

# Socioeconomic Livelihoods and Environmental Degradation: An Integrated Assessment of Artisanal Quarry Mining in Misisi Compound

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## Abstract

This paper examines the socioeconomic, environmental, and health implications of artisanal quarry mining in Misisi Compound, Lusaka, employing a mixed-methods approach that integrates a survey of 134 purposively selected miners with in-depth qualitative interviews conducted with institutional informants from key regulatory bodies, including the Zambia Environmental Management Agency (ZEMA), the Ministry of Mines and Mineral Development (MMMD), the Lusaka City Council (LCC), and the Ministry of Lands and Natural Resources (MLNR). The main conclusion is that quarrying is an essential source of income for extremely vulnerable households with few other viable economic options, but it is still a deeply ingrained paradox because it is a highly informal industry with consistently low and unpredictable pay and operates under a system of lax regulatory oversight that permits hazardous working conditions. Miners face serious health risks at work, including musculoskeletal injuries, exposure to intense heat without proper protective gear, and chronic respiratory illnesses from silica dust. This puts workers in a vicious cycle in which their immediate means of subsistence routinely jeopardize both the ecological integrity of their surroundings and their long-term well-being.

## Keywords

Artisanal and Small-Scale Mining (ASM), Quarry Mining, Socioeconomic Impacts, Environmental Degradation, Zambia, Sustainable Livelihoods, Policy Enforcement

## 1. Introduction

Zambia's development trajectory has long been shaped by the mining sector, par-

ticularly large-scale copper extraction dominated by multinational corporations. However, **Artisanal and Small-Scale Mining (ASM)** has increasingly emerged as an important yet under-documented component of the mineral economy. ASM is typically characterized by low capital investment, labour-intensive techniques, minimal mechanization, and is often undertaken by individuals or small groups operating within weak regulatory frameworks [1]. In many developing countries, ASM provides a critical livelihood option for populations excluded from formal employment.

The **Sustainable Livelihoods Approach** offers a useful framework for understanding this phenomenon, emphasizing how vulnerable households diversify income sources in response to economic insecurity and limited access to assets [2]. Within this context, ASM frequently functions as a coping or survival strategy. Globally, the sector is estimated to support about 40 million people directly and 150 million indirectly [3]. Despite its significance, ASM often operates in a regulatory grey area, exposing workers to occupational hazards, unstable incomes, and social marginalization [4].

Quarry mining, a key subset of ASM, involves the extraction of construction materials such as stone, sand, and aggregates. Its growth has been driven by rapid urbanization and increasing demand for infrastructure development. While it provides employment opportunities, particularly for vulnerable populations, informal quarrying is often associated with unsafe working conditions and environmental degradation. Studies from countries such as India, China, and Brazil highlight issues including low wages, occupational health risks, and weak labor protections [5]. Environmental impacts, such as deforestation and ecosystem disruption, have also been documented in other developing regions [6].

Across Africa, ASM supports approximately nine million people directly and over fifty million indirectly [7]. In countries such as Ghana, Kenya, and Tanzania, quarry mining plays a significant role in supporting the construction sector. However, the activity is commonly associated with hazardous working conditions, lack of protective equipment, and weak regulatory oversight [8] [9]. Economic pressures, including declining agricultural productivity, have further driven households to diversify into ASM as a livelihood strategy [10].

In Zambia, the rapid growth of the construction sector has significantly increased demand for quarry materials. This trend is particularly evident in Lusaka, where urban expansion has transformed land use patterns and intensified the need for building materials. As a result, many unemployed youth and low-income households have turned to artisanal quarry mining as a source of income. The availability of geological resources such as limestone and granite further facilitates these activities.

Despite its growing importance, artisanal quarry mining in Zambia remains largely informal and poorly regulated, leading to a range of socioeconomic and environmental challenges. These include unsafe working conditions, exposure to dust and related health risks, land degradation, and abandoned pits that pose haz-

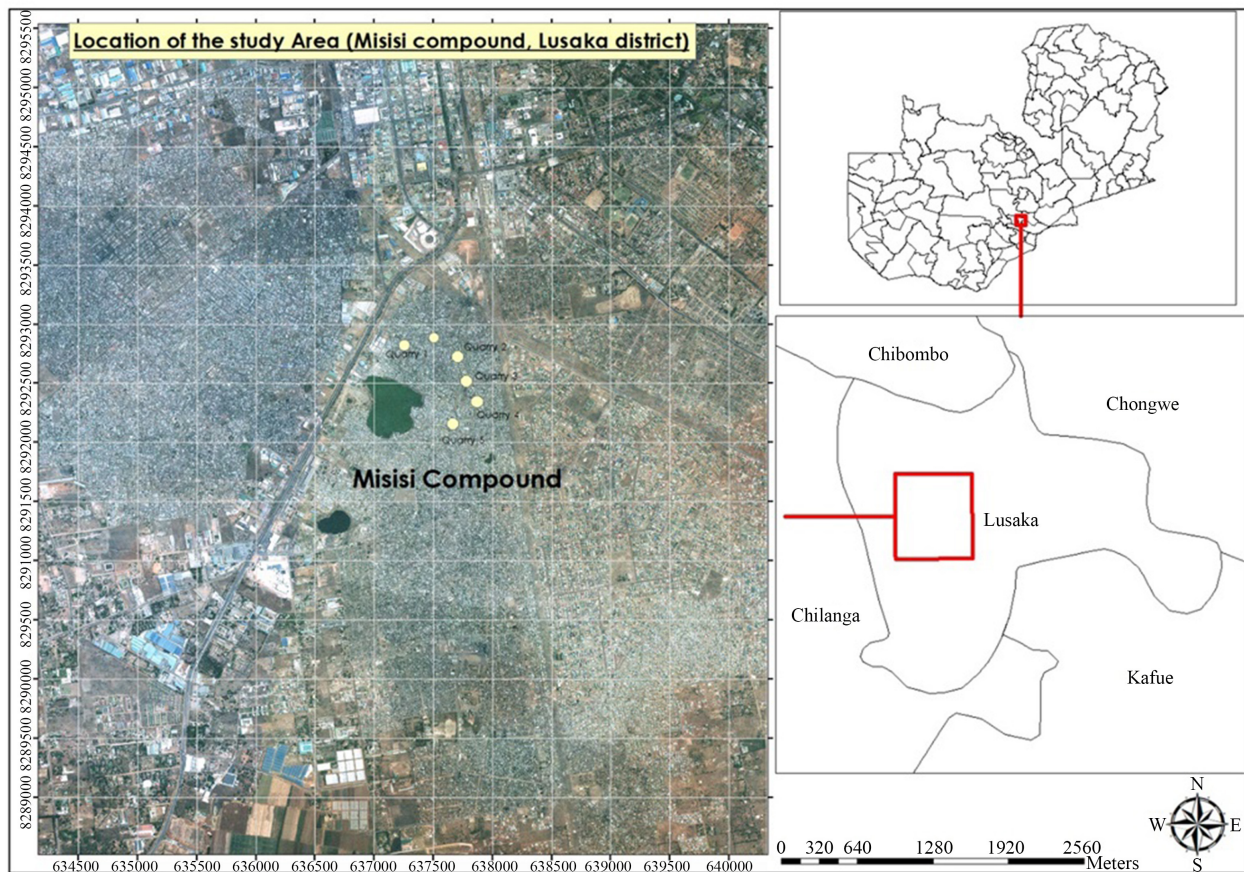
ards to surrounding communities [11] [12]. In Misisi Compound, one of Lusaka's densely populated informal settlements, quarry mining has become a key livelihood activity. However, empirical research on its impacts remains limited, with most existing accounts being anecdotal.

Given this gap, this study examines the socioeconomic and environmental effects of artisanal quarry mining in Misisi Compound. By providing empirical insights into its role in urban livelihoods and its associated challenges, the study contributes to a better understanding of informal mining economies and informs policy interventions aimed at improving sustainability, safety, and livelihood outcomes.

## 2. Materials and Methods

### 2.1. Study Area

The study was conducted in Misisi Compound, a densely populated area within Lusaka District, Zambia ( $15^{\circ}25'S$ ,  $28^{\circ}17'E$ ). Lusaka's geology comprises a Precambrian basement complex rich in dolomite, granite, and limestone, which are extensively quarried for construction. The area experiences significant soil erosion and environmental degradation linked to uncontrolled quarrying activities. **Figure 1** shows a schematic map of Misisi Compound and the surrounding features.



**Figure 1.** Misisi compound, Lusaka district.

## 2.2. Research Design

The study adopted a mixed-methods approach, combining descriptive and exploratory research designs. The descriptive design was chosen because it provides an accurate representation of the characteristics of a specific phenomenon, situation, or group [13]. The exploratory aspect involves systematic collection and presentation of data to gain deeper insights into the socio-economic and environmental impacts of artisanal and small-scale mining (ASM) in the Misisi compound of Lusaka [8].

## 2.3. Sample and Sampling Techniques

The study population consisted of artisanal quarry miners in Misisi Compound, estimated at 250 individuals. To determine a manageable yet broadly indicative sample size, Slovin's formula was applied with a population size of  $N = 250$  and a margin of error  $e = 0.0588$ , yielding a computed sample size of approximately 134:

$$\begin{aligned}n &= \frac{N}{1 + N(e)^2} \\ &= \frac{250}{1 + 250(0.0588)^2} \\ &\approx 134\end{aligned}$$

Although this calculation yielded a target figure, the sampling itself was not probability-based. Given the fluid, informal nature of artisanal mining in the compound, no complete and reliable sampling frame listing all 250 miners was available from which random selection could be conducted. Consequently, 134 respondents were selected using a purposive sampling strategy. Selection focused on individuals directly and actively involved in quarry mining, and targeted those who could provide relevant, experience-based insights into the working conditions, environmental practices, and governance challenges under investigation. The figure of 134 served as a recruitment target to ensure substantive coverage of diverse roles and perspectives within the population, not as a statistically representative sample in the probabilistic sense.

In addition, 20 key informants were purposively selected from institutions with direct regulatory or policy responsibilities in quarry mining and environmental management: the Zambia Environmental Management Agency (ZEMA), the Ministry of Mines and Mineral Development (MMMD), the Lusaka City Council (LCC), and the Ministry of Lands and Natural Resources (MLNR). These informants were chosen for their specialized knowledge and institutional vantage points, enabling in-depth exploration of governance and compliance dimensions.

## 2.4. Data Collection

Primary data were collected using semi-structured, researcher-administered questionnaires for the miners. The key informant interviews were conducted with a separate interview guide. Both instruments were pilot-tested to ensure validity

and reliability. The questionnaires covered demographics, mining activities, socio-economic impacts, environmental effects, and policy awareness. Journal articles, institutional reports, and published articles served as sources of secondary data. After distributing the questionnaires, the research team collected them from the miner respondents within a specified timeframe. The 134 surveys received a remarkable response rate of 100 percent, indicating that the intended audience was highly engaged. The survey response rate is presented in **Table 1**.

**Table 1.** Survey response rate.

Number of Questionnaires Issued	Number of Questionnaires Answered	Number of Questionnaires Unanswered
134	134	0
100%	100%	0%

## 2.5. Study Population and Data Sources

The results presented in this section are based on a cross-sectional survey of 134 artisanal quarry miners in Misisi Compound, Lusaka. Although the broader study design included both miners and community members, the quantitative findings reported here relate exclusively to miners. Insights from community members are incorporated only in the qualitative discussion, where relevant.

In addition, a qualitative strand was conducted involving 10 key-informant interviews (including local leaders, health workers, and experienced miners). Data were analyzed using Atlas.ti, following a structured process of open coding, code grouping, and theme development. Emerging themes (e.g., livelihood dependence, perceived environmental change, and health risks) were triangulated with survey findings to enhance interpretation.

## 2.6. Data Analysis

Quantitative data from the surveys were analyzed using SPSS version 23.0 and Microsoft Excel. Descriptive statistics (frequencies, percentages) were generated. Qualitative data from open-ended questions and key informant interviews were analyzed using thematic analysis. This involved coding the data, identifying recurring themes, and presenting a narrative synthesis. Thematic analysis was facilitated by software called Atlas Ti to ensure a systematic and transparent process.

## 2.7. Ethical Considerations

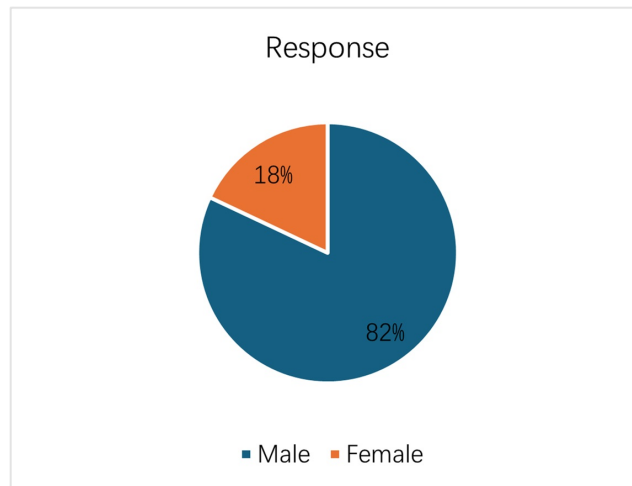
Ethical clearance was obtained from the relevant authorities. Informed consent was secured from all participants. Anonymity and confidentiality were maintained by not recording identifying information.

## 3. Results

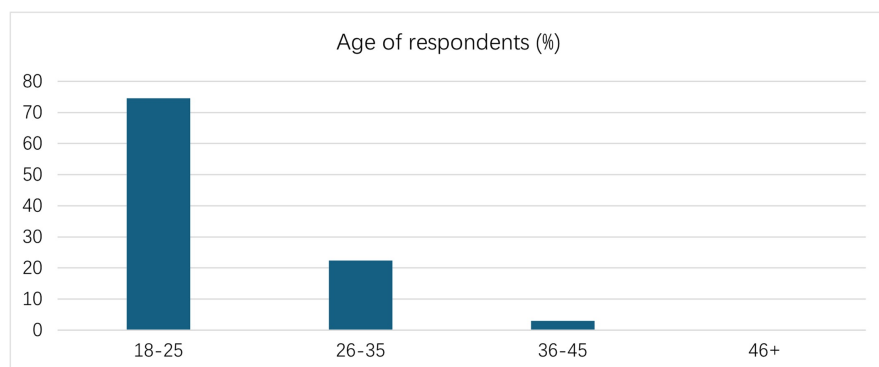
### 3.1. Demographic and Livelihood Profile

The demographic profile of the 134 surveyed quarry miners in Misisi Compound

reveals a workforce that is predominantly young, male, and characterized by low levels of formal education. As illustrated in **Figure 2**, males constitute 82.0% of respondents, while females account for 18.0%, indicating a strongly male-dominated sector, although female participation remains notable. Age distribution further highlights the dominance of youth in quarrying activities, with 74.6% of respondents aged between 18 - 25 years and 22.4% between 26 - 35 years. Only 3.0% fall within the 36 - 45 age group, and none are above 45 years (**Figure 3**). This skew towards younger individuals reflects both the physically demanding nature of quarry work and the limited alternative employment opportunities for youth.

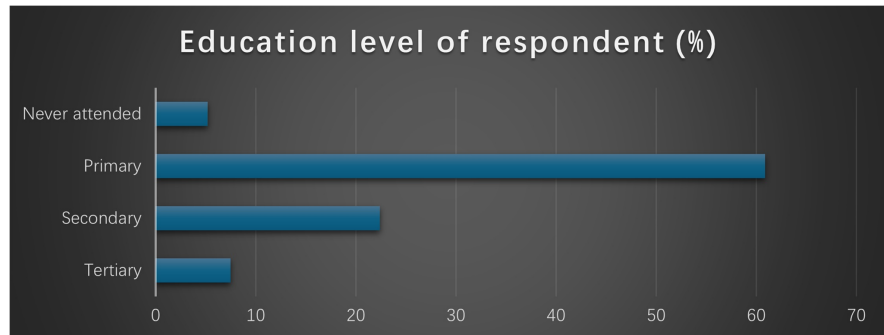


**Figure 2.** Gender of respondents.

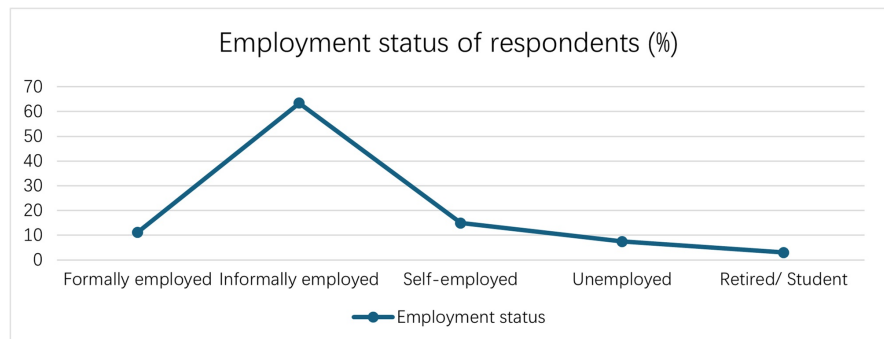


**Figure 3.** Age of respondents.

Educational attainment among miners is generally low (**Figure 4**). A majority (60.9%) have only primary education, 22.4% completed secondary school, 7.5% attained tertiary education, and 5.2% have never attended school. These low education levels significantly constrain access to formal employment, reinforcing dependence on informal livelihood strategies such as quarry mining. Employment patterns further reflect this vulnerability, with 63.4% of respondents engaged in informal employment, 14.9% self-employed, 11.2% formally employed, and 7.5% unemployed, while a small proportion (3.0%) are students or retirees (**Figure 5**).

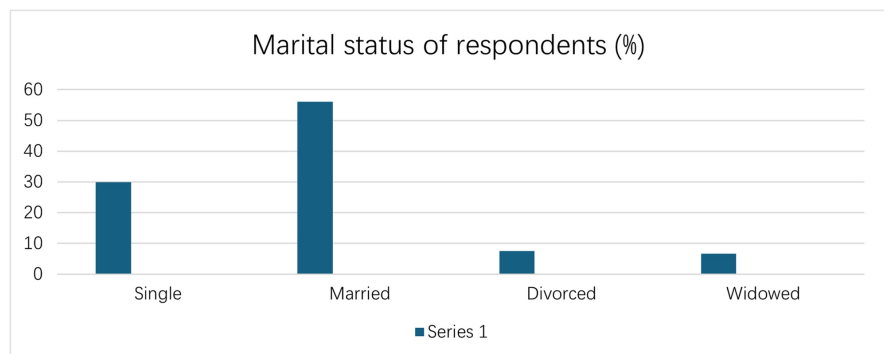


**Figure 4.** Education level of respondents.



**Figure 5.** Employment status of respondents.

In terms of marital status, 56.0% of respondents are married, 30.0% are single, while smaller proportions are divorced (7.5%) or widowed (6.7%) (**Figure 6**). These patterns suggest that quarrying income supports not only individuals but also households, increasing its importance as a livelihood source.



**Figure 6.** Marital status of respondents.

Beyond demographic characteristics, mining work patterns indicate a largely informal and survival-driven sector. As shown in **Table 2**, most miners are relatively recent entrants, with 62.7% having 1 - 5 years of experience and 29.9% between 6 - 10 years, indicating a dynamic but unstable livelihood activity. Quarrying is primarily focused on construction materials, with granite (47.7%), limestone (29.9%), and sandstone (22.4%) being the main commodities extracted.

A key feature of the sector is its high level of informality. Only 14.9% of re-

spondents possess mining licenses, while 85.1% operate without legal authorization. Among unlicensed miners, the main barriers include high licensing costs (52.6%) and bureaucratic procedures (26.3%). Quarrying activities are largely localized within Misisi (74.6%), reinforcing its status as a hotspot of informal mining.

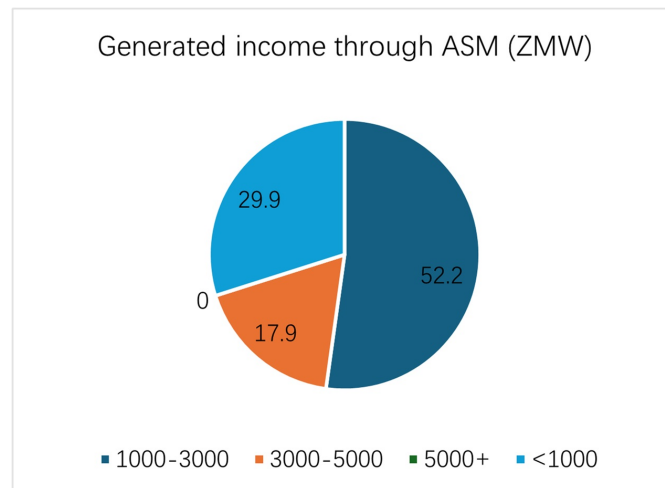
Work activities are predominantly labor-intensive, with drilling and blasting (52.2%) and crushing (22.4%) being the most common roles. Organizationally, most miners operate within family-based units (62.7%) or as individuals (37.3%), with no evidence of formal cooperatives. This structure limits access to training, financial support, and safety measures. The primary motivation for engaging in quarrying is poverty alleviation (89.6%), followed by joblessness (14.9%) and family support (3.0%).

**Table 2.** Survey responses on mining works in Misisi.

Question	Response Options	Count (n = 134)	Percentage (%)
<b>8. Years in Mining (Average)</b>	<1 year	10	7.5
	1 - 5 years	84	62.7
	6 - 10 years	40	29.9
	10+ years	0	0
<b>9. Commodity Mined</b>	Granite	64	47.7
	Limestone	40	29.9
	Sandstone	30	22.4
	Other (e.g., clay)	0	0
<b>10. Mining License</b>	Yes	20	14.9
	No	114	85.1
<b>11. Reason: No License (n = 114)</b>	Cost	60	52.6
	Bureaucracy	30	26.3
	Expired	10	8.8
	Other	14	12.3
<b>12. Mining Location</b>	Misisi	100	74.6
	Other	34	25.4
<b>13. Nature of Work</b>	Drilling/Blasting	70	52.2
	Crushing	30	22.4
	Manager	10	7.5
	Other (e.g., transport)	24	17.9
<b>14. Organizational Structure</b>	Individual	50	37.3
	Family-based	84	62.7
	Group/Cooperative	0	0
<b>15. Reason for Mining (Top 3)</b>	Poverty alleviation	120	89.6
	Joblessness	20	14.9
	Family support	4	3.0

Overall, the findings indicate that artisanal quarry mining in Misisi is dominated by young, low-skilled individuals operating within an informal and economically precarious system. The sector plays a critical role in providing livelihoods for vulnerable urban households but is characterized by limited income security, weak institutional support, and high exposure to occupational and environmental risks.

### 3.2. Socio-Economic Impact



**Figure 7.** Generated income through ASM.

#### Definition of Key Variables

- **Income change:** Self-reported comparison of current income relative to the pre-mining period (response options: increased, same, decreased).
- **Spending patterns:** Proportion of income allocated to household needs, education, savings, and other uses (based on monthly recall).
- **Payment frequency:** Typical interval of wage receipt (daily, weekly, monthly, or irregular).

#### Findings

The results indicate persistent livelihood vulnerability as shown in **Figure 7**:

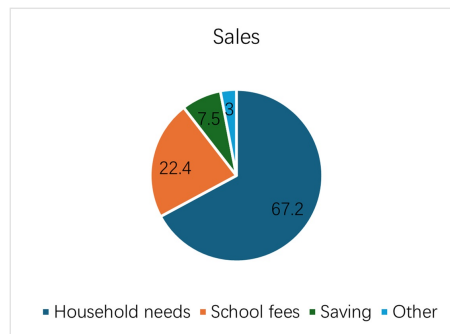
- **Income levels** are low: 82.1% earn  $\leq$  ZMW 3000/month.
- **Payment is short-term**, with 52.2% paid daily and 44.8% paid weekly, indicating a lack of income stability as shown in **Table 3**.
- **Spending is survival-focused**, with 67.2% spent on basic needs and only 7.5% saved.
- **Alternative livelihoods are limited**, with 32.8% having no other source of income.

Regarding income change, 59.7% reported increased income since joining quarrying, 29.9% reported no change, and 10.4% reported a decrease. While this suggests short-term improvement in cash flow, qualitative interviews indicate that income gains are modest and insufficient for long-term financial security.

**Table 3.** Payment frequency.

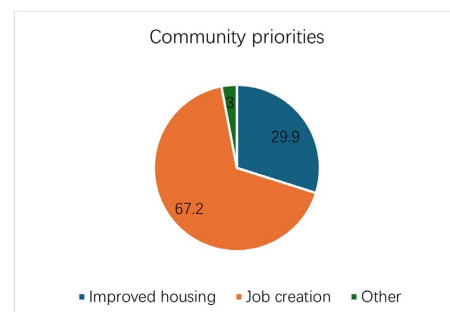
Payment Frequency	# of respondents	% of respondents
Daily	70	52.2
Weekly	60	44.8
Monthly	0	0
Irregular	4	3.0
Total	134	100.0

- **Spending Patterns:** Virtually all earnings go to basic needs. **Figure 8** shows that 67.2% of income is spent on household necessities (food, rent, utilities), and only 22.4% on school fees. Saving is rare (just 7.5% of income), indicating that households lack buffers. This spending profile, which is heavy on essentials with almost no discretionary spending, underscores miners’ financial precarity. With such limited income, few can invest in tools or fees that might improve productivity. Similar patterns have been observed in ASM communities elsewhere, where miners prioritize immediate survival expenses over investment.



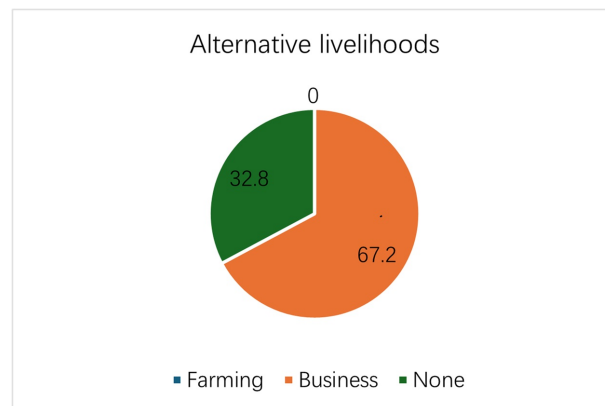
**Figure 8.** Spending patterns.

- **Community Priorities:** When asked about top community needs, 67.2% of respondents cited job creation (**Figure 9**), while 29.9% cited improved housing. The focus on jobs is consistent with the high informal unemployment/insecurity (63.4% informally employed, **Figure 5**) and low wages: mining households want more stable, higher-paying work. Housing also ranks high, reflecting that many miners live in substandard quarters. The minimal “other” responses suggest that these two issues dominate community concerns.



**Figure 9.** Community priorities.

- **Alternative Livelihoods:** Remarkably, none of the miners listed farming as an alternative income (**Figure 10**). Two-thirds (67.2%) are involved in small-scale businesses (selling goods or services), while 32.8% have *no* other livelihood. The lack of farming is not surprising in an urban settlement like Misisi (farmland has largely disappeared under urban growth). Instead, many families run market stalls or informal shops. The high share of “no alternative” signals vulnerability; nearly one-third of families depend solely on mining income, with no fallback. This limited diversification is common in urban ASM contexts.



**Figure 10.** Alternative livelihoods.

- **Income Change:** Most miners (59.7%) say their income increased since taking up quarry work (**Table 4**), 29.9% report no change, and 10.4% report a decrease. This suggests that, for many, quarrying did improve their cash flow, at least initially. However, given the generally low baseline, even an “increase” often still leaves families struggling. This partial improvement echoes the mixed literature on ASM: mining can boost local earnings, but not always enough to lift households well above subsistence.

**Table 4.** Income change due to mining.

Response	# of respondents	% of respondents
Increased	80	59.7
Same	40	29.9
Decreased	14	10.4
Total	134	100.0

### 3.3. Environmental and Health Impacts of Quarrying

The environmental and health impacts associated with artisanal quarry mining in Misisi Compound were examined, focusing on perceived environmental degradation, miners’ views on the causes of environmental damage, and associated health risks (**Table 5**).

**Table 5.** Environmental effects.

Question	Response Options	Count (n = 134)	Percentage (%)
<b>22. Affected Environment</b>	Land degradation	100	74.6
	Air pollution	90	67.2
	Water pollution	80	59.7
<b>23. Major Contributor to Degradation?</b>	True	110	82.1
	False	24	17.9
<b>24. Health Hazards Trend</b>	Increased	100	74.6
	Reduced	10	7.5
	No change	24	17.9
<b>25. Health Issues (n = 100)</b>	Silicosis/Asthma	60	60.0
	Hearing loss	20	20.0
	Injuries	15	15.0
	Other (e.g., skin diseases)	5	5.0

#### Definition of Key Variables

- **Major contributor to degradation:** Respondents' perception of whether quarrying significantly contributes to environmental damage (Yes/No).
- **Health hazards trend:** Perceived change in health risks over time (Increased/Reduced/No change).
- **Health issues:** Self-reported health conditions experienced during mining work.

#### Findings (Survey-Based Evidence)

Respondents reported significant environmental impacts:

- Land degradation (74.6%)
- Air pollution (67.2%)
- Water pollution (59.7%)

Additionally, 82.1% identified quarrying as a major contributor to environmental degradation, indicating high awareness among miners.

Regarding health:

- 74.6% reported increasing health hazards over time.
- Common self-reported conditions include:
  - Respiratory symptoms (60.0%)
  - Hearing problems (20.0%)
  - Injuries (15.0%)

These findings reflect perceived environmental and health risks, rather than directly measured exposure levels.

#### Contextual Evidence (Literature)

Evidence from previous studies [14] shows elevated dust levels in quarrying environments. However, such measurements were not conducted in this study and are presented here only as supporting context.

### 3.4. Occupational Health Risks

Health outcomes reported in this study are self-reported and not clinically diagnosed.

Respiratory symptoms (e.g., persistent coughing, breathing difficulties) were the most commonly reported, consistent with prolonged dust exposure. Hearing problems were linked to noise from blasting and crushing, while injuries reflect unsafe working conditions.

Qualitative findings reinforce these results, with respondents describing:

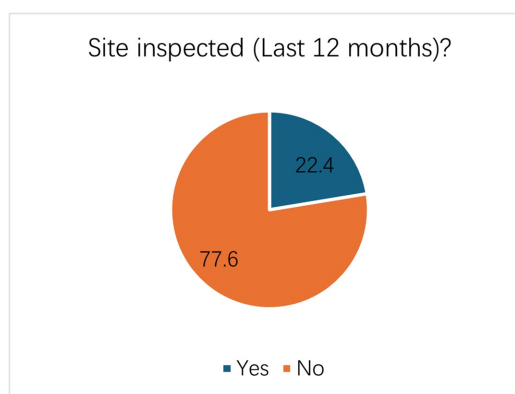
- Lack of protective equipment
- Frequent exposure to dust and noise
- Limited access to healthcare

These findings suggest high perceived occupational risk, although clinical verification was not conducted.

### 3.5. Policy and Regulatory Context

The environmental and health challenges identified must be understood within Zambia's regulatory framework. Although policies such as the Mines and Minerals Act and the Environmental Management Act exist, enforcement remains weak.

Survey findings indicate limited institutional oversight. Only 22.4% of respondents reported site inspections within the past 12 months (**Figure 11**), while just 29.9% had received safety sensitization (**Table 6**). Furthermore, 85.1% of respondents had never been arrested for mining-related activities (**Table 7**), indicating minimal enforcement.



**Figure 11.** Site inspected (Last 12 months)?

**Table 6.** Sensitized to safety?

Response Options	Count (n = 134)	Percentage (%)
Yes	40	29.9
No	94	70.1

This regulatory gap reflects broader national challenges. For instance, the Zambia Extractive Industries Transparency Initiative (EITI) report highlights

weak enforcement of ASM regulations as a major constraint to sectoral performance [15]. Similarly, enforcement actions are often reactive rather than proactive, as illustrated by cases where regulatory bodies intervene only after accidents [16].

**Table 7.** Ever arrested for mining-related activities?

Response Options	Count (n = 134)	Percentage (%)
Yes	20	14.9
No	114	85.1

Awareness of policy frameworks among miners is also limited. A majority (62.7%) reported having never heard of mining policies (Table 8), while only 14.9% identified the Environmental Management Act (Table 9). This suggests that many miners operate outside regulatory frameworks due to both limited awareness and institutional absence.

**Table 8.** Have you heard of mining policies?

Response Options	Count (n = 134)	Percentage (%)
Yes	50	37.3
No	84	62.7

**Table 9.** Policy frameworks identified by respondents.

Response Options	Count (n = 134)	Percentage (%)
Land	74	55.2
Mining Act	40	29.9
Environmental	20	14.9
None	0	0

The findings highlight weak institutional oversight:

- Only 22.4% reported site inspections in the past year.
- 29.9% received safety sensitization.
- 85.1% had never been arrested.

Awareness of policies is also low, with 62.7% unaware of mining regulations. These results indicate that quarrying operates largely outside of formal regulatory frameworks.

#### **Contextual Evidence (Literature)**

In the absence of effective governance, quarrying activities resemble a “tragedy of the commons”, where open-access resource exploitation leads to cumulative environmental degradation [17]. In Misisi, weak institutional capacity and limited enforcement have allowed environmental damage and health risks to persist unchecked, reinforcing the need for stronger regulatory intervention and community awareness.

### 3.6. Study Limitations

This study has several limitations:

- The findings are based on a **cross-sectional design**, which limits causal interpretation.
- Health outcomes are **self-reported**, not clinically verified.
- Environmental impacts are based on **perceptions rather than direct measurements**.
- The study focuses primarily on miners, limiting generalization to the broader community.

Therefore, conclusions should be interpreted as **descriptive rather than causal**.

## 4. Discussion

The findings indicate that artisanal quarry mining in Misisi Compound functions primarily as a survival livelihood strategy driven by poverty, unemployment, and limited education. The dominance of young, informally employed individuals reflects the sector's role in absorbing labour excluded from the formal economy, consistent with the Sustainable Livelihoods Approach. However, despite providing income, quarrying does not significantly improve long-term economic well-being, as most miners remain within low-income brackets with limited savings and financial security.

The study further highlights the highly informal and weakly regulated nature of quarrying activities. Low licensing levels, limited awareness of regulatory frameworks, and minimal enforcement contribute to unsafe practices and environmental degradation. These findings align with broader ASM literature, where institutional weaknesses perpetuate informality and risk exposure.

Environmental impacts, including land degradation, air pollution, and water contamination, are severe and widely recognized by the miners themselves. These are closely linked to significant occupational health risks, particularly respiratory diseases, hearing loss, and injuries resulting from prolonged exposure to dust, noise, and unsafe working conditions.

## 5. Conclusions

Artisanal quarry mining in Misisi Compound plays a critical role in supporting livelihoods for economically vulnerable populations in Lusaka. The sector is characterized by a young, low-skilled workforce operating within an informal and poorly regulated environment. While quarrying provides immediate income opportunities, it does not substantially improve long-term economic conditions, as most miners remain within low-income and insecure livelihood systems.

The study demonstrates that quarrying activities contribute to significant environmental degradation, including land destruction, air pollution, and water contamination. These impacts are closely associated with serious health risks, particularly respiratory illnesses, injuries, and hearing loss, highlighting the sector as both an environmental and public health concern.

A key challenge identified is the weak regulatory and institutional framework, characterized by low levels of licensing, limited enforcement, and poor awareness of mining policies. This has allowed unsustainable practices to persist.

In conclusion, artisanal quarry mining in Misisi is unsustainable in its current form. There is an urgent need for policy interventions focused on formalization, improved regulatory enforcement, environmental management, and occupational safety. Additionally, promoting alternative livelihoods and skills development is essential to reducing dependence on quarrying and supporting sustainable urban development.

### Conflicts of Interest

The authors declare no conflicts of interest.

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