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Environmental Compliance and Land Degradation Dynamics in Artisanal and Large-Scale Mining: Evidence from Jos South, Nigeria

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Abstract

Mining plays a dual role as both a catalyst for economic growth and a driver of severe environmental degradation, particularly in regions where compliance with environmental standards is weak or poorly enforced. In Nigeria, the coexistence of artisanal and large-scale mining presents contrasting compliance behaviors with far-reaching ecological and socio-economic implications. This study examines environmental compliance and land degradation dynamics across artisanal and large-scale mining operations in Jos South Local Government Area, Plateau State. A mixed-methods approach was employed, integrating quantitative data from 374 survey respondents with qualitative insights drawn from interviews with regulators, community leaders, and mining operators. Findings reveal marked differences in compliance and degradation outcomes between artisanal and large-scale mining. Artisanal mining was strongly linked to abandoned pits, water pollution, and the loss of farmland productivity—consequences of informal practices, weak institutional oversight, and the absence of reclamation mechanisms. Large-scale mining, though formally regulated, exhibited partial and inconsistent compliance with environmental management standards, particularly in progressive land rehabilitation, topsoil conservation, and waste disposal. These lapses resulted in vegetation clearance, soil erosion, and widespread deforestation, undermining the long-term ecological balance of the region. The study further identifies institutional weaknesses—including overlapping agency mandates, inadequate enforcement capacity, and limited stakeholder engagement—as structural barriers that perpetuate poor compliance at both mining scales. It concludes that achieving sustainable mining in Jos South requires scale-sensitive regulatory frameworks tailored to the distinct realities of artisanal and large-scale operations. Key recommendations include the introduction of mandatory rehabilitation bonds and performance guarantees for large-scale operators, the establishment of community-based monitoring and reporting systems for artisanal mining sites, and enhanced inter-agency coordination to strengthen regulatory enforcement. By adopting these measures, Nigeria can mitigate land degradation, safeguard local livelihoods, and align mining practices with broader goals of environmental sustainability and socio-economic resilience.

Keywords

Mining compliance,
Artisanal mining,
Large-scale mining,
land degradation,
Jos South,
Environmental regulation.

INTRODUCTION

Mining plays a dual role in global development. On one hand, it provides the raw materials essential for industrial growth and energy transitions; on the other, it is a major driver of land degradation where regulatory compliance is weak or fragmented (Gunawardena, Lokupitiya, & Gunawardena, 2024). Degradation linked to mining manifests in soil erosion, vegetation loss, altered hydrology, and biodiversity decline, outcomes that are particularly acute in developing economies with limited enforcement capacity (Global Environment Facility [GEF], 2024). The approach of Land Degradation Neutrality (LDN) underscores that restoration alone is insufficient; preventive compliance at every stage of mining from exploration to closure is critical to sustaining land functions (United Nations Convention to Combat Desertification [UNCCD] & World Overview of Conservation Approaches and Technologies [WOCAT], 2024).

In Africa, many countries have updated their mining statutes to include Environmental Impact Assessments (EIAs), Environmental Management Plans (EMPs), and closure obligations. Yet, practical enforcement remains weak, largely due to overlapping institutional roles and under-resourced inspectorates (Chambers and Partners, 2025). Nigeria reflects these dynamics, with evidence of poor topsoil management, unrehabilitated pits, and inadequate sediment control across artisanal and large-scale operations (Ojo, Balogun, Aluko, & Alage, 2025). Despite regulatory frameworks such as the Nigerian Minerals and Mining Act (2007) and the NESREA Act (2007), compliance often exists "on paper" rather than in practice, resulting in

significant land degradation across mining zones (Nwosu & Okonkwo, 2020).

The Plateau State context, particularly Jos South Local Government Area, provides a concentrated lens on these challenges. Historically a tin and columbite hub, the region today exhibits visible environmental crises: landform alteration, shrinking farmland, silted waterways, and degraded soils (Lawal Usman, Offiah, Anyaku, & Ugal, 2024).

Community surveys confirm abandoned pits as the most salient morphological feature of non-compliance, while weak progressive reclamation continues to depress agricultural productivity and increase disaster risks during heavy rainfall. Recognizing this, the Plateau State Government in February 2025 issued Executive Order 001 suspending mining statewide to address both security risks and "ongoing mass degradation of farmlands," underscoring the urgency of operationalizing stricter compliance measures (Nanlong, 2025). Despite these interventions, artisanal and large-scale mining continue to operate side by side, each presenting unique compliance challenges. Artisanal mining is typically informal, with limited awareness or capacity to meet regulatory obligations, resulting in widespread abandoned pits and water contamination. Large-scale mining, though bound by EIAs and EMPs, often demonstrates weak enforcement of rehabilitation bonds and reclamation clauses, leading to deforestation and soil compaction (GEF, 2024; Ojo et al., 2025).

Yet, few studies in Nigeria have systematically compared the compliance behavior and environmental consequences of artisanal versus large-scale operations. This paper

addresses that gap by examining the dynamics of environmental compliance and land degradation across artisanal and large-scale mining in Jos South, providing evidence for designing differentiated compliance frameworks that can mitigate land degradation while sustaining mining as a driver of development in Nigeria.

LITERATURE REVIEW

Mining and Land Degradation

Mining is globally recognized as a leading cause of land degradation, particularly in biodiversity-rich and agriculturally productive areas. The UNCCD (2024) identifies land cover change, soil productivity decline, and soil organic carbon loss as key indicators of mining-linked degradation. In Nigeria, mining contributes to deforestation, erosion, soil infertility, and water contamination, with artisanal and large-scale operations both implicated (Barde, Adeleye, Oladeji, & Duhu, 2024; Akakuru et al., 2024). Artisanal mining tends to produce visible scars such as abandoned pits and silted waterways, while large-scale mining contributes to deforestation, landscape fragmentation, and hydrological changes through mechanized clearing and unrehabilitated tailings (Ojo, Balogun, Aluko, & Alage, 2025).

Environmental Compliance and Institutional Enforcement

Environmental compliance refers to adherence to standards and regulations designed to minimize ecological harm from mining activities (Zhao & Qi, 2020; Asatryan, 2024). In practice, however, compliance varies significantly by scale. Large-scale mining operations are legally required to prepare EIAs, EMPs, and closure plans, yet weak

enforcement often reduces these obligations to symbolic compliance (Suleiman, 2023). Artisanal and small-scale mining (ASM), by contrast, often operates informally and outside regulatory frameworks, making compliance virtually absent (AP News, 2024). Regulatory enforcement in Nigeria is further complicated by overlapping agency mandates and resource shortages (Nwosu & Okonkwo, 2020; Bello, 2024). For instance, while NESREA, state ministries, and local authorities all share enforcement roles, communities often perceive duplication and inefficiency rather than coherent oversight (LawHubDev, 2025).

Comparative Compliance in Artisanal vs. Large-Scale Mining

Empirical evidence suggests that the scale of mining operation directly shapes compliance outcomes. Uribe and Chávez (2025) found in Chile that large-scale mines respond more to inspections and fines, while artisanal mines evade detection due to their informality. In Nigeria, similar patterns emerge: artisanal miners often lack awareness of regulations and operate with minimal technical safeguards, leading to widespread environmental degradation (Okoye, 2023).

Large-scale operators, though more visible, exploit regulatory loopholes and weak sanctions, preferring to pay fines rather than rehabilitate mined land (Adebayo, 2023). In Plateau State, studies confirm that artisanal mining contributes disproportionately to abandoned pits and water pollution, while large-scale operations are linked to deforestation and soil compaction (Lawal Usman, Offiah, Anyaku, & Ugal, 2024).

Research Gap

While Nigerian literature has extensively documented mining-induced degradation, most studies do not systematically compare artisanal and large-scale compliance behaviors in relation to environmental outcomes (Agbese, 2024; Ojonugwa & Musa, 2023). Furthermore, institutional analyses often focus on broad regulatory challenges without assessing how compliance differs across scales of operation (Okonkwo & Nwankwo, 2023). This paper seeks to fill that gap by offering a comparative analysis of artisanal and large-scale mining in Jos South, linking compliance behaviors to specific land degradation outcomes.

METHODOLOGY

Research Design

This study employed a mixed-methods research design, integrating quantitative surveys with qualitative interviews. The mixed-methods approach was chosen to capture both measurable compliance patterns and deeper contextual insights into the drivers of non-compliance among mining operators in Jos South Local Government Area (LGA). This design aligns with the pragmatist paradigm, which values the use of multiple forms of evidence to explain complex socio-environmental issues (Dawadi, Shrestha, & Giri, 2021).

Study Area and Population

The research was conducted in Jos South LGA, Plateau State, a historically significant tin and columbite mining region where artisanal and large-scale operations coexist. The population comprised residents of mining communities, artisanal miners, employees of large-scale mining firms, regulatory officials, and community leaders. This population was

targeted to capture perspectives from both operators and those directly affected by land degradation.

Sampling Procedure and Sample Size

A stratified purposive sampling technique was adopted. Communities were first stratified into artisanal mining zones, large-scale mining zones, and mixed-use areas where mining and agriculture overlap. From these strata, purposive selection ensured inclusion of miners, farmers, regulatory officers, and local leaders. Using the Taro Yamane formula, a sample size of 400 respondents was determined from a population of approximately 458,100, with 374 valid responses retrieved (94% response rate).

Research Instruments

Data collection instruments included structured questionnaires and semi-structured interview guides.

- i. **Questionnaires** were administered to mining community residents, artisanal miners, and employees of large-scale firms. The instrument captured demographic characteristics, awareness of environmental regulations, compliance practices, and perceptions of land degradation.
- ii. **Interviews** were conducted with regulatory officers, community leaders, and company representatives, focusing on compliance barriers, enforcement challenges, and observed impacts of mining on land resources.

Validity and Reliability

To ensure validity, the questionnaire and interview guide were reviewed by subject experts in environmental management and pilot-tested in a neighboring mining community.

Reliability was established using test-retest procedures, and internal consistency of questionnaire items was confirmed with a Cronbach's alpha coefficient exceeding the 0.70 threshold.

Data Collection and Analysis

Quantitative data were collected through field-administered questionnaires, ensuring clarity and high response rates. The data were coded and analyzed using descriptive statistics (frequencies and percentages), which highlighted compliance trends and degradation impacts. Comparative analysis was carried out between artisanal and large-scale mining operations. Qualitative data from interviews were transcribed and analyzed thematically,

Awareness of Environmental Regulations

focusing on recurring issues such as regulatory enforcement gaps, scale-specific compliance behavior, and community experiences of land degradation. Triangulation of quantitative and qualitative findings strengthened the validity of conclusions.

RESULTS

This section presents the findings of the study, focusing on comparative patterns of environmental compliance and land degradation between artisanal and large-scale mining operations in Jos South Local Government Area. Results are drawn from 374 valid survey responses and complemented by qualitative interviews with regulators, community leaders, and miners.

Table 1: Awareness of Environmental Regulations by Mining Type

Mining Type	Very Aware	Aware	Slightly Aware	Not Aware	Total
Artisanal Mining	12 (7%)	36 (20%)	72 (40%)	60 (33%)	180 (100%)
Large-Scale Mining	56 (28%)	83 (42%)	30 (15%)	25 (13%)	194 (100%)

Field Survey, 2025

Awareness levels are significantly higher among large-scale mining operators, with 70% reporting awareness (very aware/aware) compared to only 27% of artisanal miners. This highlights a critical compliance barrier in artisanal operations, where lack of regulatory knowledge directly contributes to non-compliance.

Only 17% of artisanal miners rated regulations as effective, compared to 45% of large-scale operators. This indicates that regulatory frameworks are more visible in formal mining contexts but remain weak in addressing informal artisanal practices.

Perceived Effectiveness of Environmental Regulations

Table 2: Effectiveness of Regulations by Mining Type

Mining Type	Very Effective	Effective	Less Effective	Not Effective	Total
Artisanal Mining	9 (5%)	21 (12%)	82 (46%)	68 (37%)	180 (100%)
Large-Scale Mining	33 (17%)	55 (28%)	53 (27%)	53 (27%)	194 (100%)

Field Survey, 2025

Types of Land Degradation Linked to Mining

Table 3: Land Degradation Impacts Reported by Mining Type

Impact Type	Artisanal Mining (n=180)	Large-Scale Mining (n=194)	Total
Loss of Vegetation	28 (15%)	56 (29%)	84 (22%)
Soil Erosion	40 (22%)	52 (27%)	92 (25%)
Water Pollution	42 (23%)	24 (12%)	66 (18%)
Abandoned Pits	54 (30%)	54 (28%)	108 (29%)
Others	16 (10%)	8 (4%)	24 (6%)

Field Survey, 2025

Artisanal mining is more strongly associated with water pollution (23%) and abandoned pits (30%), while large-scale mining is linked to loss of vegetation (29%) and soil erosion (27%).

This suggests scale-specific environmental footprints: artisanal mining produces localized but acute hazards, whereas large-scale mining drives extensive landscape transformation.

Impact on Agricultural Productivity

Table 4: Agricultural Impacts of Mining by Mining Type

Impact Type	Artisanal Mining (n=180)	Large-Scale Mining (n=194)	Total
Reduced Crop Yield	88 (49%)	64 (33%)	152 (41%)
Reduced Grazing Land	38 (21%)	56 (29%)	94 (25%)
Increased Infertility	42 (23%)	56 (29%)	98 (26%)
No Significant Effect	12 (7%)	18 (9%)	30 (8%)

Field Survey, 2025

Artisanal mining has a stronger association with reduced crop yields, directly undermining household food security. Large-scale mining, however, contributes more to loss of grazing land and soil infertility, reflecting wider ecological disturbances caused by mechanized operations.

Penalties for Non-Compliance

Table 5: Reported Penalties by Mining Type

Penalty Type	Artisanal Mining (n=180)	Large-Scale Mining (n=194)	Total
Monetary Fines	18 (10%)	87 (45%)	105 (28%)
Suspension of License	0 (0%)	39 (20%)	39 (10%)
Temporary Closure	6 (3%)	40 (21%)	46 (12%)
Warning Only	84 (47%)	7 (4%)	91 (24%)
No Penalty	72 (40%)	21 (11%)	93 (25%)

Field Survey, 2025

Large-scale miners are more likely to face formal sanctions such as fines, suspension, or closure. By contrast, artisanal miners are overwhelmingly subject to warnings (47%) or no penalties (40%), reflecting weak or absent enforcement in the informal sector. Interview narratives reinforced the quantitative findings. Respondents described artisanal mining as “highly destructive, leaving behind open pits and polluted streams,” while large-scale companies were criticized for “clearing forests and abandoning land without adequate rehabilitation.” Regulators acknowledged difficulties in monitoring dispersed artisanal sites, while communities complained that penalties against large companies were inconsistent and often negotiated down through corruption.

DISCUSSION

The findings of this study highlight the divergent compliance behaviors and environmental outcomes of artisanal and large-scale mining operations in Jos South, Plateau State. While both scales of mining contribute substantially to land degradation, they do so through different pathways, shaped by

regulatory awareness, institutional oversight, and operational practices.

The results demonstrate that large-scale mining operators exhibit higher awareness of environmental regulations compared to artisanal miners (70% vs. 27%). This aligns with Uribe and Chávez (2025), who found that formal mines are more likely to comply with regulatory frameworks due to visibility, monitoring, and reputational risks. In contrast, artisanal miners often operate informally, with weak or nonexistent regulatory linkages, thereby evading compliance requirements (Okoye, 2023). This gap reinforces the argument by Asatryan (2024) that regulatory knowledge is a prerequisite for compliance, and where awareness is absent, enforcement alone is insufficient.

The comparative analysis reveals scale-specific degradation outcomes. Artisanal mining is strongly linked to abandoned pits, polluted streams, and reduced crop yields, corroborating findings by Lawal Usman et al. (2024) that informal mining scars Plateau farmlands and threatens food security. Conversely, large-scale mining was associated with deforestation, soil compaction, and

grazing land loss, consistent with Ojo et al. (2025), who reported that mechanized mining accelerates vegetation clearance and ecosystem disruption. These findings underscore the importance of scale-sensitive assessments: artisanal mining creates localized but acute hazards, while large-scale mining drives broader ecological transformations.

The penalty structure further illustrates institutional weakness in Nigeria's mining governance. Large-scale operators were subject to fines, suspensions, and temporary closures, while artisanal miners mostly faced warnings or no penalties. This reflects the duality of regulatory enforcement, where formal operators are penalized within an existing legal framework, whereas artisanal miners are treated with leniency due to their socio-economic vulnerability, political patronage, or the impracticality of formal sanctions (Bello, 2024). However, the persistence of weak penalties even for large-scale operators suggests a symbolic rather than deterrent enforcement regime, aligning with Institutional Theory's argument that organizations often comply ceremonially rather than substantively to maintain legitimacy (Meyer & Rowan, 1977).

These results reinforce calls for differentiated regulatory strategies. For artisanal miners, community-based monitoring and awareness campaigns are critical. The UNCCD (2024) emphasizes that environmental sustainability cannot be achieved without integrating local stakeholders into compliance processes. For large-scale mining, stricter enforcement of rehabilitation bonds, mandatory progressive reclamation, and

transparent penalty mechanisms are required to ensure accountability (GEF, 2024). Furthermore, the overlapping mandates of NESREA, state ministries, and local authorities create inefficiencies in enforcement (Nwosu & Okonkwo, 2020). Institutional streamlining, clearer role definition, and improved inter-agency coordination are therefore essential.

This study contributes to mining-environment literature in Nigeria by offering a comparative perspective that distinguishes between artisanal and large-scale compliance behaviors. Most existing studies analyze mining as a homogenous sector, thereby overlooking the differentiated drivers and outcomes of environmental degradation (Agbese, 2024; Ojonugwa & Musa, 2023). By demonstrating how scale shapes compliance and land degradation outcomes, this paper advances a scale-sensitive understanding of sustainable mining governance.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study assessed the dynamics of environmental compliance and land degradation arising from artisanal and large-scale mining in Jos South Local Government Area, Plateau State. The results demonstrate that both mining scales significantly degrade the environment, though through distinct pathways. Artisanal mining is strongly linked to abandoned pits, polluted water bodies, and declining agricultural productivity—outcomes rooted in its informal nature, lack of technical safeguards, and limited regulatory oversight. Large-scale mining, while ostensibly subject to formal regulations, contributes to widespread

deforestation, soil compaction, and the loss of grazing land. These impacts are aggravated by weak enforcement of rehabilitation obligations and tokenistic compliance practices.

The analysis also reveals a paradox: awareness of environmental regulations is relatively high among large-scale operators, yet compliance is often symbolic rather than substantive, motivated more by avoidance of sanctions than genuine commitment to sustainability. In contrast, artisanal miners display limited awareness of environmental standards, and their informality further constrains adherence. Enforcement regimes themselves display inconsistency—large-scale operators are subjected to fines or suspensions, whereas artisanal miners often face minimal penalties or informal warnings.

These findings validate Institutional Theory's proposition that in weak regulatory environments, compliance frequently becomes ceremonial, with organizations adopting superficial practices to maintain legitimacy rather than effecting meaningful environmental stewardship. Unless regulatory frameworks are reformed to address scale-specific challenges, land degradation in Jos South will persist, eroding agricultural livelihoods, undermining ecosystem services, and jeopardizing the long-term sustainability of Nigeria's mining sector.

Recommendations

1. Strengthen Rehabilitation and Reclamation Frameworks: Regulatory agencies should mandate *progressive land reclamation* during mining operations rather than postponing it

until closure. The introduction of rehabilitation bonds or escrow funds, linked directly to measurable reclamation targets, will ensure financial accountability and incentivize genuine restoration.

2. Community-Based Monitoring Systems: Local communities and civil society organizations should be empowered to participate actively in compliance monitoring. This can be achieved through awareness training, grassroots reporting systems, and the formal integration of traditional leaders into oversight structures, thereby enhancing transparency and local ownership.
3. Targeted Awareness and Capacity Building for Artisanal Miners: Tailored outreach programs should be designed to improve artisanal miners' understanding of environmental standards. Partnerships among state regulatory agencies, NGOs, and mining cooperatives could provide low-cost training, simplified guidelines, and technical support, thereby enhancing compliance at the grassroots level.
4. Institutional Streamlining and Coordination: The overlapping responsibilities of agencies such as NESREA, the Ministry of Mines and Steel Development, and Plateau State regulatory authorities should be clarified. Establishing a unified compliance task force would minimize duplication, reduce bureaucratic inefficiencies, and strengthen accountability in enforcement.

5. **Scale-Sensitive Compliance Mechanisms:** Policy frameworks must recognize that artisanal and large-scale mining require differentiated approaches. Artisanal mining should be gradually formalized through licensing schemes, cooperative models, and simplified reporting structures. In contrast, large-scale mining must be subjected to stricter regulatory oversight, including independent third-party audits, transparent penalties, and public disclosure of environmental performance.
6. **Inclusive Policy Reforms for Sustainable Mining:** Long-term reforms should embed mining regulation within broader sustainable development frameworks, linking compliance to agricultural productivity, water resource protection, and climate resilience. By doing so, Nigeria can align its mining governance with national development goals and international commitments such as the SDGs.

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