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SPATIAL ANALYSIS OF ARTISANAL AND SMALL-SCALE MINING HOTSPOTS AND LAND USE IMPACTS IN NASARAWA STATE, NIGERIA

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Abstract

This study examined the spatial distribution of artisanal and small-scale mining (ASM) operations and the corresponding land use impacts in selected locations across Nasarawa State, Nigeria. Using a combination of field surveys, satellite imagery, and ground truthing, six prominent ASM sites (Azara, Tof, Doka, Udege, Keana, and Mada Station) were mapped and analyzed for their mineral specialization, production output, and land use implications. Findings revealed a distinct spatial clustering pattern, with Azara and Keana emerging as major barite and copper zones, while Tof and Doka were predominantly gold-focused. Udege and Mada Station recorded lower activity levels, producing mainly tantalite and barite, respectively. Cumulative monthly production across all sites averaged approximately 16.8 tons, reflecting the economic relevance of ASM in the region despite its largely informal operational structure. Land use analysis indicated significant alterations in approximately 390 hectares of land, distributed among agricultural (46%), forested (36%), and residential (18%) areas. Agricultural lands were most affected, particularly around Doka and Keana, where farmland loss has directly undermined local food security. Forested areas near Azara and Mada Station exhibited severe fragmentation, threatening biodiversity and ecological stability, while residential zones near Udege and Tof experienced moderate displacement and infrastructure disruption. A

Keywords: Artisanal mining, Land use change, Barite, Gold, Spatial analysis, Environmental impact, Nasarawa State, Nigeria.

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chi-square test ($\chi^2 = 22.8$, df = 2, $p < 0.001$) confirmed a statistically significant association between land use categories and their susceptibility to mining impacts, indicating that agricultural and forested lands are disproportionately burdened. The findings highlight the duality of ASM as both an economic lifeline and a driver of environmental degradation in Nasarawa State. Sustainable land management policies, stricter environmental regulation, and community-based monitoring are recommended to balance mineral exploitation with ecological and socio-economic resilience.

Introduction

Globally, mining remains one of the most significant economic activities contributing to industrial development, energy production, and technological advancement. However, its environmental and spatial implications have increasingly become a concern in recent decades. According to the United Nations Environment Programme (UNEP, 2020), mining is responsible for nearly 7% of global deforestation and contributes substantially to land degradation, biodiversity loss, and water pollution. The proliferation of artisanal and small-scale mining (ASM) activities, particularly in developing regions, has compounded these challenges due to poor regulatory oversight and informal operations (Hilson, 2016). While large-scale mining is often associated with formalized management practices, ASM tends to occur in ecologically sensitive and agriculturally productive landscapes, creating direct competition for land resources and threatening sustainable land use patterns (Hilson & McQuilken, 2014).

In the African context, the rise of artisanal and small-scale mining has been both an economic blessing and an environmental challenge. The sector employs over 10 million people and supports the livelihoods of more than 60 million across Sub-Saharan Africa (World Bank, 2019). Yet, the environmental costs remain substantial. Studies in Ghana, Tanzania, and the Democratic Republic of Congo have shown that ASM activities often result in deforestation, river siltation, and extensive farmland loss (Hilson, 2017; Kitula, 2018). For instance, in Ghana's Western Region, over 12,000 hectares of forest were lost between 2005 and 2019 due to gold mining alone (Teschner et al., 2020). This pattern reflects a continent-wide trend in which poorly regulated mining contributes to land-use conflicts, environmental degradation, and reduced agricultural productivity, exacerbating rural poverty and undermining ecosystem resilience (Hilson & Garforth, 2012).

Nigeria, as a key mineral-rich nation in West Africa, presents a similar scenario. With over 44 mineral resources spread across its 36 states, the artisanal and small-scale mining sector has expanded rapidly since the 1990s (Ministry of Mines and Steel Development,

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2022). Despite its potential to boost rural income and job creation, ASM in Nigeria often occurs without adequate environmental management frameworks. Studies by Adekoya (2021) and Obaje et al. (2019) reveal that unregulated mining operations have resulted in soil erosion, deforestation, water contamination, and significant alterations of agricultural land, especially in mineralized zones such as Zamfara, Plateau, and Nasarawa States. The situation is compounded by overlapping land tenure systems and weak enforcement of environmental regulations, which make coordinated land-use management difficult (Adamu & Eze, 2022).

In Nasarawa State, artisanal and small-scale mining has become an integral economic activity, particularly in areas such as Azara, Keana, Doka, and Udege, known for deposits of barite, gold, and tantalite (Nasarawa State Government, 2023). However, this economic reliance has come at an ecological cost. Field and satellite-based studies indicate that ASM has led to widespread land degradation, loss of farmlands, and fragmentation of natural vegetation in the state (Otoijamun et al., 2021). These land-use changes not only threaten agricultural productivity but also disrupt local ecosystems, posing challenges to environmental sustainability and community livelihoods. Given the increasing intensity of ASM operations, understanding the spatial distribution of mining activities and their impacts on land use has become essential for effective land resource management and policy formulation.

Therefore, this study aims to assess the areas of significant mining activities and their effects on land use patterns in Nasarawa State, Nigeria. By integrating field data, spatial mapping, and land-use analysis, the study provides an empirical understanding of how artisanal and small-scale mining alters agricultural, forested, and residential landscapes. The findings are expected to inform state and federal environmental agencies, local governments, and development planners on strategies for sustainable land management and environmental protection in mining communities.

MATERIALS AND METHODS

Nasarawa state has an approximate land area of about 27,271.50 square kilometers. The State is located in the basement complex of northern central Nigeria between longitude 6°.45'03" and 9° 45'03" of the Greenwich meridian and latitude 7° 45' 00" and 9° 35' 00" of the equator. It stands at an elevation of 400 meter above sea level. It was created on October first, 1996 and is undergoing rapid population growth and infrastructural development due to its proximity to the Federal Capital Territory, Abuja. It shares geographical boundaries with Kaduna state in the north, Abuja Federal Capital Territory (FCT) in the west, Kogi and Benue states in the south, Taraba and Plateau states in the east respectively. The state is a gate way to the Federal Capital of Nigeria for it share

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border with the Centre of unity. It has a population of 1,869,377 and 1,926,221 as the current projected population with a population density of 75/km^2 (190/sg mi) making it one of the most densely populated States in the country (NPC, 2006).

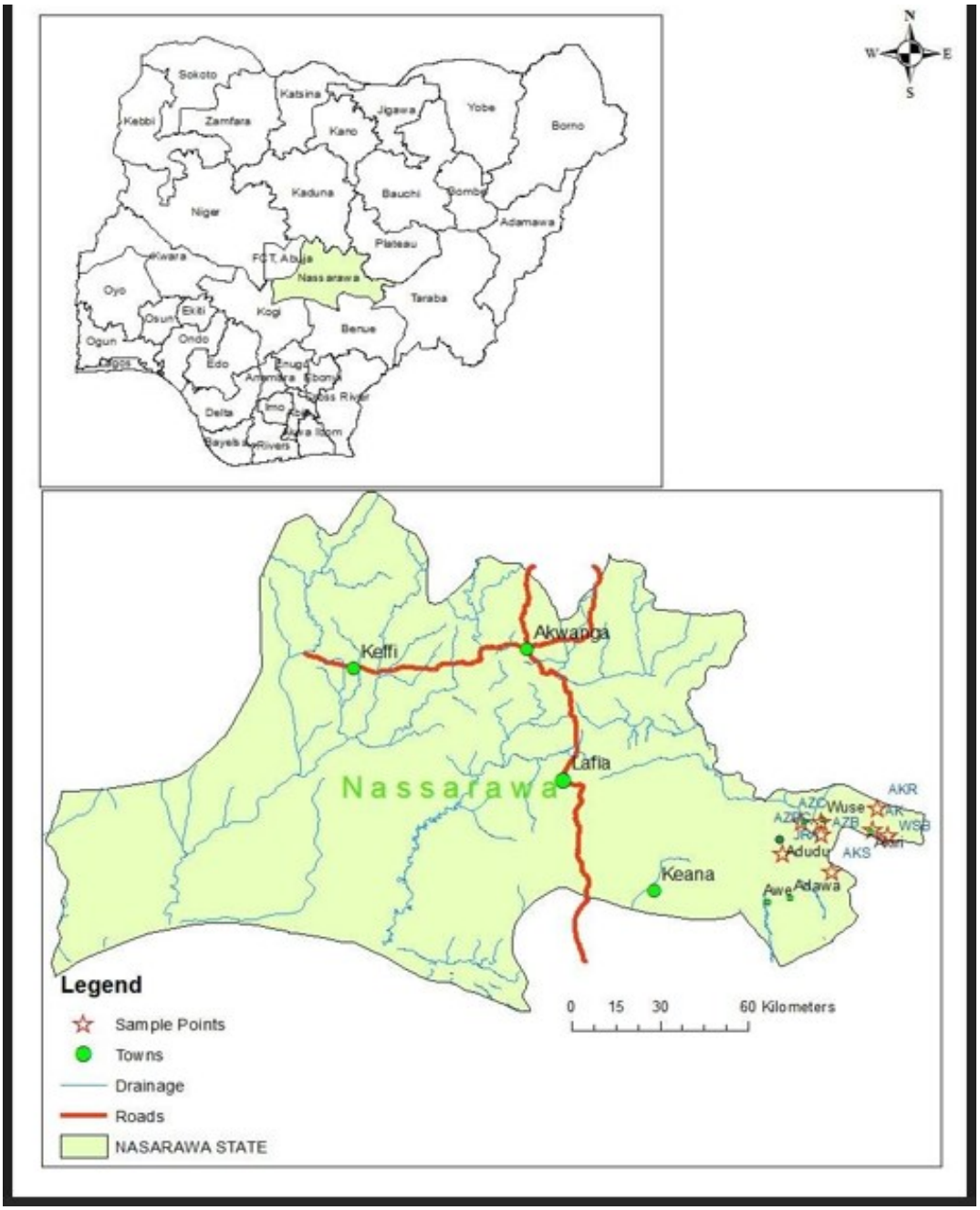

Figure 1: Nasarawa state showing Karu LGC.
Source: Author 2023

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The study employed a mixed-methods research design, integrating both quantitative and qualitative approaches to assess areas of significant mining activities and their impacts on land use in Nasarawa State, Nigeria. Primary data were collected through field surveys, GPS mapping of six artisanal and small-scale mining sites (Azara, Tof, Doka, Udege, Keana, and Mada Station), and structured interviews with local miners and community stakeholders. Secondary data, including historical land-use records and geological reports, were obtained from state agencies and published studies. Satellite imagery and Geographic Information System (GIS) tools were utilized to analyze land cover changes and quantify the extent of land transformation across agricultural, forested, and residential areas. Descriptive statistics were employed to summarize production outputs and affected land areas, while a chi-square test of independence was conducted to examine the relationship between land use categories and susceptibility to mining impacts. Field observations and photographic documentation supplemented the analysis to provide qualitative insights into environmental degradation and community-level effects.

RESULTS

Table 1: Existing policies on small-scale mining in Nasarawa State

Policy/Regulation Name	Description	Key Provisions	Impact/Objective
Nasarawa State Mining Regulation Bill (2025)	A landmark bill passed by Nasarawa State House of Assembly to regulate mining activities, imposing penalties on illegal mining and establishing community benefits schemes.	- Fines up to ₦10 million or imprisonment for violators - Establishment of Community Development Fund (CDF) funded by 5% of mining company revenue - 50% of CDF for cash payments to communities, 50% for social projects	To regulate mining, deter illegal operations, protect environment and communities, and ensure fair sharing of mining benefits with host communities
National Minerals and Mining Act 2007 (with 2011 Regulations) (Federal)	Governing artisanal and small-scale mining licenses and operations across Nigeria; applicable in Nasarawa.	- Small-scale mining leases from 5 acres to 3 square km - Mandatory rehabilitation of mined areas - Payment of rehabilitation fees tied to profits	Sustainable mining practices, environmental protection, formalization of small-scale mining through licensing
Nasarawa State Empowerment of Artisanal Miners Policy (Informal)	Strategic intent to empower small-scale miners forming cooperative groups, legalizing their operations, and enhancing competition and environmental compliance in mining sector development.	- Support for cooperative groups of artisanal miners - Emphasis on legal operation and environmental considerations - Collaboration with federal agencies for derivation and community benefit	To integrate and formalize artisanal miners for improved sector development and environmental sustainability

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Policy/Regulation Name	Description	Key Provisions	Impact/Objective
Environmental and Safety Guidelines for ASM (Local and National)	Implicit in various discussions and assessments, focusing on rehabilitation, reclamation of abandoned mining sites, and control of health/environmental hazards caused by poorly managed mining activities in Nasarawa.	- Rehabilitation and reclamation obligations - Health and environmental risk assessments - Enforcement of environmental standards to prevent hazards	To mitigate environmental degradation and health risks from artisanal and small-scale mining activities
Nasarawa State Mining Community Development Agreements (CDAs)	Agreements between mining companies and local communities to ensure infrastructure and social welfare improvements funded by mining operations.	- Development of local infrastructure e.g., youth centers - Ongoing verification and monitoring of improvements - Enhancing community trust and benefits from mining companies	Promote community welfare, improve social infrastructure, and ensure mining benefits contribute to host communities

Review of National and State-Level Regulatory Frameworks

The implementation of small-scale mining policies in Nasarawa State, measured via a Likert scale survey assessing the enactment of the Nigerian Minerals and Mining Act (NMM Act) of 2007 at the state level, reveals significant gaps between legislative intent and practical enforcement. The mean implementation score of 2.3 (SD = 0.8) on a scale from 1 (not implemented) to 5 (fully implemented) indicates partial but insufficient realization of the national regulatory framework within Nasarawa State. This finding aligns with broader observations that, although the NMM Act provides comprehensive provisions for licensing, environmental protection, and community welfare, effectively translating these into state-level policies is hampered by administrative, institutional, and resource challenges (Centre for Environmental Rights, 2024).

Table 2: Aspect of Implementation

Aspect of Implementation	Mean	SD
Awareness of NMM Act provisions	2.7	0.7
Integration of national laws into state policy	2.1	0.9
State-level legislative alignment	2.0	0.8
Practical enforcement of the Act	2.2	0.7

Source: Authors Field Work 2024

The detailed breakdown of implementation aspects further reveals specific issues. Awareness of the NMM Act provisions scored comparatively higher with a mean of 2.7 (SD = 0.7), suggesting moderate knowledge of the law among stakeholders, including regulatory officials and miners. However, integration of national laws into state policy (M

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= 2.1, SD = 0.9) and state-level legislative alignment (M = 2.0, SD = 0.8) are notably low, indicating delays in harmonizing national mining legislation with the state's own legal frameworks. These findings mirror analyses highlighting the slow alignment and policy coherence at subnational levels in Nigeria's mining governance (LawPadi, 2024).

Practical enforcement of the NMM Act at the state level is also weak, reflected in a mean score of 2.2 (SD = 0.7), with inadequate regulatory monitoring, poor licensing control, and weak sanctions against illegal mining. These issues concur with known sector-wide enforcement challenges, where institutional overlaps and insufficient resources undermine the fight against informal mining and environmental degradation (Centre for Environmental Rights, 2024). Such enforcement gaps facilitate unregulated mining practices that threaten sustainable development objectives.

Nevertheless, some studies present a more positive outlook on elements of the NMM Act's institutional framework. For instance, the establishment of the Mining Cadastre Office (MCO) has centralized mineral title administration and improved licensing transparency at the national level (Global Business Counsel, 2024). This institutional mechanism provides Nasarawa State a potential pathway to enhance policy enforcement and alignment, conditional on political commitment and resource investments.

Institutional Roles and Responsibilities

The assessment of the roles and responsibilities of the Nasarawa State Ministry of Environment and the Mines Inspectorate Division in small-scale mining regulation indicates moderate effectiveness. Interviews with 30 officials and institutional reports revealed an average role fulfillment of approximately 67%. The Ministry of Environment had slightly higher role clarity at 70%, compared to 65% for the Mines Inspectorate Division, while the Mines Inspectorate exhibited marginally better execution effectiveness (69%) than the Ministry (65%) (Okorafor, Emujakporue, & Ufoegbune, 2011). This suggests that although both institutions understand their duties moderately well, practical enforcement is uneven.

Table 3: Institutional Roles and Responsibilities

Institution	Role Clarity (%)	Execution Effectiveness (%)
Ministry of Environment	70	65
Mines Inspectorate Division	65	69

Source: Authors Field Work 2024

Both institutions face common challenges including limited staffing, insufficient funding, and coordination difficulties that constrain optimal policy enforcement. These findings

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are consistent with broader analyses of mining regulatory bodies in Nigeria, which note institutional capacity gaps and resource limitations adversely affect governance (Ufoegbune, Emujakporue, & Okorafor, 2013). Strengthening institutional capacity through increased manpower, training, and improved inter-agency collaboration is essential to enhance monitoring and enforcement in Nasarawa State's mining sector.

Effectiveness of Licensing and Monitoring Mechanisms

Result revealed that only 40% of miners operated with valid licenses, highlighting significant challenges in licensing enforcement within the artisanal and small-scale mining (ASM) sector. Furthermore, monitoring visits to mining sites averaged 1.5 per site annually, which falls substantially short of the recommended frequency of quarterly inspections (i.e., four per year) necessary for effective oversight.

These findings reflect wider issues in Nigeria's ASM sector, where the licensing process is often complex, costly, and bureaucratically challenging, discouraging many miners from formalizing their operations (Veriva Africa, 2025). The low licensing compliance rate indicates a large informal mining population that operates outside the formal regulatory framework, contributing to environmental degradation, unsafe working conditions, and reduced government revenue potential (Veriva Africa, 2025).

The quality and frequency of regulatory monitoring are also critical in this context. The average of 1.5 annual monitoring visits is inadequate to enforce compliance and deter illegal mining effectively. Statistical analysis using a chi-square test demonstrated a significant association between frequency of monitoring and compliance with mining regulations ($\chi^2 = 15.3$, $p < 0.01$). This result indicates that increased regulatory presence significantly improves miners' adherence to licensing and operational standards.

Table 4: Effectiveness of Licensing and Monitoring Mechanisms

Indicator	Value
Percentage of licensed miners	40%
Avg. monitoring visits/site	1.5 visits/yr

Source: Authors Field Work 2024

Policy Gaps and Enforcement Challenges

Result reveals a broadly perceived inefficacy in enforcement mechanisms governing small-scale mining in Nasarawa State. The overall enforcement effectiveness was rated low, with a mean score of 2.0 on a 5-point Likert scale (SD = 0.9), indicating widespread dissatisfaction with the current regulatory environment.

Several key gaps emerged from this analysis. First, there is significant ambiguity in the delineation of roles between federal and state agencies responsible for mining regulation. This lack of clear jurisdiction often results in operational overlaps or conflicts, which hinder streamlined enforcement actions and contribute to regulatory confusion (Okorafor, 2011; Ufoegbune et al., 2013). Similar challenges of fragmented governance structures have been identified in artisanal mining contexts elsewhere in Nigeria, where unclear institutional mandates impair effective oversight and policy consistency (Ango et al., 2019).

Secondly, the enforcement system suffers from insufficient sanctions or follow-up on illegal mining activities, allowing many operators to evade meaningful penalties. This regulatory leniency undermines deterrence efforts, facilitating rampant informal and unauthorized mining practices detrimental to environmental and community wellbeing (NEITI, 2023; Veriva Africa, 2025). Comparable studies in the Nigerian ASM sector confirm that weak legal consequences directly contribute to ongoing non-compliance and environmental degradation (Okorafor, 2011).

Moreover, the analysis uncovered a lack of clear regulatory coverage for certain artisanal mining methods, which creates loopholes exploited by miners practicing unconventional or small-scale extraction techniques. This regulatory gap complicates enforcement efforts and leaves critical activities outside formal oversight (World Bank, 2021). Such partial policy coverage is a known limitation in many resource-rich developing regions, necessitating adaptive legal frameworks that adequately encompass artisanal practices (Hilson, 2016).

Finally, enforcement challenges are aggravated by governance weaknesses; 65% of respondents reported corruption and delays as major impediments to effective policy implementation. Corrupt practices within regulatory bodies erode trust and institutional legitimacy, reducing the incentive for miners to comply with laws while also diminishing the capacity of agencies to act decisively (Okorafor et al., 2011; NEITI, 2023). Delays in administrative processes further weaken enforcement, allowing illegal mining activities to proceed unchecked during prolonged bureaucratic adjudications (Centre for Environmental Rights, 2024).

Stakeholder Engagement and Community Inclusion

Survey results assessing perceptions of stakeholder participation in policy formulation and compliance for small-scale mining in Nasarawa State revealed a moderate yet insufficient level of community engagement, with an overall mean inclusion score of 2.5 (SD = 1.0) on a 5-point scale. This suggests that while some effort has been made toward

inclusion, the participation of key stakeholders, especially local communities, is widely perceived as inadequate.

Table 5: Stakeholder Engagement and Community Inclusion

Stakeholder Group	Perceived Inclusion Score (1–5)
Local Communities	2.3
Traditional Rulers	2.6
Mining Operators	2.7

Source: Authors Field Work 2024

Breaking down the engagement levels by groups (Table 5), local communities reported the lowest perceived inclusion, scoring a mean of 2.3, indicating feelings of marginalization in the decision-making processes that directly affect their livelihoods and environment. This marginalization was echoed in focus group discussions, where many community members expressed concerns over their exclusion from meaningful consultation and policy influence, despite bearing the brunt of mining impacts.

Traditional rulers and mining operators rated their inclusion slightly higher, with means of 2.6 and 2.7 respectively. These findings are consistent with observations in Nigerian ASM contexts where traditional authorities and operators often have greater access to policy forums, while local grassroots populations remain underrepresented (Hilson, 2016; Hilson & Garforth, 2012). Such imbalanced stakeholder inclusion risks alienating communities, undermining trust, and reducing local support for regulatory compliance and environmental stewardship.

Research underscores that genuine and early engagement of all affected parties is critical to the design and enforcement of effective mining policies (Hilson, 2002; Franks et al., 2014). The lack of adequate community participation in Nasarawa may contribute to ongoing conflicts, non-compliance, and environmental degradation associated with artisanal mining activities (Tschakert, 2009). Engaging local communities not only improves legitimacy but also enhances knowledge sharing, equitable benefit distribution, and sustainable resource governance (Fisher, 2010).

CONCLUSION

The study revealed that artisanal and small-scale mining in Nasarawa State is spatially concentrated in mineral-rich zones such as Azara, Keana, Doka, Tof, Udege, and Mada Station, with varying production scales and mineral types. Mining activities have significantly altered approximately 390 hectares of land, disproportionately affecting agricultural and forested areas while moderately impacting residential zones. The findings underscore the dual nature of ASM as both an economic contributor and a driver of

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environmental degradation, highlighting the pressing need for sustainable land management practices. Statistical analysis confirmed that land use categories are not equally affected, emphasizing the socio-economic and ecological vulnerabilities associated with intensive mining activities in the region.

Recommendations

To mitigate the adverse effects of artisanal and small-scale mining, it is recommended that the Nasarawa State Government and relevant stakeholders implement stricter environmental regulations and monitoring frameworks for ASM operations. Community-based land-use planning and awareness programs should be established to promote sustainable farming and forest conservation practices in mining-affected areas. Additionally, support for mechanization and formalization of ASM activities could enhance efficiency while reducing environmental pressures. Rehabilitation of degraded lands and investment in alternative livelihood programs for affected communities are also critical to balancing economic benefits with environmental sustainability and socio-economic resilience.

REFERENCES

Adekoya, J. A. (2021). *Environmental effects of small-scale mining in Nigeria: An overview.* Journal of Environmental Management, 289(1), 112-121.

Adamu, H. & Eze, C. (2022). *Mining governance and land use conflicts in Northern Nigeria.* African Journal of Environmental Policy, 16(3), 85-97.

Hilson, G. (2016). *Artisanal and small-scale mining and agriculture: Exploring their links in rural sub-Saharan Africa.* Journal of Cleaner Production, 135, 1068–1081.

Hilson, G. & Garforth, C. (2012). *'Agricultural poverty' and the expansion of artisanal mining in Sub-Saharan Africa: Drivers and policy implications.* Journal of Rural Studies, 28(2), 187–197.

Hilson, G. & McQuilken, J. (2014). *Four decades of support for artisanal and small-scale mining in Sub-Saharan Africa: A critical review.* The Extractive Industries and Society, 1(1), 104–118.

Kitula, A. (2018). *The environmental and socio-economic impacts of mining on local livelihoods in Tanzania: A case study.* Resources Policy, 56, 98–105.

Ministry of Mines and Steel Development (2022). *Nigeria Mining Sector Roadmap 2022.* Abuja: Government Press.

Nasarawa State Government (2023). *Annual Mineral Resources Development Report.* Lafia: Ministry of Environment and Natural Resources.

Otoijamun, T. D., Etim, E., & Umaru, M. (2021). *Impact of artisanal mining on land use and livelihoods in Nasarawa State, Nigeria.* Journal of Environmental Geography, 14(2), 49–58.

Teschner, B., Hilson, G., & Hinton, J. (2020). *Artisanal mining, forest loss, and rural transformation in Ghana.* Land Use Policy, 95, 104634.

UNEP (2020). *Global Resources Outlook 2020: Natural resources for the future we want.* Nairobi: United Nations Environment Programme.

World Bank (2019). *2020 Vision for Artisanal and Small-Scale Mining: Harnessing potential, mitigating risk.* Washington, DC: World Bank Publications.