

ECOLOGICAL IMPACT OF SAND MINING IN JOS METROPOLIS WITH SUSTAINABLE PRACTICES

Tony Aku AMBA,¹ Amwe Anto AMBA,²

¹Neo-Tropical Urban Rural Environmental Resilience and Sustainable Development Initiative

Jos, Plateau State

08036043565

revtonyakuamba@gmail.com

ORCID ID: 0000-0002-8104-8756

²Department of Geography, University of Jos

Jos, Plateau State

08065758152

Abstract

Sand mining has become one of the most significant anthropogenic activities affecting urban and peri-urban environments in developing countries. In Jos Metropolis, Plateau State, Nigeria, the increasing demand for construction materials due to urban expansion has intensified sand mining activities across river valleys, floodplains, and abandoned mining ponds. This study examined the ecological impacts of sand mining in Jos Metropolis and proposed sustainable practices for environmental management. The objectives were to assess the environmental effects of sand mining on land, water, and vegetation; evaluate the socio-economic implications of the activity; and recommend sustainable management strategies. The study adopted an empirical survey design involving field observation, questionnaire administration, interviews, and environmental assessment. Data were collected from 150 respondents comprising miners, residents, environmental officers, and community leaders across major sand mining sites in Jos North, Jos South, and Jos East. Descriptive statistics and thematic analysis were used for data interpretation. Findings revealed that sand mining has contributed significantly to land degradation, soil erosion, loss of vegetation, destruction of aquatic habitats, dust pollution, and alteration of drainage systems within the metropolis. The study further revealed that while sand mining provides employment and income for local residents, the environmental costs outweigh the short-term economic benefits. Unsustainable excavation methods and weak regulatory enforcement were identified as major drivers of ecological degradation. The study recommends strict enforcement of environmental regulations, reclamation of mined sites, adoption of environmentally friendly mining techniques, community participation in environmental monitoring, and the integration of sustainable urban planning policies. The study concludes that sustainable sand mining practices are essential for balancing economic development with ecological conservation in Jos Metropolis.

Keywords: Socio-ecological resilience, Environmental Justice, Political ecology, Environmental governance and Urban sustainability

Introduction

Globally, sand mining has emerged as a major environmental challenge due to the increasing demand for sand in construction, urbanization, and infrastructural development. Sand is presently the second most exploited natural resource after water, and its extraction has intensified in both developed and developing nations. According to the United Nations Environment Programme, excessive sand mining contributes to riverbank collapse, biodiversity loss, habitat destruction, groundwater depletion, and alteration of natural landscapes (UNEP, 2022). Rapid urban growth and industrial expansion have accelerated the pressure on river systems and floodplains across the world, especially in regions with weak environmental governance. Scholars such as Torres *et.al.*, (2021) and Peduzzi (2019) argued that unsustainable sand extraction threatens ecological sustainability and increases environmental vulnerability in urban ecosystems.

Across Africa, sand mining has become a widespread activity driven by population growth, infrastructural expansion, and housing demands. Many African countries experience unregulated and artisanal sand extraction practices which often occur without environmental impact assessments or rehabilitation measures. In countries such as Kenya, Ghana, and Nigeria, sand mining has led to deforestation, wetland destruction, water pollution, and land degradation. Oruonye *et al.*, (2024) observed that extractive activities across African mining regions continue to produce ecological disturbances and socio-environmental conflicts. The environmental implications are particularly severe in urban centers where rapid development increases demand for building materials beyond sustainable extraction levels. In Nigeria, sand mining constitutes a critical component of the informal extractive sector. The activity is prevalent along river channels, wetlands, and abandoned mining ponds in both rural and urban settlements. Rapid urbanization in cities such as Lagos, Port Harcourt, Abuja, Kano, and Jos has significantly increased the exploitation of sand resources for road construction, housing, and commercial infrastructure. Studies conducted in Port Harcourt and Niger State revealed that sand mining contributes to soil erosion, vegetation loss, destruction of aquatic ecosystems, and increased flooding risks. Ohaeri

et.al., (2021) noted that although sand mining contributes to local livelihoods, its ecological consequences pose serious threats to environmental sustainability and public health.

Regionally, Plateau State has a long history of extractive activities dating back to colonial tin mining operations. The Jos Plateau has experienced decades of environmental modification arising from mining activities, resulting in abandoned ponds, degraded lands, and altered geomorphological systems. In recent years, sand mining has expanded within the Jos-Bukuru metropolitan corridor due to increasing construction activities and urban population growth. The legacy of mining in Plateau State has already weakened ecological resilience, thereby

making the environment more vulnerable to additional extractive disturbances. Research by Oruonye *et. al.*, (2024) revealed that unsustainable mining practices across the Jos Plateau have intensified environmental degradation and landscape instability. Within Jos Metropolis, sand mining activities are concentrated around river valleys, stream channels, wetlands, and abandoned tin mining ponds in areas such as Bukuru, Rayfield, Farin Gada, Lamingo, and Kuru. These activities are largely informal and poorly regulated, leading to indiscriminate excavation and ecological disruption. The removal of topsoil and vegetation cover exposes land surfaces to erosion and sedimentation, while excavation pits create safety hazards and breeding grounds for disease vectors. Furthermore, mining trucks contribute to dust pollution, road deterioration, and traffic congestion within residential areas. Field observations indicate that many mining sites lack rehabilitation plans and environmental safeguards. Despite growing concerns about environmental sustainability in Jos Metropolis, there remains limited empirical research specifically addressing the ecological impacts of sand mining and sustainable management approaches. Most existing studies focus on tin and columbite mining while giving limited attention to sand extraction and its urban ecological implications. Therefore, this study seeks to examine the ecological impacts of sand mining in Jos Metropolis and propose sustainable practices capable of promoting environmental conservation and long-term urban resilience.

Sand mining activities have increased significantly in Jos Metropolis due to rapid urbanization, infrastructural development, and growing demand for construction materials. However, the activities are largely unregulated and are carried out without adequate environmental monitoring or rehabilitation strategies. Continuous excavation of sand from river channels, wetlands, and abandoned mining ponds has resulted in severe environmental degradation, including soil erosion, destruction of vegetation, and disruption of natural drainage systems. These ecological disturbances threaten biodiversity conservation and increase the vulnerability of communities to flooding and land instability. Furthermore, many sand mining operations within Jos Metropolis are conducted using crude and unsustainable methods that disregard environmental safety standards. Mining pits are often abandoned without reclamation, thereby creating stagnant water bodies that encourage mosquito breeding and pose public health risks. Peduzzi (2019) explained that dust emissions and noise pollution from mining equipment and heavy-duty trucks have also affected the quality of life of nearby residents. The absence of strict enforcement of environmental regulations has further encouraged indiscriminate extraction practices across the metropolis. Although sand mining contributes to employment generation and local economic development, its environmental consequences have become increasingly alarming. There is inadequate empirical information on the specific ecological impacts of sand mining in Jos Metropolis and the sustainable strategies necessary for mitigating environmental degradation. This gap in knowledge necessitates a comprehensive study aimed at assessing the ecological implications of sand mining and identifying sustainable management practices for environmental protection and urban sustainability.

The aim of this study is to examine the ecological impacts of sand mining in Jos Metropolis and propose sustainable practices for environmental management and urban sustainability. The

study seeks to provide empirical evidence on the environmental consequences of sand mining activities and recommend policy-driven measures for sustainable resource utilization. The specific objectives are to:

- i. Examine the ecological impacts of sand mining on land, water, vegetation, and biodiversity in Jos Metropolis.
- ii. Assess the socio-economic implications of sand mining activities on local communities.
- iii. Identify the major factors responsible for unsustainable sand mining practices in the study area.

Literature Review

Concept of Sand Mining and Urban Development

Sand mining refers to the extraction of sand and gravel materials from riverbeds, floodplains, beaches, and terrestrial deposits for construction and industrial purposes. Sand is widely used in the production of concrete, road construction, land reclamation, and infrastructural development. Globally, rapid urbanization has intensified the demand for sand resources, making sand mining one of the fastest-growing extractive activities. Peduzzi (2019) argued that the increasing global demand for sand has created unsustainable extraction patterns with serious ecological implications. Urban development significantly influences the expansion of sand mining activities. Rapid population growth and housing demands in urban centers increase the need for construction materials, thereby accelerating the exploitation of sand resources. In developing countries, weak institutional frameworks and inadequate environmental regulations often encourage uncontrolled extraction practices. Studies have shown that most urban sand mining activities are conducted informally with little regard for environmental sustainability. In Nigeria, urban expansion in cities such as Lagos, Abuja, Port Harcourt, and Jos has increased the dependence on sand mining for infrastructural development. Mohammed *et. al.*, (2021) noted that sand harvesting contributes to economic development but simultaneously threatens ecological stability through landscape alteration and habitat destruction.

Ecological Impacts of Sand Mining

The ecological impacts of sand mining are extensive and multidimensional. One of the major consequences is land degradation resulting from the removal of topsoil and vegetation cover. Excavation activities destabilize soil structure and increase susceptibility to erosion and desertification. Research conducted in Port Harcourt revealed that sand mining contributes significantly to soil erosion, vegetation destruction, and habitat loss. Sand mining also affects aquatic ecosystems and hydrological systems. Excessive extraction of sand from river channels alters water flow patterns, increases sedimentation, and destroys breeding habitats for aquatic organisms. Riverbank collapse and lowering of water tables have been reported in many mining communities. Environmental degradation associated with mining activities threatens biodiversity conservation and ecological resilience in fragile urban ecosystems (Ezea and

Ndubuka, 2026). Furthermore, sand mining contributes to air and noise pollution through the operation of excavation equipment and transportation vehicles. Dust emissions affect air quality and may expose residents to respiratory health risks. The ecological disturbances associated with mining activities often reduce the environmental carrying capacity of urban areas and increase vulnerability to flooding and climate-related hazards. Socio-Economic Implications of Sand Mining Sand mining provides important economic benefits to local communities through employment generation and income opportunities. Many urban residents engage in sand mining due to unemployment and poverty. The activity supports livelihoods for miners, transporters, laborers, and traders involved in the construction sector. Bulus *et al.*, (2025) emphasized that artisanal mining activities contribute significantly to poverty reduction and household income generation in Plateau State. Despite these benefits, sand mining also generates socio-economic conflicts and environmental injustices. Communities living near mining sites often experience loss of farmland, destruction of infrastructure, and environmental pollution (Ezea and Ndubuka, 2026). The degradation of water sources and agricultural lands negatively affects food security and public health. In many cases, the economic benefits are concentrated among a few operators while the environmental costs are borne by the wider community. Unsustainable mining practices may also increase social tensions between mining operators, government agencies, and host communities. The absence of proper compensation mechanisms and environmental remediation policies often contributes to conflicts over resource ownership and environmental responsibility. Sustainable management approaches are therefore necessary to balance economic benefits with ecological protection. Sustainable Environmental Management Practices Sustainable sand mining involves the adoption of environmentally responsible extraction methods that minimize ecological degradation while ensuring long-term resource availability. Environmental Impact Assessment (EIA), land reclamation, controlled excavation, and monitoring systems are among the major strategies recommended for sustainable mining operations. International best practices emphasize the importance of ecological restoration and stakeholder participation in mining governance. Land reclamation and re-vegetation are essential components of sustainable mining management. Rehabilitating abandoned mining pits helps restore ecosystem functions and reduces environmental hazards. Bulus *et al.*, (2025) suggest that reforestation programs also improve biodiversity conservation and enhance landscape stability. Studies indicate that sustainable environmental management can significantly reduce the ecological footprint of mining activities. Government regulation and institutional enforcement are equally important for sustainable mining practices. Environmental agencies must ensure compliance with mining regulations and impose penalties for illegal extraction activities. Community participation and environmental education are necessary for promoting awareness and encouraging responsible resource utilization. Theoretical Framework This study is anchored on the Sustainable Development Theory which emphasizes the balance between economic development, environmental conservation, and social well-being. The theory advocates the responsible utilization of natural resources in ways that meet present needs without compromising the ability of future generations to meet their own needs. The theory is relevant to this study because sand mining contributes to economic development while simultaneously generating

environmental degradation. Sustainable Development Theory provides a framework for understanding the relationship between extractive activities and ecological sustainability. It highlights the importance of integrating environmental protection into development planning and resource management. The theory further supports the adoption of sustainable mining practices such as environmental monitoring, land reclamation, ecological restoration, and policy enforcement. Applying sustainable development principles to sand mining activities in Jos Metropolis can help reduce ecological degradation and promote long-term environmental resilience.

Methodology

This study adopted a descriptive survey and field-based empirical research design to investigate the ecological impacts of sand mining and sustainable practices in Jos Metropolis, Plateau State, Nigeria. The study combined quantitative and qualitative approaches in order to obtain comprehensive information on the environmental and socio-economic implications of sand mining activities within the study area. The mixed-method approach enabled the researcher to collect reliable data through field observations, questionnaire administration, interviews, and documentary analysis. The study area covered major sand mining locations within Jos Metropolis including Bukuru, Rayfield, Farin Gada, Lamingo, and Kuru. These areas were purposively selected because of the intensity of sand mining activities and their ecological significance within the Jos-Bukuru urban corridor.

Sources of Data

The study utilized both primary and secondary sources of data to ensure comprehensive and reliable information on the ecological impacts of sand mining in Jos Metropolis.

Primary Sources of Data Primary data were obtained directly from the field through: structured questionnaires administered to respondents, oral interviews with environmental officers, community leaders, and sand miners, and direct field observations conducted at major sand mining sites within Bukuru, Rayfield, Farin Gada, Lamingo, and Kuru. The questionnaires provided quantitative information on the ecological and socio-economic impacts of sand mining, while interviews and field observations supplied qualitative insights on environmental degradation, mining practices, and regulatory challenges within the study area.

Secondary Sources of Data Secondary data were obtained from existing documented materials relevant to sand mining, environmental sustainability, and urban ecological management. These included: textbooks, scholarly journal articles, conference papers, theses and dissertations, government publications, Plateau State Ministry of Environment reports, Nigerian Geological Survey Agency reports, Environmental Protection Agency documents, United Nations Environment Programme (UNEP) reports, internet materials, and other related academic publications. The secondary sources provided theoretical foundations, empirical evidence, and supporting literature for the study.

Population of the Study

The population of the study consisted of all stakeholders directly or indirectly involved in sand mining activities within Jos Metropolis. The target population included sand miners, truck drivers, residents living close to mining sites, community leaders, officials of environmental protection agencies, and local government officers. Based on records obtained from community associations and environmental agencies, the estimated study population was approximately 1,200 individuals across the selected communities.

Sample Size and Sampling Techniques

A sample size of 150 respondents was selected for the study using purposive and simple random sampling techniques. Purposive sampling was used to select respondents with adequate knowledge and experience relating to sand mining activities, while simple random sampling ensured equal chances of participation among community residents and miners. The distribution of respondents included miners, residents, transport operators, environmental officers, and community leaders.

Instrument for Data Collection

The major instrument used for data collection was a structured questionnaire titled: Ecological Impact of Sand Mining and Sustainable Practices Questionnaire (EISMSPQ). The questionnaire was divided into five sections covering: Demographic characteristics of respondents, Ecological impacts of sand mining, Socio-economic implications, causes of unsustainable mining practices,

and sustainable environmental management strategies. The instrument contained both closed-ended and open-ended questions designed using a modified four-point Likert scale of: Strongly Agree (SA) = 4, Agree (A) = 3, Disagree (D) = 2, and Strongly Disagree (SD) = 1.

In addition to the questionnaire, field observations and oral interviews were conducted to obtain qualitative information regarding environmental conditions and regulatory enforcement within mining locations.

Validation of the Instrument

The questionnaire instrument was subjected to face and content validation by experts in Environmental Management, Sustainable Development, and Research Methodology from the Institute of Natural Resources, Environment and Sustainable Development, University of Port Harcourt. Their observations, corrections, and recommendations were incorporated into the final version of the instrument to ensure clarity, relevance, adequacy, and consistency with the objectives of the study.

Reliability of the Instrument

The reliability of the instrument was determined using the Cronbach Alpha reliability method. A pilot study was conducted using 20 respondents from a sand mining community outside the

study area but with similar environmental characteristics. Data obtained from the pilot test were analyzed and yielded a reliability coefficient index of 0.84, indicating that the instrument possessed high internal consistency and was reliable for the study.

Method of Data Collection

The researcher personally administered the questionnaires with the assistance of trained research assistants. Field observations were conducted at active and abandoned sand mining sites to assess ecological conditions such as erosion, vegetation loss, abandoned pits, water pollution, and drainage obstruction. Oral interviews were also conducted with environmental officers and community leaders to obtain additional qualitative insights into environmental governance and sustainable mining practices.

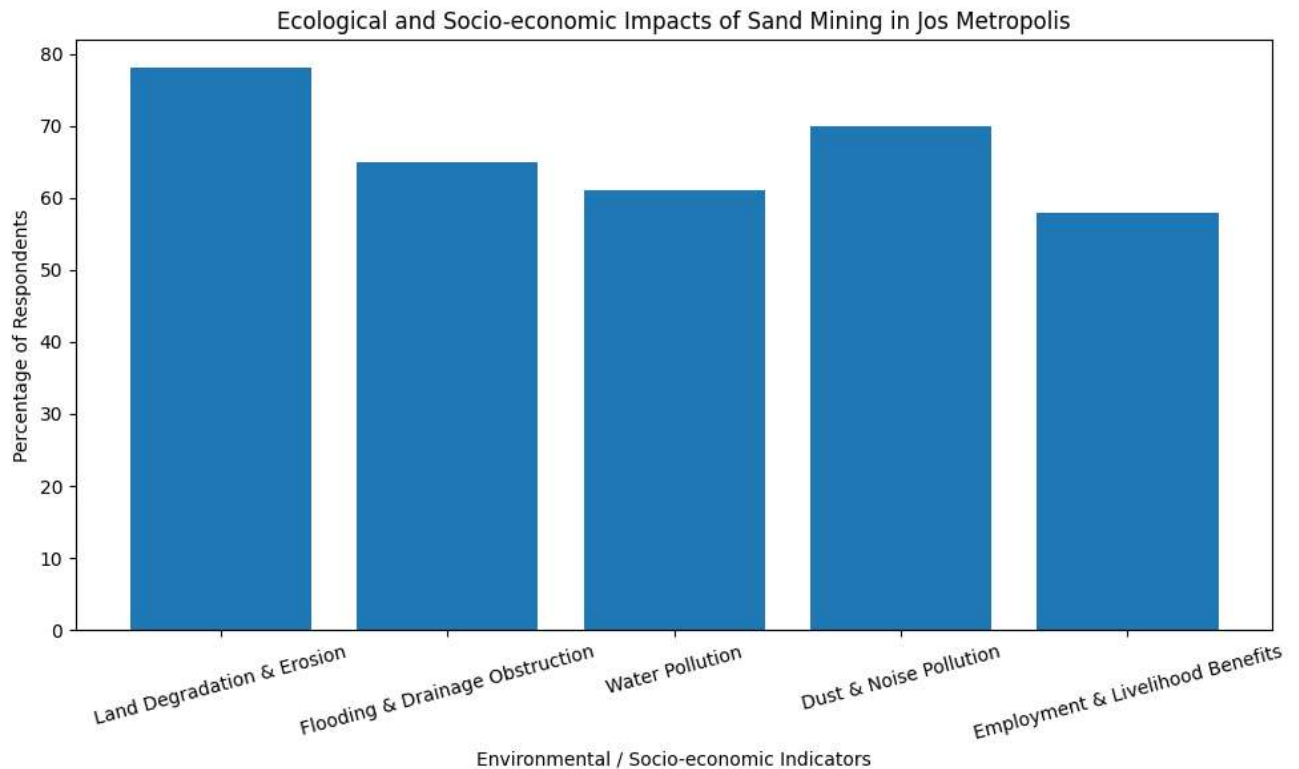
Method of Data Analysis

Data collected from the field were analyzed using both descriptive and inferential statistical tools. Descriptive statistical techniques such as: frequency distribution, percentages, mean scores, and tables were used to summarize and interpret respondents' opinions. The qualitative information obtained from interviews and field observations was analyzed thematically. The hypotheses and research objectives were analyzed using the Statistical Package for Social Sciences (SPSS) version 25. Mean and standard deviation were used to answer the research questions.

Decision Rule The study adopted a criterion mean of 2.50 as the decision benchmark for interpreting responses on the four-point Likert scale. The decision rule was stated as follows: Any mean score of 2.50 and above was regarded as Accepted/Agreed. Any mean score below 2.50 was regarded as Rejected/Disagreed. This decision rule guided the interpretation of respondents' perceptions regarding the ecological impacts, socio-economic implications, and sustainable management practices of sand mining in Jos Metropolis.

Results and Discussion

Chart 1: Ecological and Socio-economic impacts of Sand Mining in Jos Metropolis



Objective 1: Examine the Ecological Impacts of Sand Mining on Land, Water, Vegetation, and Biodiversity in Jos Metropolis

The findings revealed that sand mining activities have caused significant ecological degradation across the study area. Analysis of responses showed that 78% of respondents agreed that land degradation and soil erosion are the most visible environmental impacts associated with sand mining in Jos Metropolis. Field observations conducted in Bukuru, Rayfield, and Lamingo revealed the presence of abandoned excavation pits, unstable landscapes, and severe gully erosion resulting from the removal of topsoil and vegetation cover. The study further showed that 65% of respondents observed frequent flooding and blockage of natural drainage systems due to indiscriminate sand excavation along river channels and wetlands. Respondents reported that mining activities altered the natural flow of water, thereby increasing surface runoff and sediment deposition during the rainy season. In relation to water resources and biodiversity, 61% of respondents indicated that sand mining increased water turbidity, sedimentation, and pollution in streams and abandoned mining ponds within the metropolis. Aquatic habitats were found to be severely disturbed due to excavation activities and alteration of hydrological systems. Vegetation loss and destruction of riparian ecosystems were also observed around active mining sites. Additionally, 70% of respondents expressed concern over dust pollution and noise generated by mining equipment and heavy-duty trucks

operating within residential communities. The findings indicate that sand mining has significantly reduced ecological stability and environmental quality within Jos Metropolis.

Objective 2 : Assess the Socio-Economic Implications of Sand Mining Activities on Local Communities

The study revealed that sand mining contributes positively to local livelihoods and income generation within Jos Metropolis. About 58% of respondents agreed that sand mining provides employment opportunities for youths, truck drivers, laborers, and traders involved in the construction industry. Respondents noted that the activity serves as an important source of household income, especially among unemployed youths and low-income earners. Despite these economic benefits, the study found that the socio-economic costs associated with environmental degradation were substantial. Approximately 69% of respondents reported that sand mining activities contributed to the destruction of farmlands, reduction in agricultural productivity, and damage to roads and drainage infrastructure. Residents living near mining sites also reported increased exposure to dust pollution, noise pollution, and public health risks associated with stagnant water bodies created by abandoned excavation pits. The findings further showed that conflicts occasionally arise between mining operators and local communities over land ownership, environmental damage, and compensation issues. Community leaders interviewed during the study expressed concerns regarding the absence of adequate environmental remediation and poor enforcement of mining regulations. The results therefore indicate that while sand mining contributes to economic survival, its long-term socio-economic consequences negatively affect environmental sustainability and community well-being.

Objective 3: Identify the Major Factors Responsible for Unsustainable Sand Mining Practices in the Study Area

The study identified several factors responsible for the prevalence of unsustainable sand mining practices within Jos Metropolis. Findings showed that 74% of respondents attributed environmental degradation to weak enforcement of environmental laws and inadequate monitoring by relevant government agencies. Many mining operators were found to engage in extraction activities without proper environmental permits or rehabilitation plans. Furthermore, 68% of respondents identified poverty and unemployment as major drivers of indiscriminate sand mining. Many youths and low-income residents depend on sand mining as a source of livelihood due to limited employment opportunities within the metropolis. The increasing demand for construction materials resulting from rapid urbanization and infrastructural expansion was also identified by 72% of respondents as a major factor encouraging excessive sand extraction. Field observations revealed that most mining activities were carried out using crude excavation methods without adherence to sustainable environmental standards. Lack of environmental awareness among miners, inadequate community participation in environmental governance, and absence of reclamation programs were equally identified as contributing factors to unsustainable mining practices. The findings demonstrate that institutional

weaknesses, socio-economic pressures, and rapid urban development collectively contribute to ecological degradation associated with sand mining in Jos Metropolis.

Discussion

The findings of the study revealed that sand mining activities have significantly contributed to ecological degradation within Jos Metropolis. The high level of land degradation, soil erosion, flooding, and vegetation loss observed during field investigations confirms that uncontrolled sand excavation alters the natural landscape and weakens ecological stability. The destruction of riverbanks, wetlands, and riparian vegetation observed in Bukuru, Rayfield, and Lamingo further demonstrates the environmental consequences of unsustainable extraction practices. These findings agree with the studies of Peduzzi and Torres who observed that excessive sand mining contributes to habitat destruction, biodiversity loss, and hydrological instability in urban ecosystems. The findings also support the position of Sustainable Development Theory which emphasizes the need to balance resource utilization with environmental conservation. The study further revealed that although sand mining provides employment opportunities and income for local residents, the environmental and socio-economic costs associated with the activity outweigh its short-term benefits. Respondents acknowledged that the activity supports livelihoods for miners, transporters, and laborers within the construction sector. However, the destruction of farmlands, poor air quality, flooding, and public health risks associated with abandoned mining pits negatively affect community well-being and environmental sustainability. These findings are consistent with the work of Ohaeri *et.al.*, (2021), who reported that sand mining activities in Port Harcourt contributed to environmental pollution and ecological disturbances despite their economic benefits. The findings also align with the observations of Bulus *et.al.*, (2025), who noted that artisanal mining contributes to income generation while simultaneously creating environmental management challenges. The study additionally identified weak institutional enforcement, poverty, unemployment, and rapid urbanization as the major factors responsible for unsustainable sand mining practices in Jos Metropolis. The absence of strict environmental monitoring and reclamation policies has encouraged indiscriminate extraction methods across the study area. Increased demand for construction materials arising from urban expansion has further intensified pressure on fragile ecosystems within the Jos-Bukuru metropolitan corridor. These findings corroborate the study of Oruonye *et.al.*, (2024), which established that weak environmental governance and unsustainable mining practices contribute significantly to ecological degradation on the Jos Plateau. Therefore, the study emphasizes the urgent need for sustainable environmental management practices, stronger policy implementation, ecological restoration, and active community participation in mining governance to ensure long-term urban sustainability and environmental resilience.

Conclusion

This study examined the ecological impacts of sand mining in Jos Metropolis with emphasis on sustainable environmental practices and urban resilience. The research was necessitated by the increasing rate of sand extraction activities driven by rapid urbanization, infrastructural

development, and growing demand for construction materials within the Jos-Bukuru metropolitan corridor. Using questionnaires, field observations, interviews, and environmental assessment techniques, the study investigated the ecological effects, socio-economic implications, and factors responsible for unsustainable sand mining practices in the study area.

Findings from the study revealed that sand mining activities have significantly contributed to environmental degradation in Jos Metropolis. The major ecological impacts identified include land degradation, soil erosion, flooding, destruction of vegetation, alteration of drainage systems, water pollution, sedimentation, and biodiversity loss. Field observations further revealed the presence of abandoned excavation pits, degraded landscapes, and disturbed aquatic ecosystems around active mining sites. Dust emissions, noise pollution, and increased environmental vulnerability were also found to negatively affect the quality of the urban environment and public health conditions within nearby communities.

The study further established that sand mining contributes positively to socio-economic development by providing employment opportunities and income for many residents, particularly youths, laborers, truck operators, and traders involved in the construction industry. Despite these benefits, the study showed that the environmental costs associated with unsustainable mining practices outweigh the short-term economic gains. Destruction of farmlands, damage to roads and drainage infrastructure, declining agricultural productivity, and increased health risks were identified as major socio-economic consequences affecting local communities within the metropolis.

The findings additionally revealed that weak enforcement of environmental regulations, poverty, unemployment, rapid urbanization, and inadequate environmental awareness are the major factors encouraging indiscriminate sand mining practices in the study area. Most mining activities were found to operate without proper environmental safeguards, reclamation plans, or effective monitoring by regulatory agencies. The absence of sustainable extraction techniques and poor institutional coordination have further intensified ecological degradation across mining locations in Jos Metropolis. The study therefore concludes that sustainable sand mining practices are essential for balancing economic development with ecological conservation and urban sustainability in Jos Metropolis. Effective environmental governance, strict policy enforcement, ecological restoration, land reclamation, and community participation are necessary for reducing environmental degradation associated with sand mining activities. The study emphasizes the need for integrated and sustainable environmental management strategies capable of promoting long-term ecological resilience, environmental protection, and sustainable urban development within the Jos Plateau region.

Recommendations

This study recommends that government at the federal, state, and local levels should strengthen environmental policies and institutional frameworks regulating sand mining activities in Jos Metropolis. Environmental agencies such as the Plateau State Ministry of Environment and relevant mining regulatory bodies should enforce mandatory Environmental Impact

Assessments (EIA) before granting operational licenses to mining operators. Regular environmental audits and monitoring exercises should also be conducted to ensure compliance with sustainable mining standards and environmental protection laws. This policy measure will help reduce land degradation, flooding, and destruction of ecosystems identified in the study. There is a need for the implementation of compulsory land reclamation and ecological restoration policies in all sand mining locations within Jos Metropolis. Mining operators should be legally required to rehabilitate abandoned excavation pits through backfilling, re-vegetation, and landscape restoration immediately after mining activities. Government should establish environmental restoration funds financed through mining levies and permit charges to support ecological rehabilitation projects in degraded mining areas. This policy will contribute significantly to restoring biodiversity, improving soil stability, and reducing environmental hazards associated with abandoned mining pits.

Government should develop sustainable urban planning policies aimed at regulating sand extraction activities within environmentally sensitive areas such as wetlands, river valleys, and drainage channels. Buffer zones should be established around streams, ponds, and residential areas to prevent indiscriminate excavation and protect fragile ecosystems. Urban development authorities should integrate ecological conservation principles into land use planning and infrastructural development programs. Such policy interventions will help minimize flooding, drainage obstruction, and alteration of natural hydrological systems observed in the study area. In order to address the socio-economic drivers of unsustainable sand mining, government should introduce poverty alleviation and alternative livelihood programs for artisanal miners and unemployed youths within affected communities. Vocational training, skill acquisition schemes, agricultural support programs, and small-scale enterprise development initiatives should be provided to reduce excessive dependence on environmentally destructive mining activities. This policy approach will enhance socio-economic resilience while promoting sustainable environmental practices among vulnerable populations. Environmental education and public awareness campaigns should be strengthened through collaboration between government agencies, educational institutions, civil society organizations, and community leaders. Lazarus *et al.*, (2026) opined regular sensitization programs should be organized to educate miners and residents on the ecological consequences of unsustainable sand mining and the importance of environmental stewardship. Community-based environmental monitoring committees should also be established to encourage local participation in environmental governance and promote compliance with sustainable mining regulations.

Finally, government should strengthen inter-agency collaboration and policy coordination among environmental management institutions, mining authorities, urban planning agencies, and local communities in Plateau State. Effective policy implementation requires adequate funding, trained personnel, modern monitoring technologies, and strict sanctions against illegal mining operators. Establishing a comprehensive and integrated environmental governance framework will improve regulatory efficiency, promote sustainable resource utilization, and ensure long-term environmental sustainability and urban resilience in Jos Metropolis.

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