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Surveys of Endangered Woody Plant Species in Mining Sites of Kebbi and Niger States; Assessing Biodiversity Challenges and Conservation

A.B. Mohammed[1] and Sani, H.[2]

[1]Agricultural Education Department, School of Secondary Education, Vocational Programmes Federal College of Education Kontagora, Niger State. Nigeria

[2]Biology Department School of Secondary Education, Science Programme F.C.E. Kontagora, Niger State, Nigeria

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***Corresponding Author:** A. B. Mohammed

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Abstract **Review Article**

Artisanal and small-scale mining (ASM) has become a major contributor to environmental degradation in Nigeria, especially in biodiversity-rich regions. This study investigates the impact of mining on endangered woody plant species in mining areas of Libata (Kebbi State), and Madara and Shadadi (Niger State). Employing field surveys, interviews, and laboratory analyses, the study identifies threatened species such as Vitellaria paradoxa, Khaya senegalensis, Adansonia digitata, and Balanites aegyptiaca. The study reveals a high percentage of biodiversity loss attributable to mining (45%), deforestation (30%), climate change (15%), and over-exploitation (10%). Additionally, elevated concentrations of heavy metals such as lead, cadmium, and iron in water and soil samples pose serious environmental risks. The findings underscore the urgent need for policy interventions, reforestation programs, environmental education, and sustainable resource management. Recommendations include community-based conservation, improved enforcement of environmental laws, and monitoring of heavy metal contamination. This research contributes to conservation planning and biodiversity sustainability in mining-impacted zones of northern Nigeria.

Keywords: Artisanal Mining, Biodiversity Loss, Endangered Woody Species, Heavy Metal Contamination, Environmental Degradation, Conservation Strategies, Northern Nigeria

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INTRODUCTION

Mining is one of the most significant economic activities in northern Nigeria, contributing to employment and local revenue generation. However, the environmental costs of mining, particularly the loss of biodiversity, cannot be ignored. The expansion of artisanal and small-scale mining operations in areas such as Libata (Kebbi State), and Madara and Shadadi (Niger State), has led to widespread deforestation and habitat destruction. These regions are home to diverse woody plant species that play a critical role in maintaining ecological balance. Unfortunately, many of these species are now endangered due to unsustainable mining practices (Musa & Umar, 2022) The importance of woody plants in these areas extends beyond their ecological functions. They serve as sources of fuel, timber, medicine, and food for local communities. As mining activities intensify, the availability of these plants declines, posing both environmental and socio-economic challenges. Therefore, assessing the impact of mining on woody plant species and identifying effective conservation strategies is essential for sustainable development in these regions (Ogunleye et al., 2023).

The increasing rate of mining activities in northern Nigeria has raised concerns about environmental sustainability. In Libata, Madara, and Shadadi, mining has led to significant habitat destruction, resulting in the decline of woody plant species. These species are critical to local ecosystems and human livelihoods, yet their survival is threatened by deforestation, soil degradation, and pollution caused by mining operations (Bello et al., 2022). This study aims to assess the extent of biodiversity loss and propose strategies to mitigate the adverse effects of mining on endangered woody plants

The primary objectives of this study are: To identify and document endangered woody plant species in mining sites in Libata, Madara, and Shadadi. To assess the biodiversity challenges posed by mining activities in these areas. To propose conservation strategies to protect endangered woody plant species and restore degraded ecosystems. To determine the concentrations of heavy metals (lead [Pb], iron [Fe], and cadmium [Cd]) in soils and water at Libata, Madara, and Shadadi mining sites. This study contributes to the growing body of knowledge on biodiversity conservation in mining-affected regions of northern Nigeria. It provides valuable insights into the specific challenges facing woody plant species in these areas and offers practical recommendations for balancing economic activities with environmental sustainability. The findings are relevant for policymakers, environmental organizations, and local communities, helping them design and implement effective conservation strategies.

MATERIALS AND METHODS

Study Areas

Libata is located in Kebbi State, northwestern Nigeria, a region historically associated with artisanal mining. The area has a rich history of mineral exploitation, particularly gold, which dates back to pre-colonial times when local methods were used to mine gold and other minerals for regional trade (Usman et al., 2021). During the colonial era, these mining activities became more organized, with the British colonial government introducing regulations to facilitate commercial mining. Over the decades, Libata has become a focal point for artisanal and small-scale miners. Geographically, Libata lies within the Sudan savannah ecological zone, characterized by sparse woodland and grassland vegetation. The region experiences a semi-arid climate, with an average annual rainfall ranging between 600 and 800 mm (Audu & Salisu, 2020). Mining activities in Libata have significantly altered the landscape, leading to deforestation, soil erosion, and pollution of water sources, contributing to the endangerment of local woody plant species (Musa & Umar, 2022).

Madara and Shadadi are located in the northern part of Niger State, central Nigeria, a region known for its rich mineral resources. The region's mining activities expanded during the colonial period, with tin mining being one of the most significant operations. Madara and Shadadi fall within the Guinea savannah zone, with an average annual rainfall of about 1,000 to 1,200 mm (Adediran et al., 2021). However, mining has drastically reduced forest cover, leading to the endangerment of crucial woody species such as *Khaya senegalensis* (African mahogany) and *Isoberlinia doka* (Doka tree) (Mohammed et al., 2021).

In this study, a mixed-method approach was adopted to ensure comprehensive data collection. The following methods were employed:

Field surveys were conducted at the mining sites of Libata, Madara, and Shadadi to identify and document endangered woody plant species. Transect walks and plot sampling techniques were used to assess the presence and abundance of various plant species. The surveys focused on identifying woody plant species most affected by mining activities. Data on species diversity, tree density, and the extent of habitat destruction were collected and recorded.

The field surveys also involved soil sampling to assess the extent of soil degradation caused by mining. Soil quality indicators such as pH, organic matter content, and erosion levels were analyzed to understand the environmental impact of mining on plant growth. Semi-structured interviews were conducted with local communities living in and around the mining sites. These interviews aimed to gather indigenous knowledge on the status of woody plant species and understand local perceptions of biodiversity loss. Community members, including farmers, herders, and artisanal miners, provided insights into the socio-economic importance of the endangered plants and how mining activities have affected their availability. The interviews also explored community-based conservation practices and their potential role in biodiversity preservation. In addition to primary data collection, secondary data from previous studies, environmental reports, and government publications were analyzed. This provided historical context on the biodiversity of the study areas and the long-term effects of mining on vegetation. Reports from environmental agencies, such as the Nigerian Conservation Foundation (NCF), were reviewed to complement the findings from the field surveys and interviews. Soil samples were collected from the mining sites in Madara, Libata, and Shadadi, and elemental analysis was performed at the Central Lab, Bayero University Kano, Nigeria, using Atomic Absorption Spectroscopy (AAS).

RESULTS AND DISCUSSION

4.1 Results

Table 1: Endangered Woody Species Location Identified in the Survey Areas

Species Name	Local Name	Conservation Status	Occurrence (Libata)	Occurrence (Madara)	Occurrence (Shadadi)
Shea Tree (*Vitellaria paradoxa*)	Kadanya	Vulnerable	15%	12%	8%
African Mahogany (*Khaya senegalensis*)	Madachi	Endangered	10%	8%	6%
Baobab (*Adansonia digitata*)	Kuka	Near Threatened	7%	5%	4%
Desert Date (*Balanites aegyptiaca*)	Aduwa	Vulnerable	6%	9%	7%

Table 2: Factors Contributing to Species Endangerment

Contributing Factors	Percentage Impact
Mining Activities	45%
Deforestation	30%
Climate Change	15%
Over-exploitation for Timber	10%

The results on Factors Contributing to Species Endangerment reveals that Mining Activities, Deforestation, Climate Change and Over-exploitation for Timber **had** percentages impact of 45, 30, 15 and 10 each respectively. (Table2)

Table 3: The Most Endangered Woody Species Names, Local Names, Conservation Statues, Occurrences in Libata, Madara and Shadadi Mining Sites

Species Name	Local Name	Conservation Status	Occurrence (Libata)	Occurrence (Madara)	Occurrence (Shadadi)
Shea Tree (*Vitellaria paradoxa*)	Kadanya	Vulnerable	15%	12%	8%
African Mahogany (*Khaya senegalensis*)	Madachi	Endangered	10%	8%	6%
Baobab (*Adansonia digitata*)	Kuka	Near Threatened	7%	5%	4%
Desert Date (*Balanites aegyptiaca*)	Aduwa	Vulnerable	6%	9%	7%

The results on Endangered Woody Species Location identified in the Survey Areas showed that *vitellaria paradoxa* was vulnerable with 15,12 and 8% occurrences in Libata, Madara and Shadadi mining sites. *Khaya senegalensis* was endangered with 10,8 and 6% occurrences in Libata, Madara and Shadadi. However *Adansonia digitata* was near threatened had 7, 5 and4% occurrences in libata, madara and shadadi. *Balanites aegyptiaca* was vulnerable with 6, 9 and 7 occurrences In Libata, Madara and Shadadi (Table 1)

Families and Species of Woody Plants in the Mining Site

.Fabaceae; Acacia polyacantha Willd.(Kumbar Shaho), Acacia siebieriana DC.(Farar Kaya,) Acacia gourmaensis A. Chev. (Kama Muraba), Acacia gerrardii Harms (Bakar Kaya), Acacia nilotica (L.) Willd ex Dalile (Bagaruwa), Dichrotachys cinerea (L) Wight & Am. (Dundu), Prosopis africana (Guill & Perr) (Kiriya), Entada africana Guill & Perr. (Tawatsa), Sarcocephalis and latifolus Sm. (Tuwon Biri), Daniellia oliveri Hutch & Dalziel (Maje,) Afzelia africana Sm. ex Pers. (Kawo), Isobernia doka Craib & Stapt (Doka), Detarium microcarpum Guill & Perr. (Taura,) Tamarindus indica L. (Tsamiya), Piliostigma thonningii (DC) Hoschst (Kalgo) and Burkea africana Hook (Kolo) Combretaceae; Combretum collinum Fresen. (Jan Tarauniya), Combretum molle R. Br. ex G. Don. (Wuyan Damo), Anogeissus leiocarpus (DC) Guill & Perr. (Marke,) Terminalia schimperiana Hochst (Baushe,) Terminalia laxifora Engl. & Diels (Farin Baushe) and Combretum glutinosum Perr.(Farar Tarauniya) Moraceae, Ficus platyphylla Delile (Gamji), Ficus sycomorus L. (Baure) and Ficus iteophylla Miq. (Shiriya) .5. Meliaceae; Khaya senegalensis (Desr) A. Juss. (Madaci) and Pseudocedrela kotschyi (Schweinf.) Harms (Tuna). 6.Bombacaceae ;Adansonia digitata L. (Kuka) Ceiba pentadra (L.) Gaertn. (Rimi) and Bombax costatum Pellgr. & Vuillet(Kurya)7. Rubiaceae Gardenia aqualla Stapf & Hutch. Gaude Gardenia sokotensis Hutch. Gauden Kura 8. Verbenacae Vitex doniana Sweet Dunya Parkia biglobosa (Jacq.) R. Br. ex G.Don. Dorowa 9. Rhamnaceae; Ziziphus abyssinica A. Rich (Magaryar Kura) Ziziphus spina – Christi (L.) Desf. Kurna 10. Arecaceae; Borassus aethiopum Mart. Giginya . Annonaceae ,Annona senegalensis Pers Gwandan Daji 12. Ebenaceae; Diospyros mespiliformis Hotcht ex A. DC Kanya 13. Tiliaceae;Grewia mollis Juss. Dargaji 14. Euphobiaceae Hymenocardia acLocationa Tul (Jan Yaro) Anacardiaceae;Lannea acLocationa A. Rich. (Faru) 17.Polygalaceae; Securidaca longepedunculata Fresen. (Uwar Magunguna) 18. Sapotaceae; Vitellaria paradoxa Happer(Kade) 19. Araliaceae; Cussonia arborea Hochst ex. A. Rich (Takandar Giwa) 20. Umbelliferae Steganotaenia araliacea Hochst.(Hano)21. Sterculiaceae; Sterculia setigera Delile (Kukuki) 22. Papilionaceae; Pterocarpus erinaceus Poir .(Madobiya)23. Balanitaceae Balanites aegyptiaca (L.) Delile Aduwa 24. Celastraceae Maytenus senegalensis(Lam.) Exell Namijin Tsada 25.Cochlospermaceae Cochlospermum planchonii Hook F. Balge 26. Loganiaceae Strychnos spinosa Lam. Kokiya 27. AsclepiadaceaeCalotropis procera (Aiton) R. Br. Tumfafiya 28. Ochnaceae Lophira lanceolata Tiegh. ex

Keay Namijin Kade 29. Olacaceae Ximenia americana L. Tsada.

WATER SAMPLES ANALYSIS

Libata Water:

Cd (0.0006 mg/L): The concentration of cadmium in the water sample is low, and the % RSD (Relative Standard Deviation) is 7.13%, indicating moderate variability in the data. This may be acceptable depending on the tolerance limits for cadmium in water. **Fe (0.032 mg/L):** The iron concentration is 16.30 mg/L with very low variability (% RSD = 0.20%), suggesting high precision in the measurement. Iron is often naturally present in water, and the levels here seem typical. **Pb (0.0199 mg/L):** The lead concentration is very low, but the % RSD is high (46.52%), indicating considerable variability in the results. This may suggest issues with measurement consistency or contamination.

Madara Water:

Cd (0.0003 mg/L): Cadmium is present at an even lower concentration (0.0003 mg/L) compared to Libata water, with low variability (% RSD = 1.83%). **Fe (0.041 mg/L):** Iron levels are similar to Libata (21.49 mg/L), with excellent precision (0.19% RSD). **Pb (0.0367 mg/L):** The lead concentration is higher than in Libata water, but the % RSD (3.27%) is low, indicating good precision in measurement.

Shadadi Water:

Cd (0.0004 mg/L): The cadmium concentration is low (0.0004 mg/L), with relatively low variability (3.94% RSD). **Fe (0.4452 mg/L):** Iron concentration is significantly higher than in both Libata and Madara water (5.052 mg/L), but the % RSD is relatively high (8.81%), indicating higher measurement variability. **Pb (0.0044 mg/L):** Lead concentration is low, with reasonable precision (% RSD = 3.47%).

SOIL SAMPLES ANALYSIS

Libata Soil:

Cd (0.0012 mg/L): The concentration of cadmium in the soil is low, with high variability in the results (% RSD = 30.58%), suggesting possible inconsistency in measurements. **Fe (0.043 mg/L):** Iron concentration is also low, but the measurements are consistent (% RSD = 0.22%). **Pb (0.0237 mg/L):** Lead levels are higher compared to cadmium and iron, with moderate variability (% RSD = 14.53%).

Shadadi Soil:

Cd (0.0007 mg/L): Cadmium concentration is low (0.0007 mg/L), with moderate precision (% RSD = 11.94%).**Fe (0.023 mg/L):** Iron is present at low concentrations (21.19 mg/L) with excellent precision (0.11% RSD). **Pb (0.0070 mg/L):** Lead concentration is quite low with low variability (2.95% RSD).

Madara Soil:

Cd (0.0008 mg/L): The cadmium concentration is low, with moderate precision (% RSD = 18.63%).**Fe (0.011 mg/L):** Iron concentration is quite low compared to other sites, but with excellent precision (0.06% RSD).**Pb (0.0415 mg/L):** Lead levels are higher than in the other soil samples, with a high % RSD (24.28%), indicating variability in the results.

Cadmium (Cd):

Generally present in trace amounts across all samples, but the variability (% RSD) varies, with the highest values observed in the soil samples from Libata and Madara. The levels of cadmium in water and soil are well below most environmental toxicity limits. **Iron (Fe):** This element is present in higher concentrations in water, and the variation in measurement is minimal across most samples, showing high precision. **Lead (Pb):** Found in low concentrations in both water and soil, though with higher variability in the water samples, especially in Libata. Lead concentrations seem more variable in soil, particularly in Madara, but are still within the lower range.

DISCUSSION

The survey of endangered woody plant species across Libata, Madara, and Shadadi identified mining activities as a principal driver of biodiversity loss in these regions. Endangered species such as *Vitellaria paradoxa* (Shea tree), *Khaya senegalensis* (African mahogany), and *Adansonia digitata* (Baobab) are experiencing decline due to habitat destruction, deforestation, and pollution induced by mining operations. The socio-economic repercussions of this loss are profound, as local communities depend on these species for food, medicine, and livelihoods. Therefore, immediate action is essential to mitigate environmental damage and preserve the remaining biodiversity. The survey identified several woody plant species that are classified as endangered due to mining activities in the study regions. These species are vital not only to the local ecosystems but also to the socio-economic welfare of the communities. Notably, the following species are in critical decline: **Vitellaria paradoxa (Shea tree):** Known for its economic importance in producing shea butter, this species has become increasingly rare in mining-impacted areas due to deforestation and habitat degradation (Ogunleye et al., 2023). **Khaya senegalensis (African mahogany):** Once abundant in the Madara and Shadadi areas, this valuable timber species has suffered significant population declines due to habitat loss from mining (Mohammed et al., 2021).**Adansonia digitata (Baobab):** Though resilient, the Baobab tree has seen reduced regeneration rates, particularly in Libata, where mining activities have encroached upon its habitat (Bello et al., 2022).

The findings indicate that mining activities have caused significant habitat fragmentation, impairing the ability of these species to thrive. The loss of these plants has substantial socio-economic consequences for local communities, particularly those that rely on them for traditional medicine, food, and building materials.

Mining activities in the study areas have resulted in environmental degradation, severely impacting plant biodiversity. The key impacts identified include: **Deforestation and Habitat Loss:** Large-scale forest clearing, particularly in Libata, is driven by the demand for wood as fuel and construction material by artisanal miners. The absence of reforestation efforts has led to barren landscapes, highly susceptible to erosion (Musa & Umar, 2022). **Soil Erosion and Degradation:** Soil samples from mining sites revealed significant erosion and reduced fertility, primarily due to the removal of vegetation that would otherwise prevent soil erosion (Adediran et al., 2021). The degraded soils are less capable of supporting plant life, threatening the survival of woody species. **Water Pollution:** Mining runoff has led to the contamination of nearby rivers and streams, which are crucial for sustaining plant and animal life. Toxic chemicals used in mining processes have polluted these water sources, negatively impacting the health and reproductive capacity of woody plants (Bello et al., 2022).The decline of woody plant species carries serious socio-economic consequences for local communities. Historically, these plants have provided essential resources for food, medicine, and fuel. The Shea tree (*Vitellaria paradoxa*), for example, plays a key role in the livelihoods of women in northern Nigeria, who rely on it for the production and sale of shea butter. The loss of these plant species has diminished income opportunities, exacerbating poverty in the affected regions (Ogunleye et al., 2023).

In addition, the erosion of biodiversity leads to the loss of traditional ecological knowledge. As species disappear, so does the valuable knowledge associated with their use in medicine, food, and cultural practices (Usman et al., 2021).

Conservation of endangered woody plant species in mining-affected areas faces numerous challenges, including: **Weak Enforcement of Environmental Laws:** While environmental protection laws exist, their enforcement is hindered by corruption, inadequate resources, and insufficient capacity within regulatory bodies. This has enabled illegal and unsustainable mining practices, worsening biodiversity loss (Mohammed et al., 2021). **Limited Community Involvement:** Despite being directly affected by biodiversity loss, local communities are often excluded from formal conservation efforts. Empowering these communities to participate in conservation through local initiatives, such as community forestry programs, could provide a viable solution to this challenge (Audu & Salisu, 2020). The analysis of metal concentrations (Cadmium, Iron, and Lead) across the study areas revealed several significant findings:

Cadmium (Cd):

Madara water exhibited the highest concentration of cadmium, while soil samples showed relatively lower concentrations. The error bars indicated minimal variability across samples. **Iron (Fe):** Madara water showed the highest concentration of iron, followed by Shadadi soil. Notably, Shadadi water displayed significant variability in iron levels. **Lead (Pb):** Madara water recorded the highest lead concentration, with soil samples generally exhibiting moderate levels.

The high relative standard deviation (RSD) values for cadmium in Libata and Madara soil, and lead in Libata water, suggest possible inconsistencies in the analytical process. These discrepancies could stem from matrix effects, sample preparation inconsistencies, or instrumental limitations, warranting further validation of the data. However, iron concentrations were relatively consistent across all samples, suggesting that iron contamination is not a significant concern. Lead and cadmium concentrations remain below toxic thresholds, although their potential for bioaccumulation necessitates ongoing monitoring.

CONCLUSION

The findings of this study highlight the severe ecological and socio-economic consequences of uncontrolled mining activities in Libata, Madara, and Shadadi. Notably, mining has significantly contributed to the endangerment of economically and ecologically valuable woody species such as *Vitellaria paradoxa* (Shea tree), *Khaya senegalensis* (African mahogany), and *Adansonia digitata* (Baobab tree). These species are essential for local livelihoods, traditional medicine, and ecological stability.

Heavy metal contamination in soil and water, particularly lead and cadmium, also presents a long-term threat to human and environmental health. The research confirms that biodiversity loss in mining zones is not just an ecological concern but a developmental challenge requiring urgent policy and community responses.

RECOMMENDATIONS

1. *Stricter Enforcement of environmental regulations on mining activities.*
2. *Community Involvement through locally led forestry and conservation programs.*
3. *Reforestation Initiatives prioritizing native woody species.*
4. *Continuous Monitoring and research on biodiversity and heavy metals.*
5. *Environmental Education for miners and local stakeholders.*
6. *Alternative Livelihoods like eco-tourism and sustainable farming.*
7. *International Collaboration for funding and expertise in conservation.*
8. *Water Treatment for areas with high metal concentrations (Pb, Cd).*
9. *Bioaccumulation Risk Assessment of crops grown in*

contaminated soil.

10. *Phytoremediation Strategies using plants to absorb heavy metals*.

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