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Socio-Economic Challenges in Small-Scale Gold Mining: A Case of Geita, Tanzania

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Abstract

Small-scale gold mining is a major economic activity in Tanzania, particularly in the Geita region. Despite its importance, the sector continues to face persistent risks and operational challenges. This study examined the financial, technical, legal, environmental, and occupational challenges influencing the performance and safety of small-scale gold miners. An explanatory sequential mixed-methods design was employed. Data from miners, mining groups, and district officials were collected through structured questionnaires and interviews. Quantitative findings were summarized using descriptive statistics and visualized through figures, while a multilevel logistic regression analysis was conducted to account for clustering effects at the ward level with a 5% significance level. In contrast, qualitative data were analysed using thematic and interpretive methods. A total of 520 Small Scale Miners were included in this study. The study found that several demographics, financial, and institutional factors significantly influenced the challenges facing miners in Geita.

Older miners (≥35 years) were more likely to face challenges compared to younger miners. Higher education reduced vulnerability, while longer mining experience significantly increased risks. Access to formal credit lowered challenges, whereas inadequate equipment heightened them. Accessibility of legal support reduced risks, while lack of legal awareness strongly increased them. The study concludes that the challenges facing miners in the Geita region are interconnected, extending beyond technical constraints to encompass financial and environmental issues. Based on these findings, it recommends structured outreach and capacity-building by district officers, enhanced coordination and resource-pooling through miners' organizations, and improved skills development among individual miners.

Keywords: *Small-scale gold mining, Mining challenges, Resource governance, Occupational and Environmental Risks*

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Introduction

Globally, small-scale gold mining (SSM) has expanded significantly as many resource-rich countries adopt policies aimed at increasing control over mineral resources and maximizing socio-economic benefits. In regions such as Latin America and Asia, governments have introduced stricter mining frameworks, renegotiated contracts, and increased taxation to reclaim greater shares of mineral rents (Andreasson, 2015; Childs, 2016; Ovadia, 2016). Countries including Australia, Canada, and the United Kingdom have similarly updated legislation to secure higher national returns from mining value chains (McCrone, 2021; Nem Singh, 2014). While these reforms aim to strengthen state benefits, they have also intensified regulatory environments, often influencing how small-scale miners operate.

Across Sub-Saharan Africa, SSM plays a critical economic role but often occurs within contexts of weak regulation, limited state oversight, and rising resource nationalism. Countries such as Ghana, Zambia, Mali, South Africa, and the Democratic Republic of Congo have revised

mining laws to increase royalties, enhance state participation, and expand local content obligations (Caramento, Saunders, & Larmer, (2023; Koch & Perreault, 2019). These interventions were designed to improve national revenue and address long-standing inequalities associated with foreign-dominated mineral extraction (Kinyondo & Huggins, 2019; Wilson, 2015). However, tightening regulatory frameworks has also created compliance burdens for SSM operators, who frequently lack the technical, financial, and administrative capacity to meet new standards.

In Tanzania, the evolution of the mining sector reflects a long history of foreign control during the colonial era, followed by extensive reforms beginning in the 1990s that liberalized the industry and attracted large-scale foreign investment (Chachage, 2009; Curtis, 2012; Magai & Márquez, 2013). Subsequent decades saw growing public discontent over perceived inequitable benefit sharing, prompting new waves of resource nationalist reforms. Major policy shifts between 2009 and 2017, including the Mining Act (2010) and the 2017 Natural Wealth and Resources Acts, expanded state participation, introduced stringent local content rules, restricted raw mineral exports, and restructured licensing procedures (Poncian, 2019; Jacob & Pedersen, 2018). While these reforms strengthened national ownership of the mineral sector, they also generated more complex regulatory obligations that small-scale miners are often ill-equipped to navigate.

Despite the policy efforts, limited evidence exists on how the dynamic regulatory landscape affects small-scale miners in practice, particularly in gold-rich regions such as Geita, where SSM contributes significantly to livelihoods, employment, and local economic development (URT, 2022; 2024). Emerging literature suggests that SSM operators continue to face obstacles related to licensing, financing, technology access, environmental compliance, and market participation (Mhango, 2023; Siwale, & Siwale, 2017). Yet the implications of resource nationalism policies on these day-to-day experiences remain largely understudied. This gap underscores the

need for empirical research that examines the specific risks, challenges, and structural constraints shaping small-scale miners' operations in Tanzania. Therefore, the present study addresses this gap by investigating the challenges confronting small-scale gold miners in Geita within the broader context of Tanzania's evolving resource governance framework.

Methodology

The study adopted an explanatory sequential mixed methods design to assess risks and challenges in Small-Scale Gold Mining in Geita. This design was chosen to capture the inherent complexity and multidimensionality of mining risks, combining the extensiveness of quantitative evidence with the depth of qualitative insights. The first method began with a quantitative phase, where structured surveys were administered across all districts (Geita DC, Chato DC, Mbogwe DC, Nyanghwale DC, and Bukombe DC) to establish patterns and measure the prevalence of key risk factors. The second method was a qualitative design involved in-depth interviews with policy implementers, which provided nuanced contextual explanations that enriched and extended the quantitative findings. By integrating both designs, the study achieved a theoretically grounded and comprehensive understanding of miners lived experiences alongside statistical evidence, enabling triangulation of data to capture diverse perspectives with clarity and precision.

The gold mining industry was selected as a case study in light of major policy and institutional reforms, including the establishment of the Mining Commission, the strengthening of State Mining Company (STAMICO) and Geological Survey of Tanzania (GST), the separation of the Ministry of Mining from Energy, and the creation of mineral markets to enhance oversight, transparency, and fair pricing. Geita region, which holds the largest gold deposits and the highest concentration of small-scale miners, provides a unique context for examining the financial, technical, legal, environmental,

and occupational challenges influencing the performance and safety of small-scale gold miners. The study was conducted across all five districts of Geita region, focusing on wards with high SSM activity, including Ihanamilo, Nyakalembo, Lugongo, Nyakagomba and Lwamgasa (Kihesa).

The quantitative study population comprised 9,779 small-scale gold miners in Geita, sampled to capture the scale and distribution of mining risks. The qualitative component drew on key informants from state institutions (Ministry of Minerals, Mining Commission, OSHA, NEMC, GST, STAMICO, TRA, and Local Government Authorities), miners' associations (FEMATA, GEMATA), and selected NGOs/CSOs (including "Haki-Rasilimali" and Policy Forum). These actors were included to provide policy, regulatory, and advocacy perspectives that complemented miners' experiences. Institutional descriptions were limited to those systematically necessary for understanding their roles in shaping mining governance.

The required sample size for this study was calculated using the formula proposed by Taro Yamane (1967)**,** which provides a simplified method for determining sample size from a known population. Yamane's formula was used because the study focused on a finite population of registered small-scale gold miners with finite baseline information. The formula is expressed as:

$$n = \frac{N}{1 + Ne^2}$$

Whereby:

N = Expected total study population (9779)

e = Marginal error (5%)

$$n = \frac{9779}{1 + (9779 \times 0.05^2)}$$

$$n \approx 384.28$$

$$n = 384$$

To account for potential non-response, the minimum sample size was adjusted by 10%, resulting in a requirement of at least 426 small-scale miners. In practice, the final sample 520 exceeded this minimum threshold to ensure broader coverage across districts and to strengthen the reliability of statistical estimates. This considers oversampling enhanced representativeness and allowed more robust results analyses. For the qualitative component, the sample size was not predetermined numerically but was guided by the principle of saturation. This ensured that the qualitative data captured the diversity of experiences and viewpoints among respondents while maintaining methodological rigor.

Quantitative data were collected using structured survey questionnaires, developed with reference to similar studies across Sub-Saharan Africa (SSA) to ensure comparability and methodological consistency. Qualitative data were obtained through Focus Group Discussions (FGDs) and in-Depth Interviews (IDIs). The FGDs involved six groups of 8–12 miners per session, purposively selected to reflect diversity in age, gender, and mining experience. Each discussion lasted for approximately 60–90 minutes and was facilitated by trained moderators using a semi-structured guide to encourage open dialogue. IDIs were conducted with key informants such as policy implementers and institutional representatives, allowing for deeper exploration of governance perspectives and contextual explanations that complemented the study findings.

To attain the predetermined sample size for the study, a convenience sampling technique was employed. This non-probability method was selected due to the dispersed and scattered nature of small-scale mining operations. Recruitment was conducted at mining sites by the principal investigators in collaboration with a trained research assistant. Together, they visited pre-identified sites and engaged directly with miners who were present and available on the day of the visit. Participants were approached, informed about the study objectives, and invited to participate voluntarily. No prior appointments or randomization procedures were used; instead,

enrolment was based on immediate availability and willingness to participate. This approach was repeated across multiple sites until the target sample size was successfully achieved. While this method enhanced feasibility, it also introduced potential selection bias, limiting the generalizability of findings beyond the sampled miners. These limitations are acknowledged in interpreting the results.

Respondents who participated in FDGs and IDIs were selected based on their rich knowledge and experiences in the gold mining industry, including small-scale miners, leaders of miners' federations, and government officials such as geologists, economists, lawyers, and sociologists working in public and private institutions. This combination ensured inclusion of expert perspectives and miners' collective voices, thereby enriching the qualitative results. Both purposive and snowball sampling were applied to reach this category of respondents.

Variable Measurement

As suggested by Fischer, Boone, and Neumann (2023), this study included two main types of variables: dependent and independent. The dependent variables were assessed differently according to each objective. The primary dependent variable was the overall challenge, measured on a scale from 1 to 10, where 1 indicated "No challenge at all" and 10 represented "Extremely challenging." Respondents were asked to rate the challenges facing small-scale gold miners in their area across seven domains: access to credit and finance, availability of modern equipment, use of appropriate mining technology, technical skills and training, access to market information and fair pricing, environmental management and compliance, and occupational health and safety. The overall challenge score was then calculated by averaging the ratings across all seven domains for each individual. A mean score of 6 was used as the threshold to create a binary categorization: 1 = "challenge" and 0 = "no challenge".

Furthermore, the independent variables were categorized into several domains of challenges, including financial support, equipment access,

legal and marketing training, environmental management, and health-related issues. All questions within each domain were measured using nominal scales, while some were assessed using 4- or 5-point Likert scales. The tools were validated through pretesting, and the reliability of the scaled questions was assessed using Cronbach's alpha coefficient, which yielded a value of 0.834 (83.4%). This exceeds the commonly accepted threshold of 0.70, indicating strong internal consistency and reliability of the instrument. These domains were subsequently analysed to determine their influence on the overall challenge.

Data analysis employed two methods to address both the qualitative and quantitative data collected. The qualitative data were analysed using thematic and interpretive methods, beginning with transcription of interviews and handwritten notes into Microsoft Word for easier processing. The organized data were reviewed to identify and synthesize preliminary interpretations, leading to the formulation of themes and sub-themes. An index of these themes was created to guide final interpretation, while interview summary forms containing respondents' details, context, and emerging themes were attached to transcripts to help recall tones, explanations, and the essence of discussions.

While for quantitative data, in accordance with the recommendations of Creswell and Plano (2023), descriptive statistical procedures were employed prior to entering the data into the data collection software. Thereof, the electronic data collected were imported into Stata version 18.0 for cleaning and further analysis. The data cleaning process involved checking frequencies and proportions for categorical variables, and summarising the mean, median, minimum, and maximum values for continuous variables. Both descriptive and inferential statistics were conducted to interpret and draw conclusions from the data. For descriptive statistics, frequency distribution tables and figures were used to present the variables. For inferential statistics, given that the dependent outcomes were binary and the data were collected across multiple wards in two districts of

the Geita Region of Tanzania, a multilevel logistic regression analysis was conducted to account for clustering effects at the ward level. This approach was used to estimate both crude and adjusted effects of the independent variables on the dependent outcomes. Variables with a p-value less than 0.20 were included in the multivariate model to establish adjusted effects. Odds ratios, 95% confidence intervals, and p-values were reported. All statistical tests with p-values less than 0.05 were considered statistically significant.

Before the initiation of the study, research clearance was obtained from the University of Dar es Salaam, followed by approval from the local government authorities (LGAs) in the Geita Region. In conducting this study, strict adherence to research ethics was ensured through voluntary participation, informed consent, confidentiality, anonymity, and privacy. Respondents received information sheets explaining the research purpose and their role, signed consent forms with the right to withdraw at any time, and were assured that data would be preserved for at least 10 years after publication. To protect identities, respondents were represented by coded abbreviations (e.g., R-MM for Ministry of Minerals, R-MC for Mining Commission, R-OSHA for OSHA), with further numbering used when multiple individuals came from the same institution. Direct quotations were presented using these codes, and all identifying information was stored separately from the data to prevent any link between respondents and their contributions.

Results and Discussion

This chapter presents the findings related to the challenges facing small-scale miners (SSMs) in the Geita region of Tanzania, as well as the broader implications of these findings for Tanzania and other comparable settings. The results combine data from surveys and interviews with key informants, providing insights into the diverse challenges that influence miners' performance and the sustainability of small-scale mining activities.

In the next subsection, the demographic characteristics of the respondents is covered, followed by a detailed discussion of the key

empirical findings derived from the field data. The inclusion of demographic characteristics is justified by the need to contextualize the challenges facing miners within their social and economic backgrounds. Variables such as age, gender, education level, mining experience, among others influence access to resources, decision-making capacity, risk exposure, and adoption of improved mining practices. Examining these characteristics enables a clearer understanding of the challenges confronting small-scale gold miners in Geita within the broader context of Tanzania's evolving resource governance framework.

Demographic characteristics of the respondents

A total of 520 small-scale miners (SSMs) participated in the study. Data were collected on their age, sex, marital status, years of work experience, and other relevant characteristics (see Table 1).

Age of the small-scale miners

The median age of small-scale miners was 38 years (IQR 31-45). About 32.5% (n=169) were below 35, while 67.5% (n=351) were 35 and above. These age categories reflect the prime working years for mineral extraction, linking employment patterns to physical capacity. Miners above 35, with greater resilience and experience, form the backbone of the sector. Their sustained participation is vital for productivity, highlighting the need for policies that ensure employment security, health and safety measures, and skill development tailored to this demographic (Jan et al., 2024).

Sex and Gold Mining

The majority of respondents were male, accounting for 83.9% (n=436), while females comprised 16.1% (n=84). This sex distribution reflects traditional gender roles in mining, where men undertake physically demanding extraction tasks and women often engage in secondary roles such as mineral processing and panning. While this division of labour supports livelihoods by aligning tasks with physical capacity, it also underscores gender disparities and limited opportunities for women's advancement. Policy interventions should address barriers, including workplace safety, gender stereotypes, and inadequate facilities, to foster

inclusivity and promote women's participation across all roles, including leadership (UNDP, 2021).

Marital Status of the Respondents

Most respondents were married, representing 78.5% (n=408), while 21.5% (n=112) were single: 14.8% not married (n=77), 6.2% separated (n=32), and 0.5% widowed (n=3). The predominance of married miners suggests that many households depend directly on the mining sector, with implications for community land use and policy nationalization. As Armah *et al.* (2016) note, family bonds are a key socio-economic factor shaping household exposure and adaptive capacity to environmental, social, and political changes. Household income often relies on the head of the family, underscoring the importance of stable employment and supportive policies for miners' families.

Educational background

Most small-scale miners had limited formal education: 58.9% (n=306) completed primary school, 29.8% (n=155) secondary, 7.5% (n=39) had no formal education and only 3.8% (n=20) attained tertiary levels. This low educational attainment restricts miners' ability to adopt safer technologies, limits awareness of occupational health risks, and reduces opportunities for advancement. Policy implications highlight the need for targeted educational and vocational training, awareness campaigns on safe practices, and integration of formal education initiatives to balance economic opportunities with skills development, thereby improving livelihoods and safety standards (Annan, 2024; Tanzania Mineral Policy, 2009).

Longevity in mineral activities

The average mining experience among respondents was 5.9 years (SD=4.73), with 41.7% (n=217) having 1–3 years, 23.3% (n=121) 4-6 years, 20.0% (n=104) 7-10 years, and 15.0% (n=78) over 10 years. This distribution highlights a workforce with varied experience, requiring training and support tailored to different levels to improve practices, reduce risks, and sustain productivity (Leung, 2016; Jan et al., 2024). In addition, awareness of resource nationalism was limited, with 55.2% (n=287) unaware and 44.8% (n=233) aware, implying that effective

communication and education are essential to enhance miners' understanding, compliance, and participation in sustainable resource governance.

Table 1: Demographic characteristics of the respondents (n=520)

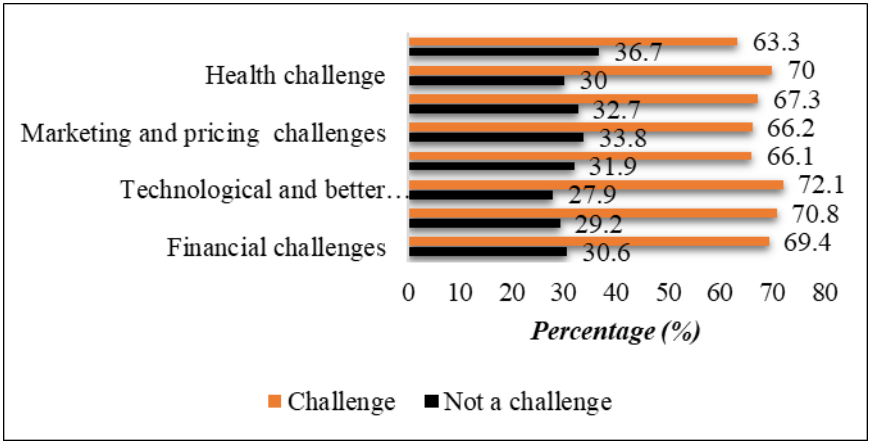
Variable	n (%)
Age (median, IQR)	38, 31-45
Age category	
Below 35 years	169(32.5)
35 years and above	351(67.5)
Sex	
Male	436(83.9)
Female	84(16.1)
Marital status	
Single	112(21.5)
Married	408(78.5)
Education background	
No formal education	39(7.5)
Primary education	306(58.9)
Secondary education	155(29.8)
Tertiary education	20(3.8)
Experience in small-scale mining activities (Mean years, SD)	5.9, 4.73
Experience category	
1-3 years	217(41.7)
4-6 years	121(23.3)
7-10 years	104(20.0)
Above 10 years	78(15.0)
Ever heard about the resource nationalism policy	
No	287(55.2)
Yes	233(44.8)

Source: Field study (2023)

Challenges Facing Small-Scale Gold Miners in Geita

The findings indicate that 63.3% of small-scale miners (SSMs) (n = 329, 95% CI: 59.0%-67.3%) experience at least one major challenge. Disaggregated results show that financial constraints affect 69.4% (n = 361, 95% CI: 65.3%-73.2%), while legal and regulatory issues are reported by 70.8% (n = 368, 95% CI: 66.7%-74.5%). Limited access to modern equipment and technology was cited by 72.1% (n = 375, 95% CI: 68.1%-75.8%), and 68.7% (n = 357, 95% CI: 64.5%-72.5%) reported inadequate training opportunities. Pricing and marketing barriers were noted by 66.2% (95% CI: 61.9%-70.1%), environmental concerns by 67.3% (n = 350, 95% CI: 63.1%-71.2%), and health-related challenges by 70.0% (n = 364, 95% CI: 65.9%-73.8%). Collectively, these results highlight the multidimensional nature of risks confronting SSMs, with Figure 1 providing a visual summary of the distribution.

Figure 1: Challenges facing small-scale miners in the study area



Source: Field study (2023)

Factors influencing the challenges facing small-scale gold miners

To examine the factors influencing the challenges faced by small-scale gold miners (SSMs), a multilevel logistic regression model was employed, accounting for clustering effects across mining wards. The

model demonstrated strong fit, with a log-likelihood of -178.87 and a statistically significant chi-square value (chi = 23.07, $p < 0.001$). The between-cluster variance was estimated at 1.95 (SE = 1.795962), and the inter-cluster correlation coefficient (ICC) was 37.3% (95% CI: 13.7%-68.9%), indicating substantial variation attributable to ward-level contextual factors. After adjusting for potential confounders, several individual-level variables remained significantly associated with the likelihood of experiencing mining-related challenges (Table 2).

Demographics characteristics

Age was a notable predictor, with miners aged 35 years and above being significantly more likely to report challenges compared to those below 35 years (AOR = 1.60, 95% CI: 1.08-2.37, $p = 0.019$). Educational attainment showed a protective effect, with miners who had completed secondary or tertiary education being less likely to face challenges than those with no formal or only primary education (AOR = 0.61, 95% CI: 0.44-0.86, $p = 0.004$). This implies that miners with secondary or tertiary education are better positioned to navigate operational, legal, and economic complexities, demonstrating stronger problem-solving, risk management, and technological adoption capacities (Hilson *et al.,* 2017; Interviews R-GST$_2$; R-LGAs$_1$, November 2023). They also show greater awareness of market dynamics, enabling fairer negotiations and long-term viability. In contrast, miners with limited education face restricted access to information, reduced technological awareness, and heightened vulnerability to exploitative practices. From a sociological institutionalism perspective, education provides not only technical knowledge but also cultural capital, enhancing miners' legitimacy with institutions such as banks, regulators, and business partners (Interview R-LGAs$_1$, November 2023). During the interview with R-GEMATA$_2$, it was emphasized that limited educational qualifications significantly hinder small-scale miners' ability to access and interpret legal resources. Many struggles with complex documents and regulatory requirements, challenges further compounded by language barriers and specialized legal jargon (Interview R-GEMATA$_2$, November 2023).

> Illiteracy remains a major constraint in the small-scale mining sector, negatively affecting productivity, growth, and access to finance. Financial

> institutions require business plans and records for loans, which miners with limited formal education cannot easily provide. Mining also demands sound financial management, including record keeping. Therefore, limited literacy limits miners' ability to manage finances effectively, secure investment, and expand investments, eventually restrict their potential to contribute meaningfully to development. (Interview with R-GEMATA$_2$, 07th November, 2023).

The quotation above highlights literacy as a foundational requirement for economic participation, demonstrating how educational deficits among miners undermine financial inclusion, business management, and sectoral development within small-scale mining sector in developing contexts.

In addition, mining experience was strongly associated with increased odds of reporting challenges. Compared to those with 1-3 years of experience, miners with 4-6 years (AOR = 1.90, 95% CI: 1.39-2.60, $p < 0.001$), 7–10 years (AOR = 3.32, 95% CI: 1.79-6.19, $p < 0.001$), and more than 10 years (AOR = 2.73, 95% CI: 1.28-5.84, $p = 0.010$) were significantly more likely to encounter operational and structural challenges. This implies that experienced miners develop advanced technical skills, intuitive risk assessment, and adaptive strategies for managing environmental challenges, equipment breakdowns, and market fluctuations (URT, 2023; Hilson *et al.,* 2017; Interviews R-NEMC$_1$; R-PF$_1$, November 2023). They also build extensive networks that foster collaboration, resource sharing, and informal support systems, strengthening social capital and sustainability. Conversely, less experienced miners often struggle with technical operations, safety compliance, and resource extraction, leaving them vulnerable to accidents, inefficiencies, and financial exclusion. Sociological institutionalism highlights that experience not only enhances technical competence but also embeds miners within socially recognized networks, reinforcing trust, legitimacy, and reputational standing in the mining community.

Access to Capital and Better Equipment

Access to financial capital and adequate equipment emerged as critical determinants of miners' ability to operate sustainably. Quantitative

results show that miners with access to formal credit were significantly less likely to report challenges (AOR = 0.27, 95% CI: 0.21-0.35, $p < 0.001$), while those with inadequate equipment were more likely to face difficulties (AOR = 2.08, 95% CI: 1.17-3.71, $p = 0.012$). Qualitative evidence reinforces this, revealing that short-term loans, strict collateral requirements, and limited financial literacy prevent miners from accessing credit, leaving them dependent on outdated tools and informal financing. As one respondent explained:

> Access to finance is a major obstacle for small-scale miners due to institutional perceptions of high risk, informality, and uncertain profitability. Therefore, financial institutions impose demanding requirements, including costly geological surveys and strict bookkeeping standards that many miners rarely have the skills, knowledge or resources to achieve. Subsequently, miners remain excluded from credit, unable to expand operations, improve practices, or formalize, perpetuating underdevelopment within the sector (Interview with R-MM, November 2023).

The quotation illustrates how institutional risk perceptions and unrealistic compliance requirements reinforce informality, limited investment, and low productivity, while impeding the sector's transition toward sustainability, modernization, and meaningful contribution to broader economic development.

In addition, geographical remoteness further intensifies these challenges, as miners in regions like Geita face high transport costs and limited access to markets. Quantitative findings highlight the economic vulnerability created by inadequate infrastructure, while qualitative accounts describe how poor roads, seasonal flooding, and long travel distances erode profits and discourage investment. As one respondent noted:

> One of the major challenges our miners face is transportation. The roads leading to mining sites and other gold fields are in terrible conditions especially during the rainy season. For instances, this rainy season, there are frequent trucks break down, fuel becomes expensive, and sometimes there's no vehicle available at all. This forces miners to spend more money just to move their minerals than they actually make in profit. Even when they manage to extract a decent amount of minerals, getting them to

> market located in urban areas becomes a huge financial burden. (Interview with R-LGAs$_3$, 04th November 2023).

Above quotation suggests that infrastructure development is essential for mining sustainability, because improved transport would reduce costs, increase profitability, attract investment, support livelihoods, and enable small scale miners to compete fairly in markets.

Legal Access Support

Legal support also played a significant role: miners with accessible legal information were less likely to report challenges (AOR = 0.41, 95% CI: 0.19-0.85, p = 0.017), whereas lack of legal awareness substantially increased the odds (AOR = 1.99, 95% CI: 1.64-2.43, p < 0.001). The legal environment governing SSM is often complex, fragmented into many parts, and difficult to navigate. Miners commonly encounter challenges such as unclear regulatory legislation, limited awareness of property and land rights, bureaucratic permitting procedures, and exposure to legal vulnerabilities (Interview with R-HR$_2$, November 2023). These challenges hinder operational efficiency, limit access to resources, and raise the risk of disputes or penalties. However, miners equipped with strong access to legal knowledge are better able to assert and protect their operational rights, align with regulatory requirements, and manage potential legal risks. Informed miners can also adopt and implement more sustainable and responsible mining ventures, positioning their activities within formal standards and community expectations (Interview with R-HR$_2$; R-PF$_1$, November 2023). Therefore, legal literacy is a significant factor in improving both productivity and long-term resilience in the small-scale mining sector.

Through an economic institutionalist perspective, access to legal knowledge and information is essential for miners to effectively collaborate with formal institutions such as financial institutions, regulatory agencies, and markets (Peters & Pierre, 2020). Miners with adequate understanding of property rights, regulatory legislation, and permitting procedures reduce transaction costs and uncertainty,

enabling them to make rational economic decisions. More importantly, miners with strong legal literacy have the capacity to secure loans, attract profitable investments and align with formal operational requirements that increase the financial viability of their ventures. Legal knowledge also prevents potential disputes and penalties from regulatory agencies, protecting economic assets and ensuring sustainability of operations. In contrast, miners without access to legal information face higher risks, limited access to formal finance, and inefficiencies that reduce profitability. Strengthening legal and informational support for miners thus functions as a critical institutional mechanism to improve productivity, investment, and economic sustainability in the small-scale mining sector.

Healthcare Factors

Despite not emerging as a statistically significant factor in the multivariate analysis, the qualitative findings indicate that environmental conditions and occupational hazards at worksites remain critical to miners' health and livelihoods. Poor planning, lack of safety measures, and reliance on basic tools expose miners to daily risks of accidents and injuries. As one respondent explained:

> When people talk about small-scale mining, they often mention the income it brings but they do not see the conditions under which this money is earned. The work is very hard, with men and women using their bare hands and very basic tools. In this way, every day they face accidents, injuries, and diseases that not only affect their ability to work but also reduce their income that families depend on. I have seen many cases where miners fall sick and the whole family suffers because there is no other source of livelihood. It is not only the miners themselves who are at risk but also their families and communities are exposed because mining is happening right where people live. Children and women may help in processing the ore or are affected too simply because their homes are close to the pits and processing areas (Interview with R-LGAs$_1$, 12th November, 2023).

In addition, health risks from hazardous chemicals remain a critical challenge for small-scale miners (SSMs). Miners are routinely exposed to mercury, cyanide, and mineral acids, which pose severe threats to

both human health and the environment. Importantly, this exposure often extends beyond the miners themselves, disproportionately likely to affect women and children living near mining sites. As another respondent emphasized:

> In our community, mining activity is not just the work of men, the entire family gets involved. You may find even women and even children helping with processing ore and this exposes them to mercury, dust, and other dangerous chemicals. In this case, women carry a heavy burden. They spend long hours at the mining site and when they return home, yet they still have to take care of the household chore. In this manner, this double responsibility makes women more vulnerable because they are often working in unsafe conditions and still caring for children in the same spaces where ore is crushed and refined. In some miners' households, processing is done very close to the cooking areas, so everyone, including the children, breathes in the dust and chemicals. Also, women occupy the lowest positions in the mining hierarchy which means they have the least protection and the least choice. Consequently, the health and safety risks fall disproportionately on them and their families (Interview with R-NEMC$_1$15th November 2023)

Table 2: Factors influencing the challenges facing small-scale gold miners

Variable	n (%)	Unadjusted OR		Adjusted OR	
		OR, 95% CI	p-value	OR, 95% CI	p-value
Demographics characteristics					
Age category					
Below 35 years	169	1		1	
35 years and above	351	1.79, 1.09-2.94	0.020	1.60, 1.08-2.37	0.019
Sex					
Male	436	1			
Female	84	10.77, 0.41-1.43	0.410		
Marital status					
Single	112	1			
Married	408	1.03, 0.60-1.77	0.908		
Education background					
No formal education + Primary education	345	1		1	
Secondary education + Tertiary education	175	1.08, 0.65-1.79	0.754	0.61, 0.44-0.86	0.004
Experience category					
1-3 years	217	1		1	
4-6 years	121	1.16, 0.64-2.1	0.635	1.90, 1.39-2.60	<0.001
7-10 years	104	3.04, 1.14-8.08	0.026	3.32, 1.79-6.19	<0.001
Above 10 years	78	2.55, 0.76-8.59	0.131	2.73, 1.28-5.84	0.010
Access to Capital and Better Equipment					

Variable	n (%)	Unadjusted OR		Adjusted OR	
		OR, 95% CI	p-value	OR, 95% CI	p-value
Access to formal credit or loans from banks or microfinance to support mining activities					
No	132	1		1	
Yes	388	0.23, 0.13-0.40	<0.001	0.27, 0.21-0.35	<0.001
Adequacy of mining equipment					
Adequate	41	1		1	
Inadequate	479	3.52, 1.57-7.89	0.002	2.08, 1.17-3.71	0.012
High interest rates (yes)	245	0.96, 0.58-1.56	0.856		
Unfavourable loan terms (yes)	204	1.19, 0.69-2.05	0.516		
Limited availability of modern equipment (yes)	181	0.92, 0.54-1.59	0.791		
Legal Access Support					
Accessibility of legal support or information regarding mining compliance					
Not accessible	155	1		1	
Limited access	313	0.97, 0.55-1.69	0.910	0.65, 0.29-1.45	0.294
Accessible	52	0.44, 0.19-0.98	0.047	0.41, 0.19-0.85	0.017
Lack of legal awareness (yes)	366	2.25, 1.29-3.96	0.005	1.99, 1.64-2.43	<0.001
Marketing Access and Pricing					
Satisfied with the prices received for the gold					
Dissatisfied	278	1			
Satisfied	242	1.16, 0.69-1.92	0.572		

Variable	n (%)	Unadjusted OR		Adjusted OR	
		OR, 95% CI	p-value	OR, 95% CI	p-value
Dependence on middlemen (yes)	175	0.82, 0.50-1.34	0.431		
Lack of price information (yes)	298	1.13, 0.67-1.92	0.643		
Lack of market information (yes)	187	0.74, 0.44-1.24	0.256		
High transaction costs (yes)	84	0.46, 0.24-0.87	0.018	0.56, 0.23-1.36	0.195
Inconsistent market demand (yes)	64	2.03, 0.92-4.50	0.080	1.33, 0.93-1.91	0.117
Quality assessment issues (yes)	157	1.58, 0.61-4.13	0.347		
Skills and Training					
Ever received any formal training in mining techniques or safety in the past 1 years					
No	311	1		1	
Yes	209	0.31, 0.19-0.55	<0.001	0.52, 0.20-1.36	0.185
Limited awareness of available training opportunities (yes)	322	1.01, 0.60-1.67	0.983		
Time constraints due to daily mining work (yes)	242	0.91, 0.55-1.52	0.735		
Low literacy or educational background (yes)	125	1.25, 0.65-2.39	0.501		
Perception that training is not necessary for mining work (yes)	109	2.36, 1.05-5.27	0.036	1.30, 0.22-7.75	0.770
Environmental Factors					
Soil degradation (yes)	291	1.06, 0.65-1.73	0.826		
Water pollution (yes)	368	1.39, 0.83-2.36	0.212		
Deforestation (yes)	357	1.82, 1.09-3.03	0.023	1.41, 0.62-3.19	0.407
Poor waste disposal (yes)	312	1.57, 0.95-2.58	0.078	1.16, 0.59-2.29	0.664
Air pollution (yes)	197	1.24, 0.72-2.12	0.454		

Variable	n (%)	Unadjusted OR		Adjusted OR	
		OR, 95% CI	p-value	OR, 95% CI	p-value
Healthcare Factors					
Access to healthcare services near your mining site					
No	73	1			
Yes	447	0.96, 0.52-1.79	0.920		
Respiratory problems (yes)	84	1.05, 0.59-1.84	0.878		
Skin conditions (yes)	215	1.20, 0.69-2.07	0.509		
Injuries/accidents from equipment (yes)	320	0.84, 0.51-1.38	0.488		
Fatigue or exhaustion (yes)	341	1.71, 1.03-2.82	0.037	1.31, 0.89-194	0.172
Waterborne diseases (yes)	194	1.21, 0.71-2.05	0.479		

Hints: OR=Odds Ratio, SE=Standard Error, 95% CI= 95 percent confidence interval, p-value=Probability value, (yes)=imply the baseline group is No

Model summary: Between cluster variance=1.95359, SE=1.795962

Inter-cluster correlation coefficient=37.3%, 95% CI: 13.7%-68.9%

Chi=23.07, $p<0.001$; Log likelihood = -178.86907

Conclusion

This study examined the risks and challenges facing small-scale gold mining in Tanzania, with a particular focus on the Geita region. The findings reveal that these challenges are not solely technical or financial but are rooted in broader structural conditions and individual-level characteristics. Miners face multifaceted constraints related to financial access, adequacy of equipment and technology, legal and market knowledge, environmental management, and occupational health and safety. Understanding the interconnected nature of these challenges provides a critical foundation for evaluating existing interventions and developing more effective strategies to support sustainable and equitable growth within the small-scale mining sector.

Recommendations

Based on the conclusion, below are the recommendations:

1. Local district officers need to establish regular on-site outreach programs that provide miners with practical training on legal compliance, environmental safety, and financial literacy to improve access to formal services and reduce operational risks.
2. Miners' organisations should strengthen collective action by pooling resources to acquire shared equipment and negotiate better market terms, while promoting internal guidelines that encourage safe practices and basic record-keeping.
3. Miners should adopt simple financial and production record-keeping and participate in available training opportunities to enhance technical skills, improve safety, and increase eligibility for formal credit.

Conflict of Interest

The author declares that there are no conflicts of interest regarding the publication of this paper.

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