nyanza et al., 2014). These studies investigated a variety of commodities in terms of environmental pollutants in water, soil, and food, as well as in human samples such as blood, urine, and hair (Mambrey et al., 2020; Mataba et al., 2016; Nyanza et al., 2014).

The impacts of ASM tend to increase environmental hazards due to the informal and uncontrollable nature of the activity. This is exacerbated by the composition of the areas, increasing the solubility of contaminants, and making them more available for plant uptake, potentially entering the food chain with associated effects (Adesipo et al., 2020). Furthermore, ASM regions, with associated gold waste deposited on the ground surface and later used for cultivation after abandonment, lead to increased gold waste contaminants such as heavy metals like Lead, Copper, Cadmium, Iron, Mercury, Arsenic, and Zinc.

Studies conducted from 2013 to 2023 (Bisimwa et al., 2022; Kayembe-Kitenge et al., 2020; Muimba-Kankolongo et al., 2022; Muimba-Kankolongo et al., 2021) addressed food safety by investigating chemical pollutants (heavy metals) in environmental (water and food) and human samples (blood and urine). In Botswana, the country with the lowest registered ASM population in 2014, studies (Ditlhakanyane et al., 2022; Eze et al., 2020) investigating chemical pollutants (heavy metals) in soil and plants, also related to food safety. Physical pollutants were poorly assessed in the region, with a study conducted in Mozambique (Carvalho et al., 2014) being related to radiation exposure of workers in mining facilities.

Vulnerable groups exposed in mining settings

Occupational hazards in the mining sector have received significant attention and seen advancements in risk reduction efforts in some areas over the past decade. However,

effective health interventions for miners regarding occupational exposures in this sector are still lacking (Tsang et al., 2019). Studies on mercury exposure have been a primary focus among these investigations, along with other toxic substances such as lead and arsenic. Additionally, concerns have been raised about hygiene and sanitation, the rise of sex workers, and associated reproductive health problems in mining communities.

While there is a focus on workers in ASGM, other relevant subgroups that are not occupationally involved in the activity, such as family members and residents in mining areas, may also be affected by mercury exposure. Exposure occurs across all age groups due to large quantities of semi-volatile elemental mercury released into the air in crowded neighborhoods without emission controls, as well as gold shops regularly burning off mercury into residential streets in towns and cities (Steckling et al., 2014).

Studies investigating health in female and child subjects within specific subgroups, such as pregnant women, women near delivery, or children under 18 months old, do not assess their nutritional needs. However, it is particularly relevant to focus specifically on children due to the potential damage to their neurological systems from chronic exposure to toxic mercury (Steckling et al., 2014).

Food insecurity and artisanal mining

ASM activities result in environmental degradation due to extensive excavation and waste contamination, which can lead to human health problems not only for miners but also for their families and communities (Tsang et al., 2019). This environmental impact from mineral extraction damages productive sectors like agriculture by affecting water and land resources, thus hindering human development through the degradation of natural resources such as water and land (Galli et al., 2022).

One potential mechanism linking artisanal mining to food safety is that alluvial mines need to be located near rivers, benefiting from fertile alluvial silt, which can impact fisheries due to their proximity to river reaches. Additionally, metal leakages increase turbidity, which can lower fish productivity, reduce stocks, and make catches more difficult (Galli et al., 2022).

Barenblitt et al. (2021) demonstrated the causal relationship between artisanal mining and low food production, with farmland being lost to mine conversion areas in mining communities. In these areas, agriculture and poverty play key roles in the trend of

decreasing small-scale agriculture, negatively impacting the economy. In Southern Africa, the environmental richness, and the increased rate of artisanal mining in the past decade have major implications for economic wealth and the future of agriculture and food security (Barenblitt et al., 2021; Galli et al., 2022).

Path and solutions to sustainability

ASM activities are still growing in the continent and the region, prompting an urgent call for solutions to minimize their impacts at various levels. This is crucial for ensuring the sustainability of the activity and its contribution to the country's overall economy. A path to sustainable development has already been outlined by the Intergovernmental Forum on Mining, Minerals, (2018), which involves:

(i) Capacity building and partnerships; (ii) Organizing miners through cooperatives and associations; (iii) Collaborating with large-scale mining companies to benefit from capacity building; (iv) Improving miners' access to efficient and cleaner technologies; (v) Benefiting from capital to support their overall activities.

In Mozambique, some solutions outlined in the Extractive Industry Statistics Report (Mozambique, 2023) include optimizing mineral production, adding value to mineral resources, promoting the participation of the national cooperative and associative private sectors, granting preference to nationals in identifying economically valuable mineralized bodies, promoting gender equity, and ensuring institutional development.

For the success of these solutions, Southern African countries should enhance their multisectoral collaboration in this domain. This includes the social, environmental, health, and economic sectors working together to jointly implement activities that could ultimately benefit the sustainability of future generations. This collaborative effort aims to minimize the risks and hazards associated with ASM activities at all levels.

Conclusions

Environmental pollution from mining activities in Southern Africa leads to reduced food production due to water and land contamination. This decline in agricultural productivity has significant implications for food security, with serious concerns for the economy and human health.

While the rise in mining activities provides an important source of income and economic subsistence for local and rural communities where poverty and unemployment are prevalent, the resulting environmental pollution is causing unprecedented harm to agriculture and fisheries, negatively impacting food security and the overall health of the region's population.

Recommendations

There is a crucial need for investment in science and research across all countries in the region to address environmental and health challenges in mining settings. This includes the implementation of cleaner mining technologies, environmental monitoring programs, sustainable agricultural practices, and policies. Swift and effective measures should be taken to mitigate the impacts of artisanal and small-scale mining (ASM) activities and other environmental hazards on food security and human health.

Future research should focus on the diverse environmental hazards to which ASM communities are exposed, emphasizing pathways of human exposure to pollutants, particularly among the most vulnerable groups. The worsening food insecurity in Africa, exacerbated by factors such as ASM and environmental hazards, poses a significant challenge to achieving global sustainable development goals

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