Assessing the Environmental and Socioeconomic Impacts of Artisanal Gold Mining in Zimbabwe: Pathways Towards Sustainable Development and Community Resilience

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Article

Assessing the Environmental and Socioeconomic Impacts of Artisanal Gold Mining in Zimbabwe: Pathways Towards Sustainable Development and Community Resilience

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Abstract: Artisanal gold mining provides critical livelihoods for many Zimbabwean communities but also causes severe environmental degradation and social challenges that undermine sustainable development. This study investigates these impacts through qualitative interviews with miners, residents, officials, and environmental experts in mining areas. Key findings reveal significant ecological damage, including deforestation and water contamination, as well as adverse effects on community health and livelihoods, reflecting a trade-off between immediate economic benefits and long-term sustainability. It is recommended that training and support be implemented to help miners adopt safer, environmentally friendly techniques that mitigate these impacts. By evaluating current policies and proposing practical interventions, the study contributes to the discourse on balancing economic development with environmental conservation, aligning with the Sustainable Development Goals.

Keywords: artisanal gold mining; environmental degradation; community resilience; sustainable development; Zimbabwe

1. Introduction

Artisanal gold mining (AGM) has become a significant economic activity worldwide, particularly in developing countries. This form of mining, characterized by small-scale and informal operations, provides essential livelihoods for millions in regions with limited formal employment opportunities [90]. The rapid expansion of AGM raises significant concerns regarding its environmental and social impacts, as nations face increasingly complex challenges in navigating the dual imperatives of economic advancement and environmental sustainability [28, 67]. The interplay of these factors necessitates a nuanced understanding of the implications of artisanal mining within a broader global context.

Artisanal mining is widespread in sub-Saharan Africa, serving as a vital source of income for disadvantaged communities. Countries such as Ghana, Mali, and the Democratic Republic of the Congo have seen a rise in artisanal mining activities, driven by the allure of gold and the need for economic survival [34]. While AGM offers immediate financial benefits, it also poses considerable environmental risks, including deforestation, soil erosion, and water pollution [13]. The lack of a regulatory framework governing gold mining often exacerbates environmental challenges, leading to sustained ecological degradation that threatens the livelihoods of both animals and human beings [33].

Zimbabwe exemplifies the dual impacts of artisanal gold mining. Although the country had observed a rise in Agricultural Growth Models (AGMs) in the previous decades, agricultural practices have recently diminished due to economic instability and climate change [74, 95]. Artisanal mining constitutes a vital income source and survival strategy for numerous Zimbabweans facing systemic poverty and unemployment, though this has caused substantial environmental impacts [70,

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74]. It has been observed that most AGMs are unregulated and do use toxic substances, like mercury, which pose significant health risks to miners and surrounding communities, while simultaneously disrupting local ecosystems and adversely affecting agricultural productivity and biodiversity [30, 59, 67].

The socioeconomic issues associated with AGM in Zimbabwe extend beyond environmental degradation, since artisanal mining frequently leads to social unrest, land disputes, and the displacement of communities, particularly when it encroaches upon agricultural lands and traditional communal areas [23, 30, 74]. The informal nature of these operations makes miners vulnerable to exploitation and unsafe working conditions, thereby worsening existing inequalities [74]. Social tensions can impede community cohesion and hinder sustainable development initiatives, underscoring the need for comprehensive strategies that consider both the economic benefits and the adverse effects of AGM [30].

This study critically analyses the complex relationship between economic growth from artisanal mining and the need for environmental sustainability in Zimbabwe, by seeking to assess the social and ecological impacts of AGM. This is essential for fostering community resilience and protecting the health of individuals and the environment from the effects of economic activities. Understanding these dynamics is crucial for developing effective policies that enhance livelihoods while maintaining the ecological integrity of mining regions.

1.1. Research Objectives

The objectives that we seek to solve and have answers to in this study are:

1. To assess the environmental impacts of artisanal gold mining on terrestrial ecosystems, aquatic resources, and biodiversity in affected regions, and to propose evidence-based mitigation strategies to minimize these effects.
2. To examine the socioeconomic consequences of artisanal gold mining on local communities, focusing on social dynamics, livelihoods, and health outcomes, while utilizing a network perspective to understand the interrelationships among these factors.
3. To provide stakeholders with actionable recommendations derived from comprehensive socioeconomic and environmental analyses, ensuring alignment between ecological conservation initiatives and sustainable economic development.

2. Literature Review

2.1. Environmental Impacts of Artisanal Gold Mining

Environmental degradation refers to the decline of the natural environment resulting from resource depletion, ecosystem destruction, and pollution, which presents considerable risks to biodiversity and human health, thereby requiring immediate attention and action [8, 17]. The ecological impacts of artisanal gold mining (AGM) are substantial and multifaceted, affecting both ecosystems and the communities dependent on them [58]. The most immediate consequence of AGM is the considerable degradation of forests and ecosystems, which leads to significant deforestation for gold extraction, thereby resulting in considerable landscape modifications [8, 105]. This degradation, therefore, reduces forest cover and disrupts local biodiversity, thereby threatening various plant and animal species reliant on these ecosystems for survival.

According to [5], the decrease in vegetation leads to various interconnected ecological effects, as deforestation results in soil erosion when the protective layer of vegetation is removed. Without roots to stabilize the soil, heavy rainfall can lead to topsoil erosion, thereby reducing the arable land available for agricultural practices [58]. Erosion reduces farm productivity and contributes to sedimentation in nearby water bodies, thereby impacting aquatic ecosystems and water quality [8]. The degradation of ecosystems resulting from AGM causes habitat fragmentation, which isolates species and reduces their ability to thrive [17]. Habitat fragmentation leads to a decrease in biodiversity, as species that rely on large territories may struggle to survive in altered environments

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[24, 92]. The reduction in biodiversity is concerning, as it undermines ecosystem resilience and increases vulnerability to diseases, pests, and climate change.

The persistent impacts of mining on land rehabilitation pose a significant concern, as the likelihood of effective restoration following land mining is often low [81, 107]. Research indicates that issues related to mining, including soil compaction, chemical contamination, and alterations in hydrology, significantly hinder the restoration of land to its original state [83]. Rehabilitation efforts can span decades and may fail to restore ecological functions before mining activities are fully restored. In contrast, mining waste, which contains hazardous substances used in gold extraction, poses additional environmental risks [81, 107]. Tailings, the residual materials remaining after extraction, can release harmful compounds into soil and waterways, thereby contributing to ecological degradation [51, 106]. This contamination hurts local flora and fauna, posing health risks to communities that rely on these environmental resources.

2.1.1. Contamination of Water Sources

Water contamination is a significant environmental issue associated with artisanal gold mining (AGM), which has adverse effects on ecosystems and human health [9, 24]. The authors argue that gold extraction methods often employ toxic substances, chiefly mercury and cyanide. These compounds are utilized in gold extraction from ore; however, their introduction into adjacent water bodies poses considerable risks, leading to significant contamination of surface and groundwater resources [2, 50]. Artisanal miners frequently use elemental mercury for the amalgamation of gold particles, a technique recognized for its efficiency and cost-effectiveness. When released into the environment through improper disposal or accidental spills, it can enter the food chain [43]. Microbial processes convert elemental mercury into methylmercury, a toxic compound that bioaccumulates in fish and other aquatic organisms [9, 50]. Communities reliant on these water sources for drinking and fishing experience heightened mercury exposure, leading to significant health consequences, including neurological disorders and developmental issues in children [6, 59].

Cyanide, a chemical frequently used in gold extraction, poses similar risks. Although commonly utilized in regulated industrial processes, its application in artisanal mining typically lacks regulation [7, 12]. However, cyanide leaks or inadequate waste management can lead to the contamination of nearby water sources, rendering them toxic [49]. Cyanide contamination in aquatic ecosystems negatively affects marine organisms, leading to fish mortality and ecological disruption, and poses direct health risks to adjacent populations [12]. Extended exposure to cyanide can lead to respiratory issues, skin irritation, and various serious health problems [49]. Water supply pollution has a substantial impact on agricultural output, and many communities in mining areas rely on local water sources for irrigation and the management of livestock [61]. The decline in water quality due to pollution negatively impacts agricultural productivity, leading to food shortages and economic instability [54]. Contaminated water adversely affects agriculture by enabling plants to absorb harmful substances from soil and water, thereby exacerbating food security issues [67].

Contamination of aquatic ecosystems can trigger a cycle of degradation and heightened vulnerability as water quality and accessibility decline. Communities may be forced to seek alternative sources, often at greater distances and costs [54]. This may lead to increased time and labour requirements, particularly for women and children, who are typically responsible for obtaining water for household purposes [12, 49, 67]. The strain on community resources may intensify tensions and conflicts regarding access to clean water.

2.1.2. Decline in Biodiversity

The reduction in biodiversity resulting from artisanal gold mining (AGM) presents a significant challenge with far-reaching consequences for ecosystems and human livelihoods [25, 75]. Mining operations substantially alter landscapes, disrupt ecosystems, and present threats to various plant and animal species [96]. Gold mining operations result in the destruction of vegetation and

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fragmentation of habitats, both of which are critical for the survival of various species, and likely to result in decreased species populations and, in the long term, lead to local extinctions [25, 105].

Habitat degradation plays a significant role in reducing biodiversity within mining areas. Deforestation and the degradation of natural landscapes result in the elimination of ecological niches for numerous species, which may hurt specialized species that rely on specific conditions for survival [96]. Species experiencing habitat loss demonstrate increased susceptibility to environmental stress, leading to population isolation, which reduces genetic diversity and increases susceptibility to diseases and environmental changes [96, 108]. The authors note that the decline in biodiversity has a significant impact on ecosystem services, which denote the benefits ecosystems provide to humans. These services encompass essential processes, including pollination, natural pest regulation, and nutrient cycling, vital for agricultural sustainability [26]. Crops depend on pollinators, including bees and butterflies, which are often adversely affected by habitat destruction. They may result in reduced crop yields and pose a threat to food security in agricultural regions [26, 84, 96, 108].

The reduction in biodiversity may disrupt natural pest management systems. Predatory species that control pest populations may experience a decrease in their numbers alongside their prey, leading to an increase in pest outbreaks. This, in turn, may lead to a greater reliance on chemical pesticides, ultimately exacerbating the harm to local ecosystems and human health [99]. The interdependence of species within ecosystems demonstrates that the decline of one species can significantly impact and destabilize entire ecological communities. The decrease in biodiversity negatively impacts ecosystem services and diminishes the resilience of ecosystems to environmental changes [96]. Diverse ecosystems exhibit enhanced resilience to disturbances, including climate change, disease, and invasive species [26]. The decline in biodiversity increases ecosystem vulnerability and reduces their ability to adapt to changing conditions, which may lead to further degradation and loss of ecosystem functions [83]. The significance of biodiversity in cultural contexts should not be overlooked, as many societies maintain significant relationships with their indigenous flora and fauna, relying on them for traditional practices, sustenance, and medicinal uses [96, 108]. Therefore, the extinction of species diminishes cultural heritage and has adverse effects on the quality of life for impacted communities, leading to significant social and economic consequences.

2.1.3. Strategies for Mitigation

Various solutions can be implemented to address the environmental challenges linked to artisanal gold mining (AGM). These initiatives aim to enhance sustainable mining practices, optimize waste management, and promote community engagement. Each element is crucial for minimizing ecological impacts and fostering long-term sustainability in mining regions [57, 72].

The adoption of sustainable mining practices is essential for minimizing environmental impact and improving resource conservation. The use of toxic substances, such as mercury and cyanide, in gold extraction significantly contributes to environmental degradation; therefore, utilizing biodegradable alternatives can markedly decrease pollution levels. Investing in environmentally sustainable extraction methods, including plant-derived solvents and bioremediation processes, has the potential to reduce hazardous waste significantly, as these strategies can mitigate the impact on water resources and adjacent ecosystems [11, 19, 71]. Moreover, there is a need for the implementation of more efficient and less detrimental extraction methods to mitigate environmental impact [39]. Gravity separation and panning serve as effective alternatives to chemical processes, which require training miners in these techniques, thereby enhancing productivity and mitigating environmental impact [56, 102]. Effective land use planning in mining operations can minimize habitat destruction and fragmentation, which necessitates the execution of ecological impact assessments (EIAs) before the commencement of mining operations to identify sensitive areas that require protection [42]. Implementing buffer zones around critical areas can improve biodiversity protection, in addition to effective management of mining waste, particularly tailings, to prevent contamination of water resources and adjacent ecosystems [42, 98]. Designing tailings storage facilities to minimize leakage and mitigate environmental impacts can effectively reduce associated

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risks, in addition to continuous assessment of tailings sites for adherence to safety regulations [20, 72]. The promotion of recycling materials used in mining operations helps minimize waste. For example, the utilization of recycled water in processing reduces the demand for freshwater resources and mitigates the overall environmental impact [68, 107]. This, therefore, implies that promoting waste-reduction strategies among AGMs is essential for sustainable operations. Restoration and rehabilitation are crucial after mining operations are completed to ensure the land is restored to a functional condition, which process encompasses the reestablishment of indigenous flora, restoration of soil composition, and rehabilitation of natural hydrological systems [53, 94]. Therefore, formulating rehabilitation plans is essential before the commencement of mining activities to facilitate the incorporation of restoration initiatives within the mining framework.

2.1.4. Community Engagement

Local community involvement in the planning and decision-making processes related to mining activities is crucial for the effective implementation of mitigation strategies [44]. Engaging community members facilitates the acknowledgment of their perspectives, needs, and knowledge, resulting in more effective and culturally relevant solutions [9]. Initiatives aimed at educating and training local miners on sustainable practices could promote environmental stewardship [45, 86]. Workshops and training programs that emphasize reducing pesticide use, improving waste management, and protecting biodiversity can enable communities to engage in proactive initiatives [5].

Engagement with local officials, non-governmental organizations (NGOs), and environmental experts can improve the efficacy of mitigation initiatives [63, 101]. Collaborations offer resources, technical expertise, and financial support for sustainable initiatives, thereby enhancing the effective implementation of environmentally friendly practices [88]. The implementation of monitoring systems that incorporate community participation enhances adherence to environmental regulations and increases accountability [80]. The implementation of feedback systems, enabling communities to express concerns and report issues, enhances the adaptation of initiatives and improves outcomes over time [10].

2.2. Socioeconomic Impacts of Artisanal Gold Mining

2.2.1. Economic Opportunities and Livelihoods

Artisanal gold mining (AGM) is a significant source of income for numerous communities in Zimbabwe, particularly in rural regions with limited formal employment opportunities [74]. In numerous households, AGM serves as a vital source of income, allowing families to fulfil essential needs such as food, education, and healthcare [30]. Artisanal mining offers individuals, particularly women and youth, the opportunity to participate in income-generating activities at their own pace, making it a viable option in regions with limited alternative livelihood opportunities [79]. A considerable number of miners are drawn to the potential for rapid financial gains, particularly during economic recessions when alternative employment options are scarce [46].

Although AGM represents a significant source of revenue, its economic advantages are occasionally overshadowed by the negative impacts associated with mining operations [79, 109]. Although miners can achieve rapid financial benefits, the long-term viability of these positions is often undermined by environmental degradation, health hazards, and social instability [9, 30]. Toxic compounds like mercury and cyanide present significant health risks to miners and their families, in addition to contaminating local water supplies, thereby jeopardizing agricultural productivity and food security [7, 90]. Consequently, communities may become ensnared in a cycle of poverty, wherein initial economic advantages are offset by ongoing costs related to environmental degradation and health issues.

The informal nature of AGMs frequently results in miners operating beyond legal boundaries, consequently restricting their access to resources, support, and protections. Miners lacking formal

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recognition may face challenges in securing land and resource rights, rendering them susceptible to exploitation and disputes over land use [11, 89]. The absence of governmental regulation may hinder the advancement of sustainable practices that benefit both the economy and the environment [36, 57]. Enhancing the positive impacts of AGM on livelihoods requires the implementation of legislation that promotes formalization, provides training and resources for sustainable practices, and ensures the active participation of local communities in decision-making processes related to mining operations [36]. Addressing these challenges allows stakeholders to establish a more sustainable and equitable framework for artisanal mining, fostering economic development alongside environmental health.

2.2.2. Health Risks

The health effects of artisanal gold mining (AGM) are substantial and thoroughly documented, presenting considerable risks to miners, their families, and nearby communities [76]. The use of hazardous substances, especially mercury, in gold extraction poses a substantial risk [104]. Miners frequently manage mercury without sufficient protective gear, resulting in dangerous exposure that can lead to significant health problems, including neurological impairment and cognitive deficits [9]. Exposure to dust and fumes during mining activities can lead to respiratory disorders, negatively impacting the health and work performance of miners [26].

Miners and their families face various health issues beyond chemical exposure, including skin conditions and injuries associated with hazardous working conditions [106]. Artisanal mining involves labour-intensive tasks that typically demand extended hours in challenging environments, thereby elevating the risk of accidents due to insufficient safety protocols [93]. Dermatological issues can arise from exposure to contaminated soil or chemicals, thereby increasing health risks in communities with poor living conditions [106]. The psychological impacts of stress resulting from mining activities, economic instability, and environmental degradation can contribute to heightened levels of anxiety and depression among miners and their families [11, 14].

Limited access to healthcare services significantly increases health risks, rendering communities susceptible to chronic health conditions that may hinder economic productivity [3, 21]. In numerous mining areas, healthcare facilities are limited, inadequately funded, or difficult to access, which restricts individuals' ability to obtain prompt medical care for injuries or illnesses [91]. The lack of access affects miners and their families, as unresolved health issues can hinder their ability to work and earn an income, and mitigating health risks requires comprehensive initiatives, including enhancing healthcare access, implementing safety standards in mining operations, and increasing awareness about the hazards posed by toxic substances [21, 29, 37]. Prioritizing health and safety can therefore foster a sustainable and resilient mining industry that safeguards the interests of all stakeholders.

Social dynamics and conflicts are interrelated phenomena that influence group interactions and societal structures. AGM has a substantial impact on social structures and dynamics within communities, often leading to increased competition for scarce resources. This is because the increasing involvement of humans in mining activities results in a heightened demand for land, water, and other critical resources [62]. The competition may lead to disputes over land rights, as miners could encroach upon areas that have been historically used for agricultural or communal activities. This could erode community cohesion and dismantle social relationships that have been developed over extended periods [1, 60].

Tensions frequently emerge not only from competition for physical resources but also from disputes regarding the allocation of mining revenues within the community [27, 73]. The idea that benefits arising from the AGM exclusively favour a select group may foster resentment among individuals who perceive themselves as marginalized, which is likely to lead to fragmentation within the community, fostering distrust and social instability [52]. Escalating conflicts can result in violent confrontations or ongoing hostilities, consequently jeopardizing social [66].

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The social implications of AGM extend beyond immediate conflicts, as the influx of miners and associated activities may transform established cultural norms and systems. The swift economic transformations induced by mining can alter power dynamics, frequently benefiting resource holders and marginalizing other stakeholders [100]. The transformation may alter established roles within families and communities, leading to social dislocation and a decline in conventional support systems [104]. Therefore, addressing these challenges requires the development of inclusive governance and conflict resolution systems that involve all community members in decision-making processes, thereby fostering a more equitable and harmonious social environment.

2.2.3. Strategies for Improving Community Resilience

Improving resilience in mining communities affected by AGM necessitates the implementation of initiatives aimed at diversifying income sources. Training and resources for alternative livelihoods, including agriculture, small-scale enterprises, and eco-tourism, help communities reduce their dependence on mining as their primary source of income [80, 84]. Diversification enhances economic stability and mitigates risks associated with fluctuations in gold prices and market demand [52], thereby providing households with multiple avenues for income generation.

Enhancing community involvement in decision-making processes is crucial for fostering resilience and promoting a sense of community ownership. Engaging community members in discussions regarding mining operations and their impacts fosters a sense of ownership and accountability for local resources [38]. Establishing platforms for dialogue, such as community assemblies or workshops, enables citizens to express their concerns and collaborate on sustainable initiatives [4]. This participatory approach yields more equitable solutions that consider the interests of all community members, thereby promoting social cohesion.

Integrating educational and awareness campaigns into resilience-building activities equips community members with essential knowledge and skills to advocate for their rights and make informed decisions [47, 104]. Enhancing comprehension of the environmental and health implications of AGM, as well as the importance of sustainable practices, can empower communities to cultivate a stewardship mentality that prioritizes economic growth while preserving environmental integrity [82, 87, 95]. These approaches establish a strong foundation for resilience, enabling mining communities to address the challenges associated with artisanal gold mining.

2.3. Guidance for Reconciling Environmental Conservation with Economic Advancement

2.3.1. Regulatory framework

Regulatory frameworks are essential systems that govern the operations and compliance of various industries [78, 96]. Protocols and criteria are established to ensure accountability and transparency within organizations, and hence, they are crucial for addressing the challenges associated with AGM [99]. Governments should implement more stringent regulations on mining operations to protect environmental integrity and ensure community safety, and this involves imposing restrictions on the use of hazardous chemicals, enforcing land-use regulations, and requiring environmental impact assessments before the commencement of mining activities [35]. A regulatory framework that emphasizes sustainability can help authorities mitigate the negative impacts of AGM on ecosystems and local communities [95]. Regulatory measures must be complemented by governmental support to AGMs with efforts aimed at improving skills training, broadening access to microfinance, and providing resources, which aspects can promote the diversification of income streams for communities dependent on mining. Investing in alternative economic opportunities can help policymakers alleviate pressure on natural resources and foster sustainable economic stability [35, 78, 95]. Therefore, the combination of regulation and support can promote a shift towards more sustainable practices in communities.

Collaboration among governmental entities, local communities, and non-governmental organizations (NGOs) is essential for the effective implementation of these projects [63, 88].

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Stakeholder engagement facilitates the acknowledgment of the needs and perspectives of impacted groups within the policy-making process [32, 41]. Governments can establish more inclusive and effective frameworks to tackle the challenges of AGM by fostering partnerships and encouraging discourse [18]. Hence, an articulated policy plan can improve sustainable mining operations and strengthen environmental health and community resilience.

2.3.2. Community Engagement

Community involvement in policymaking is crucial for the successful execution of AGM legislation. Engaging local communities in the formulation of mining legislation facilitates the integration of their distinct needs and viewpoints, resulting in more relevant and practical outcomes [69]. This participatory approach fosters ownership among community members [16], thereby increasing their likelihood of supporting and adhering to established norms. Engaging communities in decision-making processes enhances transparency and accountability, ultimately strengthening their ability to assert their rights and demand accountability from authorities for their decisions [4]. Enhanced comprehension can foster community cohesion and promote a collective commitment to sustainable practices that safeguard local resources and ensure long-term well-being.

Promoting collaboration among community members, government officials, and non-governmental organizations (NGOs) enhances the inclusivity of the decision-making process [22, 65]. The establishment of communication platforms, including community forums and advisory committees, enhances knowledge sharing among stakeholders, reduces tensions, and fosters collaborative planning that benefits all involved parties [16, 69]. This collaborative approach improves policy outcomes and strengthens the resilience of communities facing challenges associated with artisanal gold mining.

2.3.3. Methods for Environmentally Sustainable Mining

The adoption of sustainable mining practices is essential for aligning economic development with environmental preservation in AGM communities. Training programs for miners enhance stakeholder knowledge of sustainable extraction methods that minimize environmental impact [15, 48]. Initiatives may encompass strategies aimed at reducing the use of toxic chemicals, implementing safe waste disposal procedures, and promoting the rehabilitation of mined areas [15].

Alongside extraction techniques, education on effective waste management is crucial for mitigating the environmental impacts of mining activities [21, 48]. Miners can acquire knowledge regarding the efficient management and disposal of waste materials to mitigate soil and water source contamination [78]. Effective waste management is crucial for communities to minimize pollution and protect natural resources, which are essential for their livelihoods and overall well-being [11].

Educating miners about the importance of water conservation can improve sustainable practices in the mining industry [68]. The acknowledgment of water's critical function in mining activities and surrounding ecosystems requires miners to adopt measures to safeguard this vital resource [21]. Integrating water conservation into training programs promotes sustainability, as noted in [48], thereby enhancing economic development and safeguarding the long-term health of the environment.

2.3.4. Comprehensive Approaches to Sustainable Development

Integrating environmental and socioeconomic factors into development planning is crucial for achieving long-term sustainability in artisanal gold mining communities [78, 80]. This approach acknowledges the need to balance economic benefits with the obligation to conserve natural resources by integrating environmental assessments and community needs into policy frameworks and thereby enabling stakeholders to develop strategies that promote sustainable development and safeguard the ecosystem [3]. This integration can enhance societal resilience in addressing the challenges posed by AGM, as development plans can mitigate the negative impacts of mining

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activities by addressing issues such as land degradation, water resource management, and community health concerns [78, 80, 103]. Implementing programs that support alternative lifestyles in conjunction with mining can enhance economic stability, reduce reliance on a single resource, and foster diverse revenue streams [27]. Facilitating collaboration among governmental entities, local communities, and NGOs is essential for the effectiveness of sustainable policies [99]. Involving all stakeholders in the planning process facilitates the incorporation of varied perspectives, resulting in more effective solutions [5, 80]. This collaborative effort creates a sustainable framework that fosters economic development and prioritizes environmental stewardship, thereby enhancing community health and resilience. The following section presents the materials and methods used in conducting this study.

3. Materials and Methods

This section outlines the research methodology that was employed in conducting this study. This research employed interpretivism, emphasizing the understanding of subjective meanings and individual experiences within their social contexts. This philosophical perspective was particularly relevant for analysing the complexities of AGM and its impact on local communities. The study aimed to clarify the complex social dynamics and cultural influences that shape sustainable mining practices by focusing on the perspectives of community members, miners, and stakeholders. An inductive research methodology was employed, enabling the development of ideas and insights derived from empirical data collected in the field. This methodology was suitable for examining novel events and understanding the experiences of individuals within AGM communities. This study aimed to identify patterns and themes within participants' narratives through the collection of qualitative data, thereby enhancing the understanding of sustainable development in artisanal mining.

This research utilized a case study methodology, focusing on AGM communities to provide a thorough analysis of their social, economic, and environmental challenges. This technique enabled a comprehensive examination of the unique conditions in these communities, facilitating a detailed analysis of their experiences and responses to mining operations. The study aimed to generate thorough, contextual insights by concentrating on examples, thereby contributing to broader discussions on sustainable mining practices. A qualitative research approach was utilized to clarify the complexities of human experiences and relationships within AGM communities. Qualitative methods, such as interviews, enabled the analysis of individuals' perceptions, beliefs, and behaviours, which aligned with the interpretivist perspective, emphasizing the significance of the meanings individuals attributed to their experiences and the social contexts in which they occur.

The research employed a cross-sectional temporal framework, collecting data at a specific point in time to reflect the current condition of AGM communities. This method facilitated an analysis of the current difficulties and challenges encountered by these communities, offering insight into their perspectives. Cross-sectional studies, while unable to document longitudinal changes, effectively elucidated current dynamics and offer timely policy recommendations. Data collection employs qualitative methods, such as interviews with community members, miners, and local stakeholders. The analysis employed thematic analysis to identify key themes and patterns in the qualitative data. Interviews were systematically categorized to identify recurring themes and concepts, which enabled the researcher to establish connections among various data sources, leading to a deeper understanding of social dynamics and sustainable practices within AGM communities. The following section presents results:

4. Results and Discussion

A thematic analysis of interview responses from diverse AGMs in Zimbabwe reveals a multifaceted picture of how artisanal gold mining affects their communities. The miners' perspectives highlight significant economic benefits derived from mining alongside severe

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environmental degradation, health risks, and social challenges. Participants also discussed their views on government policy, community responses, and proposed solutions. The analysis below synthesizes these insights under clear thematic headings, reflecting the range of experiences and viewpoints shared by the interviewees.

4.1. Economic Opportunities and Challenges

Many participants emphasized that AGMs offer substantial economic opportunities, particularly in regions with limited formal employment opportunities. Mining has become a vital source of income for families that might otherwise have no livelihood. To emphasize the importance of gold mining, one responder remarked:

"Through gold mining, I can finance my children's education and procure essential goods for my family."

Indeed, artisanal mining serves as a lifeline for those facing economic hardship, helping alleviate poverty by generating cash flow in mining communities. Several miners noted that their earnings from gold enabled them to invest in better housing, schooling, and small businesses, thereby improving their living standards. Local economies have also benefited indirectly as traders and service providers thrive by catering to the needsof miners. One sponsor involved in mining even observed that profits are sometimes reinvested in public goods, leading to improvements in local infrastructure, education, and healthcare facilities for the community. This aligns with literature suggesting artisanal mining can reduce poverty in resource-dependent areas [85].

Notwithstanding these advantages, miners voiced deep concerns about the volatility of mining income and the fragility of their economic gains. Gold earnings are highly unpredictable; output and prices fluctuate, leading to boom-and-bust cycles. To highlight the unstable returns from mining, one participant remarked:

"In some months, I earn sufficient income to support my family; in other months, I scarcely earn anything."

Several families experience brief periods of prosperity followed by downturns that plunge them back into poverty. This boom-bust cycle was commonly described as an ongoing challenge that undermines financial stability. Additionally, miners noted that when gold is plentiful and cash flows, local prices for essentials often rise, making food and supplies more expensive for everyone—a form of inflation that disproportionately affects the poorest households. Such economic instability can create community-wide effects, and to emphasize this, one miner remarked:

"When gold prices decline, it impacts all. When individuals cease expenditure, local enterprises also endure adverse effects."

This interconnection means that entire villages, not just the miners, feel the impact of the downturns. Moreover, over-reliance on mining was identified as a risk, as participants acknowledged that focusing solely on gold extraction, to the neglect of agriculture or other livelihoods, can perpetuate poverty cycles if mining output declines. Younger community members sometimes drop out of school, lured by quick mining income, which yields short-term gain at the cost of long-term human capital development. The dual character of artisanal mining, its immediate cash benefits versus long-term economic risks, was a recurring theme. While some families have attained a degree of financial security through gold, others remain vulnerable to market shocks and lack a safety net. Participants consistently emphasized that diversifying livelihoods and stabilizing incomes are crucial to converting mining's short-term gains into lasting economic resilience.

One key aspect shown by this part of the study is the economic vulnerability and dependency cycle associated with artisanal mining. The study highlights how entire communities, not just miners, are affected by fluctuations in mining output, emphasizing the risks of over-reliance on gold extraction, which agrees with the view that was given by [72] that there is a need to diversify and not be solely dependent on mining, as this puts stress on the environment. It also underscores the trade-off between short-term financial gains and long-term economic stability, particularly in terms of education and human capital development. The study suggests that diversification of livelihoods is

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crucial to mitigating these risks and ensuring sustainable economic resilience, which aligns with the views of the literature [90].

4.2. Environmental Degradation

A common theme across all interviews was severe environmental degradation caused by artisanal gold mining. Miners spoke with alarm about the damage to land, water, and ecosystems, often despite their reliance on mining for income. Deforestation was frequently mentioned as an immediate consequence of mining operations, as forests and vegetation are cleared to expose soil or create mining pits. To underscore that the community values its environment and is pained by its destruction, one miner lamented and went on to state:

"Each fallen tree represents a loss; we seek not only gold but also the land that nourishes us."

The loss of trees and plant cover has led to habitat destruction and a decline in biodiversity. Several participants noted that some areas once rich in flora and fauna are now barren, with one commenting:

"We are ravaging the land that has sustained us for generations. If we persist in this manner, there will be nothing remaining for our offspring."

This poignant reflection reveals growing awareness among miners that current practices jeopardize the environment for future generations. In practical terms, deforestation and soil disturbance have led to soil erosion and land degradation, as fertile topsoil is stripped away, leaving gullies and abandoned pits to scar the landscape. In farming communities, this is especially damaging as fertile fields become unproductive, undermining food security and traditional livelihoods.

Another primary environmental concern raised in the interviews is the pollution of water resources due to mining. Most artisanal miners use mercury and sometimes cyanide to extract gold, an inexpensive technique with dire consequences. Participants observed that mercury runoff from processing sites has contaminated local rivers and streams, poisoning vital water sources. One respondent remarked that:

"The rivers we once drank from are now contaminated."

Community members can no longer rely on these waters for drinking, bathing, or irrigation without risking health. Miners described water that runs turbid with sediment and laced with chemicals, killing fish and rendering the water unsafe for humans and livestock. Participants expressed a worry about aquatic life die-offs and the endangerment of animals that rely on streams. Several interviewees in mining communities noted that even laundering clothes or using river water for daily chores has become dangerous. This corresponds with more exhaustive research on mercury's health hazards [21, 26], and indeed, miners themselves linked environmental contamination to health problems in their villages. In addition to mercury, siltation from soil erosion was mentioned, referring to the washing of loose earth into waterways, which clogs rivers and can lead to increased flooding or stagnant pools. Some miners have observed that abandoned pits fill with water, becoming breeding grounds for mosquitoes and contributing to an increase in malaria in the area. Overall, the decline in water quality was universally regarded as one of mining's most destructive impacts, which concurs with the literature [2, 90, 104].

The interviewees expressed frustration that they lack the resources or technology to mine more sustainably, even though they are aware of the damage, but feel constrained by their circumstances. One participant highlighted the gap between knowing the problem and having solutions by stating that:

"The environmental impact is profound… without modern methods, it is difficult to lessen these effects."

Some miners are aware of safer techniques, for example, using borax instead of mercury to process ore, but they lack access to the training and equipment necessary for these alternatives. Others noted that regulatory oversight is weak, allowing destructive practices to continue unchecked. Despite these challenges, there were hints of a conservation ethic emerging, as a few miners spoke of the need to protect the ecosystem for future generations and appealed for help in adopting better

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practices. The findings in this theme underscore that the environmental impact of artisanal mining, encompassing deforestation and water pollution, is substantial and increasing. Without intervention, miners fear further ecological collapse in their regions. They advocated for reforestation efforts, reclamation of mined lands, and stricter controls on the use of toxic substances. In essence, the discussion aligns with the view of [64] who argue that the community must recognize that environmental stewardship must improve if they are to preserve the very land and water that sustain their lives alongside the pursuit of gold.

4.3. Health Implications

Health concerns pervaded the miners' responses, revealing how environmental issues translate into human suffering. Participants reported a range of health issues associated with mining activities, including respiratory ailments, which are prevalent in both mining and surrounding communities. One miner reported that:

"Daily, we inhale dust and chemicals; unsurprisingly, many of us experience respiratory difficulties."

Several respondents reported that inhaling dust from digging and crushing ore can lead to coughing, chest problems, and diseases such as silicosis and chronic bronchitis. The use of mercury in enclosed or poorly ventilated spaces exposes miners to toxic fumes, causing headaches and dizziness at best, and long-term neurological damage at worst. Indeed, mercury poisoning was cited as a serious issue afflicting miners and their families. One miner remarked that:

"We acknowledge that mercury is hazardous, yet it remains the sole method for efficient gold extraction."

Miners know that handling mercury with bare hands and inhaling its vapor can lead to tremors, memory loss, organ damage, or even birth defects in children. However, without a readily available alternative, they feel compelled to continue using it to retrieve gold. This trade-off between health and livelihood is a source of distress, as miners effectively sacrifice their well-being for economic survival.

Beyond the miners themselves, broader community health impacts were observed. Polluted water and environmental disruption have caused illnesses among villagers, such as gastrointestinal diseases from contaminated water and increased malaria from mining pits. Several participants highlighted the plight of children in mining areas by stating that many miners work with minimal safety measures, and their families can be exposed to mercury or dust at home. There are cases of children suffering skin rashes and other symptoms consistent with toxic exposure. Moreover, several miners deplored the prevalence of child labour in artisanal mining. This aligns with the observation that economic desperation drives some families to involve children in digging or panning, exposing them to physical danger and pulling them out of school [29, 90]. One participant noted regretfully that:

"Numerous children are unable to attend school as their families require their assistance in mining."

This not only endangers the children's health through injury or poisoning but also harms their prospects, continuing a cycle of poverty and limited opportunity. Accidents and physical injuries are another health hazard from interviewees as they recounted incidents of tunnel collapses, falls into pits, or accidents with rudimentary machinery that have maimed or even killed miners. Such tragedies impose a heavy emotional and economic toll on families. Additionally, an indirect health impact raised by some respondents is the rise of sex work and sexually transmitted infections in mining boomtowns. The influx of mostly young male miners has attracted commercial sex workers, leading to higher rates of HIV/AIDS and other STDs in these communities.

There is a strong consensus that health and safety interventions are urgently needed in artisanal mining areas. Miners called for basic protective gear, such as dust masks and gloves, to be made available and at affordable prices. Many participants also indicated that they desire education on safely handling chemicals to reduce inadvertent poisonings and advocated for regular health

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check-ups or mobile clinics in mining regions to treat illnesses early. The connection between environmental protection and health was frequently mentioned, and by curbing pollution, especially mercury in water and soil, the community's health would improve. To emphasize the importance of this, one participant appealed for external help by stating:

"Government intervention is necessary to implement better practices; without such support, we remain susceptible."

Overall, the interviews portray artisanal miners as acutely aware of the health risks they face, from chronic respiratory disease to acute toxic exposure. They feel these risks have been largely ignored or accepted as part of the job due to poverty. However, there is a palpable yearning for change, and miners want to work in conditions where making a living does not mean slowly losing one's health. Strengthening health and safety regulations, improving environmental conditions, and offering healthcare support were all seen as critical steps toward a more sustainable and humane mining practice in Zimbabwe.

4.4. Social Dynamics and Conflicts

Artisanal gold mining has profoundly transformed the social fabric of the communities in which it takes place. Interviewees described a dual-edged social impact, whereby, on one hand, those who strike gold or profit from mining enjoy improved status and wealth. On the other hand, those who do not participate (or who earn little) often remain in poverty, leading to noticeable inequalities and resentments. Highlighting the widening gap even within the same village, one miner remarked:

"It seems there are two worlds here - those who have discovered gold and those who have not,"

The influx of money for some has created envy and competition, eroding the solidarity that once existed among them. Several participants mentioned that visible signs of wealth, such as new houses, vehicles, or consumer goods purchased with gold, contribute to feelings of relative deprivation among neighbors, which has resulted in bitterness and divisions within communities that were previously more egalitarian. This finding aligns with research that the unregulated nature of artisanal mining sometimes leads to outsiders from other regions arriving to share in the bonanza, which can foster tension among residents [22, 27, 93]. Long-time villagers may feel excluded from rich mining claims now controlled by newcomers, adding to us-versus-them sentiments.

With the rush for gold, land-use conflicts have become increasingly frequent as mining sites overlap with farmland or grazing areas, sparking disputes between miners and farmers. Lamenting that mining pits were consuming agricultural land, one long-term resident stated:

"We previously cultivated this land, but now we must struggle to retain what little remains."

As arable land shrinks and water sources are tainted, farmers grow desperate, sometimes clashing with miners whom they blame for lost livelihoods. Interviewees recounted incidents where arguments over who has the right to a particular piece of land escalated into physical fights. There are also conflicts among miners themselves: without a formal title, multiple groups may compete to mine the same gold-bearing area, leading to confrontation. In some areas, violent encounters have occurred, occasionally involving machetes or firearms, as rival groups battle for control. The presence of criminal gangs exploiting the chaotic situation was noted as contributing to local insecurity. Furthermore, the migration of young men into mining zones has sometimes upset local social balances, with cases of theft, alcohol abuse, and other crimes mentioned as rising in mining towns. Community leaders worry that the social cohesion of their villages is fraying under these pressures. The expansion of mining has even caused the displacement of entire families in some instances, as the discovery of a rich deposit under a homestead has resulted in the occupants being forced out of the area to make way for mining. This agrees with the view that uprooting dismantles extended family networks and can sever people's connection to ancestral lands, which has a profound cultural impact [70, 97, 108].

Several miners voiced concern that the traditional way of life and cultural norms are being eroded. One participant said with regret:

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We are losing our way of life. The younger generation is disconnected from our traditions and solely concentrated on mining."

Rituals, farming cycles, and community gatherings have all been disrupted by the all-consuming pursuit of gold. Elders find it harder to pass on cultural practices when youth are preoccupied with mining, and this cultural loss is an often-overlooked social cost of the mining boom. In response to these dynamics, participants strongly advocated for increased community involvement and dialogue in managing the impacts of mining. They felt that inclusive decision-making could ease tensions. When calling for residents to have a say in how mining is conducted and how its benefits and burdens are shared, one interviewee had this to say:

"We must engage in the discourse regarding the impact of mining on us. Our voices hold significance."

Many believe that if miners, farmers, and community leaders sat together, possibly with mediators, they could negotiate agreements on land use, compensation, and conflict resolution. Indeed, some communities have formed committees or associations to address grievances and establish basic rules, such as prohibiting mining near schools or sacred sites. This type of grassroots governance was viewed as crucial in preventing violence and maintaining peace. This study reveals that AGM has introduced significant social stresses, bringing both economic opportunities and inequality, as well as conflict, crime, and cultural disruption. This finding aligns with research that suggests confronting these issues requires fostering social cohesion through open communication, equitable resource management, and respect for cultural heritage, even as the community adapts to new economic realities [5]. Without such efforts, as one participant warned:

"The social cohesion of mining communities is at risk of further disintegration, jeopardizing the potential advantages that artisanal mining may offer."

4.5. Perceptions of Government Policies

The interviews revealed a complex mix of opinions on the government's role and policies regarding artisanal mining. Nearly all participants were aware that laws and regulations on mining exist on paper, and there was widespread frustration with how those policies are implemented. This sentiment captures the prevailing view that government authorities have largely failed to enforce environmental and safety regulations in the artisanal mining sector. Miners described the regulatory environment as inconsistent or even chaotic, as some areas see occasional police crackdowns on illegal mining. In contrast, other areas see officials turning a blind eye or accepting bribes. Corruption was mentioned as a barrier that undermines trust in any official intervention. Several miners recounted that they had no mining licenses and that, although this is technically against the law, enforcement officers rarely visit unless there is an accident or a political motive. As a result, many artisanal miners operate in a grey area, feeling ignored by the state except when they are harassed. This lack of consistent enforcement means that environmental rules, such as bans on mercury use or requirements to fill in pits, are routinely flouted, simply because miners know there is little chance of penalties. The participants expressed that government inaction has essentially left their communities to fend for themselves. Regarding the absence of the state in providing guidance, one respondent said:

"It seems as though we are abandoned to manage on our own."

While criticism of weak enforcement was common, some miners acknowledged recent government initiatives aimed at helping them. For example, a few were aware of programs aimed at formalizing artisanal mining by registering miners and establishing official gold-buying depots, which could integrate them into the formal economy. There have also been training workshops on safer mining techniques organized either by a government ministry or in partnership with NGOs. In theory, these initiatives address miners' needs; however, some miners reported that limited resources and lack of awareness have impeded their success, even though training sessions have reached only a fraction of miners, and many remain unaware of best practices. Several participants had heard of the government's push for mercury-free mining technologies and land rehabilitation projects.

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However, they observed that such programs are typically small-scale or pilot projects, rather than widespread mandates. A recurring critique was that policy measures focus on penalties rather than incentives, and miners believed that simply outlawing certain practices is ineffective when people have no alternative sources of income. Instead, they suggested the government should provide tangible support. One miner reflected that:

> "Rather than merely prohibiting artisanal mining, the government ought to collaborate with us and instruct us on responsible mining practices and supply the necessary tools."

This highlights a desire for a more inclusive and supportive approach from officials. Many believe that if the government collaborated with miners through education, subsidized better equipment, and created legal avenues for gold sales, both the community and the state would benefit, possibly through reduced environmental harm and increased tax revenue. The perception among miners is that current government policies fall short of what is needed to make artisanal mining sustainable. Regulations may be well-intended, aiming to reduce environmental damage and channel mining into formal markets, but without proper enforcement, adequate funding, and community engagement, their impact has been minimal. When summarising the status quo, one respondent said:

> "The government's efforts have been somewhat ineffective… without strong enforcement and better support systems, these policies have had limited success."

At the same time, there is a clear call for more cohesive governance. Many participants want to see collaboration between the government, miners, local community leaders, and NGOs. Such partnerships could bridge the gap between policy and practice by involving those directly affected. For example, the creation of local mining committees or cooperatives, under the guidance of authorities, was suggested to regulate miners from within the community and improve compliance with rules. Some miners praised instances where NGOs and government departments collaborated, such as NGO-led environmental monitoring with government endorsement, and urged the development of more public-private partnerships.

The aspect of the study that aligns with the literature reveals that interviewees conveyed a mixture of hope and skepticism. On the one hand, they expressed hope that, with better policy execution and genuine stakeholder involvement, artisanal mining could be managed for the benefit of all. On the other hand, they harbored skepticism because past promises by authorities had not materialized at the grassroots level [31, 55, 101]. The overarching sentiment is a distinct demand for regulations that both regulate and empower miners, creating a situation where miners are not treated as outlaws but as partners in a transition to sustainability.

4.6. Community Responses and Proposed Solutions

Faced with the challenges above, communities have not remained passive. The interviews highlight that local people are developing their responses to the environmental and social impacts of artisanal mining, even if on a small scale. Notably, community opinions on mining are divided, as some residents remain focused on the economic necessity of mining. In contrast, others voice growing concerns about its long-term consequences, which aspect has spurred conversation and action. In some mining areas, grassroots initiatives have emerged to mitigate damage. For instance, a few miners mentioned that local NGOs and community leaders have organized educational workshops on safer mining practices, which teach miners about the dangers of mercury and demonstrate alternative methods, such as using borax or improved panning techniques, to reduce environmental harm. While such efforts are limited in reach, they mark an important step in raising awareness. Additionally, reforestation projects have been initiated in some areas, as community volunteers, often youth groups or church groups, have begun replanting trees in previously mined areas to restore vegetation cover. In one account, miners themselves agreed to designate certain days for environmental rehabilitation, such as filling in abandoned pits or planting saplings, to give back to the land. Some communities have also experimented with local regulations by establishing their own rules that prohibit mining in riverbeds that supply drinking water, or by setting up a community task force to monitor miners' compliance with agreed-upon practices. These community-led measures

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demonstrate that locals recognize the importance of striking a balance between mining and environmental care. However, participants candidly noted that such initiatives often struggle due to a lack of resources and coordination. Reflecting on isolated tree-planting events that, while positive, remain too small to counter the vast scale of deforestation, one miner stated:

"These efforts are not widespread enough to make a significant impact."

Moreover, without external support, community programs can be underfunded and have a short lifespan. Even so, the existence of these responses demonstrates a proactive mindset as communities are trying to organize and find solutions even in the absence of decisive government intervention. When asked what should be done to improve the situation, miners across the board offered concrete suggestions for sustainable development. A key proposal was the introduction of safer, modern mining techniques, and miners are eager for training in methods that would allow them to extract gold without poisoning the environment or themselves. To emphasize the importance of replacing mercury with alternative processing techniques and the fact that it could significantly reduce water pollution, one participant stated:

"One important measure is providing comprehensive training programs for miners on the use of less harmful chemicals."

Training on proper waste handling and mine site rehabilitation was also frequently mentioned. Many interviewees believe that if they knew how to mine in an eco-friendlier way and had the right tools, they would be willing to adopt such practices. Alongside training, the idea of equipment and technology upgrades arose; miners proposed access to machinery that can increase gold recovery efficiency, thereby reducing the need to dig and process as much ore, thereby lowering the environmental footprint. For example, it was suggested that small portable sluice boxes or modern gold concentrators could allow more gold to be extracted with less labour and less chemical use. Some even suggested using protective technology, such as retorts, to capture mercury vapor, thereby reducing exposure to toxic substances. Another set of solutions centered on economic diversification and alternative livelihoods, as participants emphasized that reducing overdependence on mining is crucial. They suggested programs to support agriculture, animal husbandry, or new enterprises in their communities, aspects that would broaden the community's income base, making it easier to impose sustainable limits on mining. In practice, this might involve NGOs or government agencies providing seeds, farming training, or small business loans to mining families, enabling them to earn a supplementary income outside of the mining seasons. One miner noted that some organizations have initiated alternative livelihood programs in his area, such as beekeeping and market gardening projects, and that these initiatives should be scaled up to reach more communities.

The interviewees overwhelmingly believe that collaboration among stakeholders is the linchpin of any successful solution. They called for a multi-stakeholder approach involving miners, community members, traditional leaders, government officials, and NGOs working together. Several mentioned that artisanal miners should form cooperatives or associations. When united, they could more easily obtain government licenses, access training, share resources, and collectively market their gold for better prices. Such organizations could also foster peer accountability for environmental practices. To emphasize the importance of creating formalized cooperatives and how this could benefit communities, one participant had to say:

"……. improving working conditions for miners helps in increasing the efficiency of gold extraction and thereby reducing the overall ecological footprint".

In terms of governance, participants suggested that there was a need for regular dialogue with authorities, like scheduling community meetings with representatives from the Ministry of Mines or the Environmental Management Agency to discuss ongoing issues. Where local District Development Committees or similar bodies exist, miners want them to actively include artisanal mining in their agenda, rather than treating it as an illegal or taboo subject. Support from outside is also crucial, as interviewees welcomed the involvement of NGOs and international organizations to provide funding, technical expertise, and neutral oversight. They cited examples of NGOs assisting with environmental monitoring or establishing health clinics and expressed that expanding these

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partnerships would greatly benefit their communities. We propose that the solutions proposed by those on the ground form a comprehensive vision, since it aims to educate and equip miners for safer practices, enforce regulations fairly while supporting miners' livelihoods, rehabilitate the environment, diversify economic opportunities, and ensure that those affected by artisanal mining have a seat at the table when decisions are made. As one miner succinctly put it:

"We require improved alternatives; dependence exclusively on gold is unsustainable."

This plea encapsulates the community's desire to strike a balance between economic gains, social well-being, and environmental conservation. By heeding these voices and implementing their suggestions, stakeholders can work towards transforming Zimbabwe's artisanal gold mining sector into a more sustainable and community-centered enterprise.

5. Conclusions

The study concludes that while artisanal gold mining is economically essential for Zimbabwean communities, it incurs considerable environmental and social costs. The key findings highlight extensive deforestation, soil erosion, and water pollution resulting from mining activities, as well as health risks including mercury exposure and dust, and livelihood disruptions in local communities. These impacts underscore the urgent need for sustainable mining practices and robust governance to strike a balance between economic development and environmental protection. The research contributes to policy discourse by incorporating community perspectives and evidence-based recommendations, aiming to align artisanal mining with broader sustainable development objectives.

However, there are apparent gaps that future research can address to build on these findings. Future studies should conduct detailed measurements of environmental pollution, such as mercury levels in water and soil, as well as public health outcomes, to complement the qualitative insights gained from this study. Additionally, longitudinal research is necessary to assess the long-term effectiveness of proposed interventions, such as miner training programs, the introduction of safer extraction techniques, and alternative livelihood initiatives, in reducing environmental damage and enhancing community well-being. Additional investigation into artisanal mining in various regions or countries would help generalize the findings and determine how differing regulatory frameworks and local contexts impact the success of sustainable mining practices.

By addressing these gaps, future research can deepen the understanding of the impacts of artisanal gold mining and guide more effective strategies for mitigating environmental damage while enhancing socioeconomic resilience.

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