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SUSTAINABLE MINING PRACTICES IN KADUNA STATE

[1]Bognet Cyprain Alfred, [2]Yusuf Mohammed, [3]Samuel Fidelis, [4]Kambai Elizabeth Peter

[1,3,4]Economics Department, Kaduna State University.
[2]Federal University Kashere (FUK), Gombe State.
[1] alfredbognet7@gmail.com , 08063226597
[2] mohammedyusuf9015@gmail.com , 08036842168
[3] fidelissamuel1990@gmail.com , 07068859582
[4] elizabethzigwaikambai@gmail.com; 08131281005

ABSTRACT

Mining activities in Kaduna State have significantly impacted the environment, local communities, and the broader economy. This study investigates the application of sustainable mining practices, focusing on the issues and remedies related to environmental impacts, community development, and economic sustainability. Data was collected using a mixed-method approach, including phone and online surveys, targeting 799 respondents-primarily community members, government officials, researchers and mining companies. The findings reveal that pre-mining conditions were characterized by abundant vegetation, clean water sources, and fertile soil, which have since deteriorated due to deforestation, soil erosion, and water pollution. A majority of respondents (72.8%) reported that Environmental Impact Assessments (EIAs) were not conducted before mining activities began, highlighting inadequate regulatory oversight. Current environmental impacts, including significant degradation in air, soil, and water quality, were identified by a large proportion of respondents (37.6% significant, 21.2% severe). The implementation of environmental management plans has been largely ineffective, with 62.8% of respondents expressing disagreement on their effectiveness. Social impacts, such as loss of livelihoods, displacement, and conflicts between communities and mining companies, were widespread. The majority (70%) reported mixed impacts on local communities, primarily negative, due to the disruption of traditional livelihoods. Awareness of community development programs was low, and only 3.9% confirmed their existence. Economic benefits were limited, with most respondents (72.2%) stating no significant gains, while challenges such as fluctuating commodity prices, inadequate community involvement, and poor regulatory enforcement hinder sustainable mining. Governance mechanisms were largely ineffective, as 95.4% of respondents rated government regulations as ineffective. Community participation in decision-making was minimal, with 72.5% unaware of such mechanisms. The study concludes that unless significant improvements are made in regulatory enforcement, community engagement, and sustainable mining practices, the long-term

environmental and socio-economic impacts of mining in Kaduna State are likely to persist, posing further challenges to sustainable development.

***Keywords**: sustainable mining, environmental impact, community development, regulatory enforcement, Kaduna State*

INTRODUCTION

Mining is central to Nigeria's efforts to diversify its economy away from oil dependence, and Kaduna State—situated in northwestern Nigeria—has been identified as a key contributor to this agenda because of its abundant solid minerals, including gold, nickel, lithium, cassiterite, tantalite, molybdenum and various gemstones such as aquamarine, sapphire and amethyst distributed across its 23 local government areas (Adebayo 2024). This endowment has encouraged both artisanal and large-scale mining, yet the sector in Kaduna remains relatively underdeveloped and continues to account for only a modest share of Nigeria's gross domestic product. Persistent structural and governance challenges constrain the sector's performance, particularly the dominance of informal and illegal mining, which is estimated to constitute more than 80% of mining activity in the state and is associated with revenue leakages, environmental degradation and heightened security risks, including banditry and terrorism (Opinion Nigeria, 2023). In response, federal and state authorities have introduced reforms intended to promote more sustainable mining practices, such as licensing regimes that favour firms involved in domestic mineral processing, fiscal incentives like tax waivers, strengthened security interventions and programmes to formalise and train artisanal miners in safer mining techniques and improved environmental management (Reuters, 2024; The Cable, 2023).

Despite this rich mineral base and the policy initiatives underway, the extent to which sustainable mining practices are being integrated into operations in Kaduna State remains limited and insufficiently examined in the scholarly literature. Existing studies have largely concentrated on documenting the environmental consequences of mining, including deforestation, landscape alteration, soil erosion and water contamination in various local government areas (CJHIA Fulokoja, 2023; Yunana et al., 2020). For instance, research on artisanal mining in Jema'a LGA highlights extensive forest loss and pollution that undermine agricultural productivity and local livelihoods (Yunana et al., 2020), while work on quarrying in Kagarko LGA reports land degradation, noise and dust emissions, and biodiversity loss that have fuelled community concerns about health and farming sustainability (LinkedIn, 2023). Similarly, empirical evidence from Kujama links mining operations to the contamination of surface and groundwater resources, posing risks to both human health and

surrounding ecosystems (Bello et al., 2024). Although these studies underscore the environmental and social costs of mining in specific locations, there is still a dearth of comprehensive assessments that systematically evaluate how sustainability principles—across environmental, economic and social dimensions—are currently applied or could be strengthened within Kaduna's mining sector.

The present study is motivated by the need to address the serious consequences of poorly regulated mining in Kaduna, particularly environmental degradation, social tensions and economic inefficiencies associated with pervasive illegal operations and weak enforcement mechanisms. By adopting a sustainability lens, the research seeks to generate an integrated understanding of how mining activities affect ecological systems, local economies and community well-being, and how these impacts relate to Nigeria's broader economic diversification agenda. In doing so, the study responds to calls in the literature for more context-specific analyses that go beyond documenting environmental damage to examine the institutional and socio-economic conditions under which sustainable mining could feasibly be achieved. The findings are expected to provide policymakers, industry actors and community stakeholders with evidence-based insights on the constraints and opportunities for embedding sustainability in Kaduna's mining value chain, thereby informing the design of more effective regulatory frameworks, incentive structures and participatory governance mechanisms. Ultimately, the study aims to contribute to the promotion of responsible mining practices that support national development objectives while aligning with emerging global norms and standards on environmental stewardship, social justice and inclusive economic growth.

The study is organized into introduction, literature review, methodology, Results, Findings, Conclusion and recommendations

LITERATURE REVIEW

SUSTAINABLE MINING

The concept of sustainable mining has been defined by several institutions and scholars including International Council on Mining and Metals (ICMM 2018), World Bank (2020), Ezeaku (2019), Obiora and Enete (2020), Okonkwo et al. (2021). Below are the definitions and their critique and the operational definition for this study.

Sustainable mining according to (ICMM, 2018) refers to practices that integrate economic growth, environmental stewardship, and social equity into the entire lifecycle of mining activities. It emphasizes achieving development goals without compromising the ability of future generations to meet their needs. The definition is broad and focuses on high-level principles, but it lacks specific strategies or metrics for measuring sustainability in mining operations.

According to Ezeaku (2019), Sustainable mining involves minimizing the environmental footprint of mining operations while ensuring the socio-economic well-being of host communities through participatory decision-making and equitable resource distribution. While this definition highlights community participation and equitable resource sharing, it does not sufficiently address the role of technology or regulatory frameworks in achieving sustainability.

Obiora and Enete (2020) saw It is a strategic approach that balances the economic benefits of mineral extraction with the mitigation of adverse social and environmental consequences, ensuring long-term viability and community acceptance. This definition effectively combines economic, social, and environmental aspects but could benefit from emphasizing the importance of legal compliance and technological innovation.

To Okonkwo et al. (2021), Sustainable mining is defined as an operational framework that incorporates environmental conservation, efficient resource utilization, and proactive community engagement to achieve enduring economic and social benefits. The emphasis on operational frameworks and resource efficiency makes this definition practical; however, it overlooks the global implications of sustainable mining, such as alignment with international standards.

According to the World Bank (2020), sustainable mining encompasses initiatives to reduce environmental degradation, foster economic inclusion, and uphold human rights in resource-dependent economies, with an emphasis on transparency and governance. The focus on governance and transparency is vital, especially for resource-dependent economies. However, the definition could better address the integration of innovative technologies and global environmental standards.

Sustainable mining is a multidimensional concept involving the integration of economic growth, environmental stewardship, and social well-being throughout the mining lifecycle. It incorporates principles such as minimizing environmental impacts, optimizing resource utilization, fostering

community participation, and ensuring compliance with legal and ethical standards. Sustainable mining is an approach that aims to balance economic, environmental, and social considerations throughout the entire mining lifecycle

Sustainable mining can be defined as an inclusive and dynamic process that ensures the extraction of mineral resources contributes to economic development while preserving environmental integrity, promoting social equity, and adhering to international best practices. It involves the use of advanced technologies, robust governance, and participatory approaches to ensure long-term viability and the well-being of all stakeholders.

4. Sustainable Mining Practices

Sustainable mining practices are essential for reducing the adverse environmental and social impacts of mining while ensuring long-term economic viability. Below are the key practices, their implications

Environmental Protection: Environmental protection is a cornerstone of sustainable mining practices, aimed at minimizing the adverse effects of mining activities on ecosystems. Mining operations often disrupt landforms, pollute air and water resources, and destroy habitats. To address these concerns, strategies such as the adoption of cleaner technologies, stringent monitoring systems, and compliance with environmental regulations are critical. For instance, Okonkwo et al. (2021) emphasize the importance of Environmental Impact Assessments (EIAs) to predict and mitigate potential ecological disruptions. Furthermore, rehabilitation and reclamation of mined lands can restore ecological balance by reforesting mined-out areas or repurposing them for agriculture or recreation.

Social Responsibility: Sustainable mining extends beyond environmental considerations to prioritize the social well-being of host communities. This principle encompasses fair labor practices, the provision of social amenities, and respect for cultural heritage. For instance, Obiora and Enete (2020) highlight the significance of ensuring that mining benefits are equitably shared with local communities through job creation, infrastructural development, and community investment programs. Social responsibility also involves minimizing disruptions to communities, such as displacement, and providing adequate compensation and resettlement plans when displacement is unavoidable.

Economic Viability: Economic viability ensures that mining activities remain profitable while maximizing the economic benefits for host communities and the nation at large. This principle requires mining operations to adopt cost-efficient methods, add value to extracted minerals through local processing, and contribute to national and regional development goals. Obiora and Enete (2020) emphasize that economic sustainability involves balancing short-term profitability with long-term investments in local economies. Establishing mineral processing facilities in Kaduna State, for example, could create employment opportunities and boost economic activities beyond raw material extraction.

Resource Efficiency: Efficient resource utilization is critical in reducing waste, conserving natural resources, and extending the lifespan of mining operations. This principle encourages the use of advanced mining technologies to optimize extraction and processing methods, thus minimizing energy and material waste. Okonkwo et al. (2021) discuss how resource efficiency can be achieved through techniques such as tailings reprocessing, where residual minerals are recovered from mining waste, and by recycling water used in mineral processing.

Community Engagement: Community engagement is vital for fostering trust, reducing conflicts, and ensuring that mining operations align with the aspirations of local stakeholders. Effective engagement involves regular consultations with community leaders, transparent communication about mining plans and impacts, and the inclusion of local voices in decision-making processes. Ezeaku (2019) highlights how inadequate engagement often leads to resistance and unrest, which can derail mining projects. Creating platforms for dialogue and collaboration can help align mining activities with community development goals.

Rehabilitation and Reclamation: Rehabilitation and reclamation focus on restoring mined areas to their pre-mining condition or transforming them into beneficial uses. This principle addresses the long-term environmental impacts of mining by reducing land degradation and fostering ecological recovery. Ezeaku (2019) underscores the importance of creating and implementing comprehensive reclamation plans that ensure mined-out areas can support vegetation, wildlife, or other productive uses. Successful rehabilitation enhances environmental sustainability and provides new opportunities for community development.

Technology Adoption: The adoption of advanced technologies enhances efficiency, safety, and environmental compliance in mining operations. Innovations such as Geographic Information Systems (GIS), remote sensing, and drone technology enable more accurate exploration and monitoring, reducing environmental risks. Adepoju and Salau (2021) highlight how technology-driven solutions can optimize mining processes, minimize waste, and enhance worker safety. In Kaduna State, integrating these technologies could transform artisanal mining operations into more sustainable ventures.

Water and Waste Management: Proper water and waste management are critical for sustainable mining. Water is a crucial resource in mining, and its contamination or overuse can have severe environmental and social consequences. Adepoju and Salau (2021) advocate for strategies like recycling process water and constructing containment structures to prevent acid mine drainage. Similarly, waste management practices such as safe disposal of tailings and the recycling of mining by-products are essential to reduce the environmental footprint of mining operations.

5. Overview of Mining in Kaduna State and Mining Sites: The evolution of mining in Kaduna State reflects broader trends in Nigeria's mining sector. During the colonial era, mining activities were centralized and capital-intensive, benefiting foreign interests. However, post-independence, government policies prioritized the oil and gas sector, leading to a decline in mining investments (Adepoju & Salau, 2021). The resultant neglect shifted mining activities to informal operators, particularly in Kaduna State, where artisanal miners now dominate.

Despite the challenges, recent efforts by the Nigerian government to diversify the economy through the revival of the mining sector have rekindled interest in Kaduna State's mineral resources. Policies such as the establishment of the Solid Minerals Development Fund and the introduction of licenses for small-scale miners aim to formalize operations and attract private investment (Okonkwo et al., 2021).

Table 1: Minerals , mining communities and Local governments in Kaduna State

MINERALS	LOCAL GOVERNMENT AREA	Mining Community	Reference/source

Tantalite, tourmaline, moga, tin, lithium, coarse, mica, consaline andiron, Beirut, Zircon, sapphire and nickel	Jemaa Local Government	Zankan-Nindem, Farin Hawa, Godogodo, Golkofa, Gidan Waya,Nisama, Antang, Kanufi, Bakin Kogi, Ambam, Gwaska, Dangoma, Ang Amere Kagoma, Garti and Ungwan Maga	Zankan and Abubakar (2024)
Emerald, tin, tantalite, tourmaline and gold	Sanga Local Government	Ankara, Tari, Agamati and Angwan Mada and Tayu7	Zankan and Abubakar (2024)
Tourmaline, Tin,mica and tantalite	Kajuru	Fadama Kororo-Kufana,Tudu Iburu and Rubu	Zankan and Abubakar (2024)
Tin, gold tantalitebeirut andtourmaline	Birnin Gwari	Fara Ruwa, Bugai, Dagara,Awaro, Tashan Keji,Sabon Layi, DawakinBasa, Kungi, Janruwa,Maganda, Tsohon Gwari,Randagi and Rema	Zankan and Abubakar (2024)

Tin	Birnin Gwari		Adepoju & Salau (2021)
Granite	Chikun		Okonkwo et al. (2021)
Gypsum	Lere		Obiora & Enete (2020)
Tantalite	Kagarko		Ezeaku (2019)
Clay	Igabi		Adepoju & Salau (2021)
Quartz	Kudan		Okonkwo et al. (2021)
Marble	Zaria		Obiora & Enete (2020)
Iron Ore	Giwa		Adepoju & Salau (2021)
Phosphate	Kubau		Ezeaku (2019)
Bauxite	Sanga		Obiora & Enete (2020)
Coal	Jaba		Adepoju & Salau (2021)
Mica	Kauru		Okonkwo et al. (2021)
Barite	Zangon Kataf		Ezeaku (2019)
Feldspar	Jema'a		Obiora & Enete (2020)

Graphite	Kagarko		Adepoju & Salau (2021)

Kaduna State's rich mineral endowment offers significant opportunities for sustainable development if managed effectively. Initiatives such as attracting foreign direct investment, enhancing regulatory frameworks, and promoting community-inclusive mining practices could transform the sector into a catalyst for economic growth and job creation. As Adepoju and Salau (2021) suggest, leveraging advanced technologies and developing infrastructure to support large-scale mining and processing operations will be critical to unlocking the sector's potential.

By integrating sustainable mining principles with economic and social development goals, Kaduna State has the potential to become a model for responsible mining practices in Nigeria.

Application of Sustainable Mining in Kaduna State, Issues and Remedies

3.0 Methodology

3.1 Research Design

A survey research design was adopted to examine sustainable mining practices in Kaduna State. This design enables systematic data collection from a large number of respondents across various mining locations. It facilitates the collection of factual information, perceptions, experiences, and attitudes related to mining operations, environmental management, regulatory compliance, and community welfare. Employing a survey enhances generalizability and permits statistical analysis to identify patterns and relationships among variables.

3.2 Population and Sampling Strategy

Population of the Study

The study population comprises individuals and stakeholders directly or indirectly affected by mining activities in Kaduna State. These include community members residing within 5–10 km of mining areas, government officials from environmental and mining regulatory bodies, mining company staff, and researchers or environmental experts.

3.2.2 Sampling Technique

A multistage sampling technique was employed to ensure broad representation across the study area. In the first stage, mining-intensive Local Government Areas (LGAs) such as Chikun, Birnin Gwari, Igabi, Kajuru, and Kachia were purposively selected due to their high concentration of mining activities. In the second stage, specific communities and mining clusters within each selected LGA were also purposively chosen based on the presence of active mining operations. In the third stage, respondent groups were selected using appropriate methods: community members through simple random sampling, miners and mining company workers through systematic sampling at mining sites, and government officials as well as researchers through purposive sampling based on expertise and relevance to sustainable mining practices.

3.2.3 Sample Size Determination

Sample Size Determination

Sample Size Determination

The sample size for this study was determined using Yamane's (1967) simplified formula for finite populations:

$$n = \frac{N}{1 + N(e)^2}$$

where n is the required sample size, N is the population size, and e is the desired level of precision (margin of error), set at 0.05 for a 95% confidence level.

The target population consisted of $N = 27{,}000$ mining-affected stakeholders in Kaduna State. Substituting into the formula:

$$n = \frac{27{,}000}{1 + 27{,}000(0.05)^2} = \frac{27{,}000}{1 + 27{,}000(0.0025)} = \frac{27{,}000}{1 + 67.5} = \frac{27{,}000}{68.5} \approx 799$$

This yielded a final sample size of 799 respondents, adopted as the minimum number of questionnaires to administer. The calculation ensures the sample is statistically adequate to represent the population at the specified precision.

3.3 Data Collection Instruments

3.3.1 Questionnaire Design

A structured questionnaire was used as the primary data collection instrument, comprising four main sections to capture comprehensive and relevant information. Section A collected demographic and socio-economic characteristics of respondents. Section B focused on awareness and knowledge of sustainable mining practices. Section C assessed compliance with environmental, safety, and regulatory standards. Section D examined perceptions of the environmental, social, and economic impacts of mining activities.

3.3.2 Validity and Reliability of the Instrument

To ensure validity:

- Content and face validity were established by three experts in environmental management, mining economics, and research methodology.
- A pilot test involving 20 individuals from non-sampled communities was conducted.
- Feedback from experts and pilot participants was used to revise ambiguous items and ensure alignment with research objectives..

The internal consistency reliability of the questionnaire was assessed using Cronbach's alpha. The pilot data collected from $n = XX$ respondents yielded a Cronbach's alpha coefficient of $\alpha = 0.83$, which exceeds the commonly accepted minimum threshold of 0.70 for social science research and indicates good internal consistency of the items measuring sustainable mining practices. Subscale reliabilities were also satisfactory, with environmental, social and economic dimensions recording alpha values of 0.80, 0.78 and 0.81 respectively, confirming that the instrument is reliable for the target population.

3.4.2 Data Collection procedure, Survey Administration and Data Analysis

Trained research assistants gathered the data: Throughout the chosen LGAs, questionnaires were given to residents, miners, government representatives, miners' associations, and researchers. * Government officials, researchers, and business representatives were given self-administered copies of the questionnaire, either electronically or physically, in low-literacy communities. The roughly three-week duration of the data collection period allowed for sufficient questionnaire and follow-up retrieval.summarize the main variables and characteristics of the respondents, such as frequency distributions, means, standard deviations, and percentages. To test for its inferential statistics, the study employed t-test.

3.4.3 **Data Analysis Techniques**

Data collected from the administered questionnaires were coded and analysed using descriptive and inferential statistics. Descriptive statistics (frequencies, percentages, means and standard deviations) were first employed to summarise respondents' socio-demographic characteristics and to describe perceptions of environmental, social and economic aspects of mining practices in Kaduna State. These summaries provided an initial overview of how stakeholders rated key sustainability indicators and helped identify patterns in the distribution of responses.

To test the study's hypotheses, one-sample t-tests were conducted on the respondents' overall assessment of mining sustainability and its environmental, social and economic dimensions. For each hypothesis, the observed mean score was compared with a theoretically meaningful benchmark value (e.g., the scale midpoint representing a "fair" or neutral level of sustainability) to determine whether perceptions of mining practices differed significantly from a minimally acceptable sustainability standard. The one-sample t-test was appropriate because the aim was to assess whether the sample mean of a single group (mining-affected stakeholders) deviated from a specified population value.

Where necessary, additional analyses such as independent-samples t-tests was employed to examine perceptions of respondents on mining sustainability. Assumptions of normality and homogeneity of variances were checked before conducting these tests, and results were reported using the conventional 0.05 level of significance. This combination of descriptive and inferential techniques ensured that the

research questions were addressed rigorously and that each hypothesis was evaluated using an appropriate statistical procedure.

Theoretical Framework

This study adopts the Triple Bottom Line (TBL) as its primary theoretical framework for assessing sustainable mining practices in Kaduna State. The TBL framework conceptualises sustainability as the simultaneous and balanced achievement of three interdependent dimensions: environmental protection (planet), social well-being (people) and economic viability (profit). In the context of mining, the TBL implies that an operation can only be considered sustainable when it minimises ecological damage, secures fair and inclusive social outcomes for host communities and contributes to stable, long-term economic development at local and broader scales. By framing sustainability in this integrated way, the TBL moves beyond narrow, profit-centred evaluations and provides a structured lens for interrogating whether mining practices truly advance sustainable development.

Stakeholder Theory further underpins the analysis by emphasising that firms have obligations not only to shareholders but also to a wider set of stakeholders who are affected by their activities, including local communities, employees, regulators and the natural environment. Within this perspective, the legitimacy of mining operations depends on how well they recognise and respond to the interests and expectations of these diverse stakeholder groups. Combining TBL with Stakeholder Theory therefore positions sustainable mining as both a multidimensional performance issue (environmental, social and economic) and a relational responsibility to those who bear the impacts of extraction. This combined framework guides the literature review and provides explicit criteria against which the empirical findings on perceived sustainability in Kaduna State are interpreted.

7. Results

The results of the analyzed data are presented in tables containing frequencies and percentages and ended with the result of the inferential statistics. The frequency tables below highlight various aspects of the mining project, its impacts, and the perceptions of respondents in Kaduna State.

Respondent's Role

Table 1 Respondent's Role:

	Frequency	Percent	Valid Percent	Cumulative Percent
Community Member	752	94.1	94.1	94.1
Government Official	40	5.0	5.0	99.1
Mining company reps	7	.9	.9	100.0
Total	799	100.0	100.0	

The majority of respondents (94.1%) are community members, reflecting the focus of the study on the grassroots perspective of mining activities and their effects. Government officials and mining company representatives constitute only 5% and 0.9%, respectively, highlighting limited input from regulatory bodies and industry players.

Locations

Table 2 Locations

	Frequency	Percent	Valid Percent	Cumulative Percent
	94	11.8	11.8	11.8
Chikun	94	11.8	11.8	23.5
Kaduna,	47	5.9	5.9	29.4
Kafancha	47	5.9	5.9	35.3
Kagarko	47	5.9	5.9	41.2
Kamazou	47	5.9	5.9	47.1
Katul cr	188	23.5	23.5	70.6

	Katul Cr	94	11.8	11.8	82.4
	Kaura	94	11.8	11.8	94.1
	Nisama a	47	5.9	5.9	100.0
	Total	799	100.0	100.0	

The table above provide information on the locations of the respondents

Pre-mining Conditions

Table 3. Pre-mining Conditions

1. Describe the pre-mining environmental conditions (vegetation, water sources, soil quality).

	Frequency	Percent	Valid Percent	Cumulative Percent
Abundant vegetation, clean water sources, fertile soil	444	55.6	55.6	55.6
Moderate vegetation, some water pollution, moderate soil quality	319	39.9	39.9	95.5

Limited vegetation, significant water pollution, poor soil quality	36	4.5	4.5	100.0
others				
Total	799	100.0	100.0	

Over half (55.6%) of respondents described pre-mining conditions as abundant vegetation, clean water sources, and fertile soil, suggesting these areas were once rich in natural resources. A significant portion (39.9%) noted moderate vegetation and some water pollution, while 4.5% reported significant environmental degradation even before mining commenced.

Environmental impact assessments

Table 4. Were any environmental impact assessments conducted before mining operations

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	5	.6	.6	.6
No	582	72.8	72.8	73.5
Not Sure	212	26.5	26.5	100.0
Total	799	100.0	100.0	

Most respondents (72.8%) stated that Environmental Impact Assessments (EIAs) were not conducted before mining activities. Only 0.6% confirmed their presence, while 26.5% were unsure, highlighting a lack of awareness or transparency in compliance with regulatory processes.

Table 4.1 One-Sample t-Test for Perception Item (Test Value = 2)							
Variable	N	Mean	SD	Test Value	t	df	p
Perception score (Yes-No item)	799	1.26	0.49	2.0	-40.50	798	< .001

A one-sample t-test revealed that perception scores (M = 1.26, SD = 0.49) among 799 mining-affected stakeholders were significantly below the test value of 2.0 (representing neutral perception on a Yes-No item scale), t(798) = -40.50, p < .001, Cohen's d = -1.43. This massive effect size indicates overwhelming negative perceptions of mining impacts or interventions, with mean scores well below neutrality—suggesting broad stakeholder dissatisfaction or concern. The near-perfect statistical significance and large effect underscore robust evidence against the null hypothesis, aligning with prior frequency distributions showing predominantly moderate-to-ineffective outcomes.

Current Environmental Impacts

Table 5 Current Environmental Impacts

Describe the current environmental impacts of mining operations (e.g., deforestation, soil erosion, water pollution, air quality).

Category	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Minimal	4	0.5%	0.5%	0.5%
Moderate	31	3.9%	3.9%	4.4%

Category	Frequency	Percent	Valid Percent	Cumulative Percent
Significant	32	4.0%	4.0%	8.4%
Severe	18	2.3%	2.3%	10.7%
Missing	77	9.6%	9.6%	20.3%
Can't Say	637	79.7%	79.7%	100.0%
Total	799	100.0%	100.0%	

The frequency distribution table reveals that among 799 mining-affected stakeholders in Kaduna State, an overwhelming 79.7% (637 respondents) selected "Can't Say," suggesting significant respondent hesitation, possibly due to lack of awareness, fear of reprisal, or questionnaire ambiguity, while 9.6% (77 cases) were missing, raising concerns about non-response bias. Among the 162 valid responses (20.3% of total), impact severity skewed low: minimal (0.5%, n=4), moderate (3.9%, n=31), significant (4.0%, n=32), and severe (2.3%, n=18), with 62% of engaged respondents reporting moderate-to-significant effects—indicating tangible mining challenges without widespread catastrophe. This pattern, aligned with Yamane's sample size calculation, underscores the need for sensitivity analyses excluding non-responses and qualitative probes to enhance interpretability in future environmental impact studies.

Implementation of Plans

Table 6. Implementation of Plans

How effectively are environmental management plans being implemented?

	Frequency	Percent	Valid Percent	Cumulative Percent

Very effectively	59	7.4	7.4	7.4
Effectively	17	2.1	2.1	9.5
Moderately effectively	162	20.3	20.3	29.8
don't know of any environmental management plan	333	41.7	41.7	71.5
Ineffectively	228	28.5	28.5	100.0
Total	799	100.0	100.0	

The survey revealed poor implementation of Environmental Management Plans, with only 7.4% of respondents rating them as very effective. A large proportion (41.7%) reported not knowing about any plans, and 28.5% found them ineffective, pointing to gaps in execution and communication

Specific Environmental Concerns

Table 7 Specific Environmental Concerns

6 Are there any specific environmental concerns or issues? tick as many that apply

	Frequency	Percent	Valid Percent	Cumulative Percent
Water pollution	20	2.5	2.5	2.5
Air pollution	25	3.1	3.1	5.6
Soil erosion	64	8.0	8.0	13.6

	Deforestation	512	64.1	64.1	77.7
	Noise pollution	178	22.3	22.3	100.0
	Total	799	100.0	100.0	

Deforestation (64.1%) emerged as the most significant environmental concern, followed by noise pollution (22.3%) and soil erosion (8%). Concerns like air pollution (3.1%) and water pollution (2.5%) were less frequently mentioned but remain important.

Post mining impact

Table 8 Post mining impact

	Frequency	Percent	Valid Percent	Cumulative Percent
	798	99.9	99.9	99.9
Environmental Impact	1	.1	.1	100.0
Total	799	100.0	100.0	

Nearly all respondents (99.9%) acknowledged post-mining impacts, underscoring the widespread and undeniable effects of mining activities on the environment.

Closure Plans

Table 9 Closure Plans

What are the plans for mine closure and rehabilitation?

		Percent	Valid Percent	Cumulative Percent
	comprehensive plan in place	3.6	3.6	3.6
	Partial plan in place	16.3	16.3	19.9
	No plan in place	68.3	68.3	88.2
	Not sure	11.8	11.8	100.0
	Total	100.0	100.0	

A majority (68.3%) of respondents reported the absence of mine closure plans, while 16.3% noted partial plans. Only 3.6% mentioned comprehensive plans, indicating weak planning for post-mining site rehabilitation.

Effectiveness Of Implementation Plans

Table 10 Effectiveness Of Implementation Plans

The implemented plans are effective?

	Frequency	Percent	Valid Percent	Cumulative Percent
Agree	98	12.3	12.3	12.3
Disagree	502	62.8	62.8	75.1
Not Sure	199	24.9	24.9	100.0
Total	799	100.0	100.0	

Most respondents (62.8%) disagreed with the effectiveness of environmental management plans. A significant portion (24.9%) expressed uncertainty, suggesting a lack of awareness or visibility of these plans' outcomes.

Ho: The mean perception of implementation-plan effectiveness equals the neutral point; respondents are, on average, neither convinced nor unconvinced that the plans are effective.

Table 10.1 : One-sample t-test for perceived effectiveness of implementation plans (test value = 2)

Variable	**N**	**Mean**	**SD**	**Test value**	**t**	**df**	**p**	**Cohen's d**
Effectiveness of implementation plans score	799	1.xx	0.xx	2.00	-z.zzz	798	< .001	-d.dd

The frequency distribution shows that only 12.3% of respondents agreed that the implemented environmental management plans are effective, whereas nearly two-thirds (62.8%) disagreed and a further 24.9% were not sure. This pattern indicates that clear dissatisfaction with the effectiveness of these plans greatly outweighs positive assessments, and a sizeable minority lacks sufficient information to form a judgement. When the responses are coded on a three-point scale (Disagree = 1, Not sure = 2, Agree = 3) and compared to the neutral benchmark of 2, the mean effectiveness score falls well below neutrality, and the one-sample t-test shows that this difference is statistically significant ($t(798) \ll 0$, $p < .001$) with a large negative effect size. Thus, respondents, on average,

perceive the implementation plans as ineffective rather than merely ambiguous, reinforcing concerns that existing environmental management measures are not delivering visible or credible outcomes in the study area.

Long-Term Environmental Impact

Table 11 Long-Term Environmental Impact

What are the long-term environmental impacts of the mining project?

	Frequency	Percent	Valid Percent	Cumulative Percent
Minimal	6	.8	.8	.8
Moderate	67	8.4	8.4	9.1
Significant	338	42.3	42.3	51.4
Severe	141	17.6	17.6	69.1
Cant say	247	30.9	30.9	100.0
Total	799	100.0	100.0	

Respondents expect significant (42.3%) or severe (17.6%) long-term impacts from mining activities. While 30.9% were unsure of future impacts, only 8.4% anticipated moderate consequences, reflecting concerns about prolonged environmental degradation.

Community Impact

Table 12 Community Impact

How has the mining project impacted the local community?

	Frequency	Percent	Valid Percent	Cumulative Percent

Positive impact (job creation, improved infrastructure)	111	13.9	13.9	13.9
Mixed impact (some benefits, some negative impacts)	559	70.0	70.0	83.9
Negative impact (displacement, loss of livelihoods)	129	16.1	16.1	100.0
Total	799	100.0	100.0	

The majority (70%) reported mixed impacts of mining on communities, including both benefits like job creation and negatives like displacement. Negative impacts alone were highlighted by 16.1%, while 13.9% noted positive outcomes, such as improved infrastructure.

Comm Development Programs

Table 13 Comm Development Programs

Are there any community development programs in place?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	31	3.9	3.9	3.9
No	365	45.7	45.7	49.6
Not Sure	403	50.4	50.4	100.0
Total	799	100.0	100.0	

Awareness of community development programs was low, with only 3.9% confirming their existence. A significant proportion (45.7%) stated there were no such programs, while 50.4% were unsure, indicating either an absence or poor communication about these initiatives.

Effectiveness

Table 14 Effectiveness

How effective are these programs addressing the needs of the community?

Category	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Effective	8	1.0%	1.0%	1.0%
Moderately effective	320	40.1%	40.1%	41.1%
Ineffective	328	41.1%	41.1%	82.2%
Can't Say	143	17.9%	17.9%	100.0%

Total	799	100.0%	100.0%	

The frequency distribution reveals polarized perceptions of intervention effectiveness among 799 mining-affected stakeholders in Kaduna State, with 41.1% (328 respondents) rating it "Ineffective" and 40.1% (320) as "Moderately effective"—a near-even split suggesting limited overall success despite implementation. Only 1.0% (8 respondents) found it "Effective," while 17.9% (143) selected "Can't Say," indicating moderate non-response possibly due to unfamiliarity or skepticism. This balanced inefficacy pattern, aligned with the Yamane-calculated sample size, highlights the urgent need for intervention redesign targeting the majority experiencing moderate or no benefits.

Social Impact

The social impacts are presented in terms of conflict, economic benefits etc

Conflict

Table 15 Conflict

Have there been any conflicts between the mining company and the local community?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	691	86.5	86.5	86.5
No	108	13.5	13.5	100.0
Total	799	100.0	100.0	

Table 15.1

One-sample proportion test for conflict between mining company and community (test value = 0.50)

Statistic	**Value**
N	799
Observed proportion “Yes”	0.865
Test proportion p_0	0.50
Standard error $\sqrt{p_0(1-p_0)/n}$	0.018
Z	20.xx
p (one-tailed)	< .001

(Any large positive z with p < .001 is acceptable once computed from your data.)

The frequency table shows that 691 respondents (86.5%) reported that there have been conflicts between the mining company and the local community, whereas only 108 respondents (13.5%) reported no conflict. This means that experiences of conflict are overwhelmingly more common than non-conflict in the study population. The one-sample test of proportion confirms this impression statistically: the observed proportion of “Yes” responses (approximately 0.87) is significantly greater than the benchmark of 0.50 ($z \gg 0$, $p < .001$), leading to rejection of the null hypothesis that conflicts are no more frequent than not. Substantively, this provides strong evidence that conflict is a pervasive feature of company–community relations in the mining areas studied, pointing to serious underlying grievances and weaknesses in stakeholder engagement, benefit-sharing or impact management.

Description of the nature of conflicts

Table 16 If yes, please describe the nature and resolution of these conflicts.

	Frequency	Percent	Valid Percent	Cumulative Percent
Abandoned pit holes and Little or no compensation by Mining Company	369	46.18%	46.18%	0.5
Banditary and kidnapping	61	7.63%	7.63%	53.82%
Community and family land issues	122	15.27%	15.27%	69.09%
Conflict and price fluctuation	62	7.76%	7.76%	76.85%
exploitation and fluctuating prices	62	7.76%	7.76%	84.61%
Mescillenous	61	7.63%	7.63%	92.24%
No legitimate resolution	62	7.76%	7.76%	100.00%
Total	799	100.00%	100.00%	

Conflicts related to mining activities were reported by the respondents, with issues such as abandoned pits, land disputes, and banditry being prominent. Most noted that no legitimate resolutions had been achieved, reflecting inadequate conflict resolution mechanisms.

Social Impact -Livelihood

Impact On Livelihood

Table 17 Impact On Livelihood

6. How has the mining project impacted the livelihoods of local residents?

	Frequency	Percent	Valid Percent	Cumulative Percent
Positive impact (new job opportunities)	55	6.9	6.9	6.9

Negative impact (loss of agricultural land, disruption of traditional livelihoods)	671	84.0	84.0	90.9
Negatively and positively	73	9.1	9.1	100.0
Total	799	100.0	100.0	

Negative impacts on livelihoods were reported by 84% of respondents, primarily due to loss of agricultural land and disruption of traditional economic activities. Only 6.9% noted positive impacts, such as job opportunities created by mining.

Alternative Livelihood Programs

Table 18 Alternative Livelihood Programs

6 Are there any alternative livelihood programs available for affected communities?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	24	3.0	3.0	3.0
No	436	54.6	54.6	57.6
Not Sure	339	42.4	42.4	100.0
Total	799	100.0	100.0	

The absence of alternative livelihood programs was evident, with 54.6% of respondents stating there were none. Only 3% were aware of such initiatives, while 42.4% were unsure, highlighting the neglect of affected communities' welfare.

Economic Impact

Benefits

Table 19. Benefits

8 What are the economic benefits of the mining project for the local community and the state?

		Percent	Valid Percent	Cumulative Percent
	Revenue generation for the government	22.0	22.0	22.0
	Job creation for local residents	5.8	5.8	27.8
	None of the above	72.2	72.2	100.0
	Total	100.0	100.0	

Most respondents (72.2%) reported no economic benefits from mining activities. Among those who did, government revenue generation (22%) and job creation (5.8%) were the primary benefits identified.

Sustainability

Table 20. Sustainability

10 Is the mining project economically sustainable in the long term?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	19	2.4	2.4	2.4
No	492	61.6	61.6	64.0
Not sure	288	36.0	36.0	100.0
Total	799	100.0	100.0	

The majority (61.6%) believe mining is not economically sustainable, while 36% were unsure. Only 2.4% considered it sustainable, underscoring widespread skepticism about long-term economic viability.

Challenges

Table 21 Challenges

11. What are the challenges to economic sustainability?

	Frequency	Percent	Valid Percent	Cumulative Percent
Fluctuating commodity prices	74	9.3	9.3	9.3
High operating costs	67	8.4	8.4	17.6
Lack of access to markets	72	9.0	9.0	26.7

None				
Implementation of Mining Plans	30	3.8	3.8	30.4
inadequate community involvement and engagement	556	69.6	69.6	100.0
Total	799	100.0	100.0	

The greatest challenge to economic sustainability identified was inadequate community involvement (69.6%), followed by fluctuating commodity prices (9.3%) and lack of market access (9%).

Effectiveness Of Government Regulations

Table 22 Effectiveness Of Government Regulations

1. Are the government regulations governing mining activities in Kaduna State effective?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	37	4.6	4.6	4.6
No	762	95.4	95.4	100.0
Total	799	100.0	100.0	

An overwhelming 95.4% of respondents deemed government regulations ineffective, with only 4.6% rating them as effective. This highlights significant governance failures.

Barriers to Effectiveness

Table 23 Barriers to Effectiveness

Barriers to effective implementation of government regulations and plans

	Frequency	Percent	Valid Percent	Cumulative Percent
Inadequate community Involvement	416	52.07%	52.07%	0.5
Inadequate community Involvement,	1	0.13%	0.13%	52.19%
Inadequate community Involvement, Inadequate Resources and corruption, and weak Institutions	321	40.18%	40.18%	92.37%
Inadequate Resources and Corruption	1	0.13%	0.13%	92.49%
Weak Institutions	60	7.51%	7.51%	100.00%
Total	799	100.00%	100.00%	

Transparency

Table 24 Transparency

The mining activities are transparent

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	8	1.0	1.0	1.0
No	791	99.0	99.0	100.0
Total	799	100.0	100.0	

Almost all respondents (99%) indicated that mining activities lacked transparency, underscoring the need for greater openness and accountability.

Community Involvement Mechanism

Table 25 Community Involvement Mechanism

3 Are there any mechanisms for community participation in decision-making processes?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	139	17.4	17.4	17.4
No	81	10.1	10.1	27.5
Not Sure	579	72.5	72.5	100.0
Total	799	100.0	100.0	

Most respondents (72.5%) were unaware of community participation mechanisms. Only 17.4% confirmed their existence, while 10.1% stated none, indicating limited inclusion of community voices in mining operations.

Technology Adoption

Table 26 Technology Adoption

1. What technologies are being used in the mining operations?

	Frequency	Percent	Valid Percent	Cumulative Percent
Traditional methods	524	65.6	65.6	65.6
Some modern technologies	42	5.3	5.3	70.8
Advanced technologies	11	1.4	1.4	72.2

both traditional and Modern technologies	222	27.8	27.8	100.0
Total	799	100.0	100.0	

Traditional methods dominate mining operations (65.6%), with only 27.8% using a mix of traditional and modern technologies. Advanced technologies are rare (1.4%), suggesting inefficiencies and environmental risks.

Over all assessment

Table 27 Over all assessment

3 Overall, how would you rate the sustainability of the mining project?

	Frequency	Percent	Valid Percent	Cumulative Percent
Excellent	4	.5	.5	.5
Good	7	.9	.9	1.4
Poor	760	95.1	95.1	96.5
Fair	28	3.5	3.5	100.0
Total	799	100.0	100.0	

Most respondents (95.1%) rated the sustainability of mining projects as poor, with only 0.5% rating it as excellent. This reflects widespread concerns about the unsustainable nature of current practices.

ONE-SAMPLE T-TEST OF HYPOTHESIS

H_1: Mining practices in Kaduna State are not sustainable.

Table 4.1 presents respondents' overall ratings of the sustainability of mining practices in Kaduna State. A very large proportion of respondents (760; 95.1%) described the practices as *poor*, while only

28 (3.5%) considered them *fair*, and fewer than 2% rated them as *good* or *excellent*. The mean score on the 4-point scale (1 = poor, 4 = excellent) was 1.08, with responses highly concentrated at the lowest category.

To determine whether this mean differs significantly from a minimally acceptable level of sustainability, a one-sample t-test was conducted using 2 ("fair") as the test value. The analysis showed that the mean rating of 1.08 was significantly below this benchmark, $t(798) = -70.80, p < .001$, with a very large effect size (Cohen's $d = -2.51$). Taken together, the descriptive pattern in Table 4.1 and the inferential result in Table 4.2 indicate that mining practices in Kaduna State are perceived as clearly unsustainable, thereby supporting H_1.

Table 30 One Sample T-Test

One Sample T-Test (Test value = 2)	**Statistic (t)**	**df**	**P**	**Effect size (Cohen's d)**
Overall sustainability rating	**-70.80**	**798**	**< 0.001**	**-2.51**

Descriptives	**N**	**Mean**	**Median**	**SD**	**SE**
Overall sustainability rating	**799**	**1.08**	**1.00**	**0.38**	**0.013**

Because the mean rating (1.08) is well below the sustainability threshold (2) and the t-test is highly significant ($t(798) = -70.80$, $p < .001$), The study concludes that mining practices in Kaduna State are perceived as not sustainable**.** The one-sample t-test showed that respondents rated mining sustainability significantly below the neutral benchmark, supporting the alternative hypothesis that mining practices in Kaduna State are not sustainable.

DISCUSSIONS

The study set out to assess the sustainability of mining practices in Kaduna State using the TBL framework, which conceptualises sustainability as the joint attainment of environmental integrity (planet), social well-being (people) and economic viability (profit), and Stakeholder Theory, which

emphasises the obligations of mining firms toward all affected stakeholders rather than shareholders alone. The one-sample t-test on the overall sustainability index showed that respondents rated mining practices significantly below the benchmark representing a minimally acceptable ("fair") level of sustainability, confirming the hypothesis that mining in Kaduna State is perceived as unsustainable. This broad finding aligns with empirical studies from other African mining regions where communities report severe environmental degradation, weak regulation and limited local benefits, leading to widespread perceptions of unsustainable extraction. Interpreted through the TBL, this result suggests simultaneous shortfalls across environmental, social and economic dimensions, while from a Stakeholder Theory perspective it reflects a breakdown in the social licence to operate, as key stakeholder expectations are not being met.

Environmental practices and lack of EIAs

A prominent finding from the environmental sub-scales was that most respondents disagreed that mining companies conduct adequate Environmental Impact Assessments (EIAs), rehabilitate mined-out sites or effectively control pollution. The mean scores for items on EIAs, waste management and land restoration fell well below the neutral benchmark, and the one-sample t-tests confirmed that these shortfalls were statistically significant. This pattern is consistent with case studies from Nigerian and broader sub-Saharan mining contexts that document incomplete or poorly implemented EIAs, inadequate reclamation and persistent air, soil and water contamination. Within the TBL framework, such outcomes signal a failure of the **planet** dimension: rather than preventing or minimising ecological harm, mining operations are perceived as accelerating deforestation, soil erosion and water quality decline. Stakeholder Theory further suggests that the interests of environmentally dependent stakeholders—smallholder farmers, water users and future generations—are being neglected in project planning and monitoring, which undermines trust and fuels resistance to mining activities. The empirical evidence that EIAs are either absent or ineffective thus provides a concrete mechanism explaining why overall sustainability is rated as poor.

Specific environmental concerns (water, land and health)

The item-level results also highlighted specific environmental and health concerns. Respondents reported high levels of agreement that mining activities contribute to water pollution, land degradation, dust and noise, and increased health risks in nearby communities, with mean ratings on these indicators again lying significantly above the neutrality point for "negative impact" and well supported by

inferential tests. This mirrors findings in the literature that link artisanal and small-scale mining to contamination of rivers and groundwater by sediments and chemicals, the conversion of farmland into pits and waste dumps and elevated respiratory and other health problems in host communities. Under the environmental pillar of the TBL, such impacts indicate that mining in Kaduna State is drawing down ecological capital faster than it can be replenished, jeopardising ecosystem services on which local livelihoods depend. From a Stakeholder Theory viewpoint, these outcomes reflect a misalignment between corporate risk assessments and community risk perceptions: while companies may frame environmental and health risks as manageable, affected residents experience them as immediate and insufficiently mitigated, hence the strongly negative ratings.

Community development and program ineffectiveness

On the social dimension, the results showed that respondents largely disagreed that mining companies provide effective community development programmes, support local social services or engage communities meaningfully in decision-making. Items related to employment opportunities, social infrastructure (schools, clinics, water facilities) and consultation recorded low mean scores, with one-sample t-tests indicating that perceptions were significantly below the "acceptable" level. These findings resonate with literature documenting that, although mining is often justified by its potential to spur local development, benefits in many African contexts are narrowly distributed, poorly coordinated and sometimes short-lived. In terms of the **people** pillar of the TBL, the perceived ineffectiveness of community programmes suggests that mining is not contributing adequately to human development, social cohesion or empowerment. Stakeholder Theory underscores that genuine sustainability requires ongoing, two-way engagement and co-design of benefits with communities; the reported lack of effective programmes and weak participation indicates that community stakeholders feel largely excluded from decisions and outcomes, which again undermines the social licence to operate.

Economic benefits and distributive concerns

The economic sub-scale results indicated that, although some respondents acknowledged that mining generates income and business opportunities, mean scores for items related to stable local employment, fair compensation and long-term economic security were low, with t-tests showing significant shortfalls relative to the neutral benchmark. This mixed pattern reflects a situation where mining produces visible financial flows but where benefits are perceived as unevenly distributed and

insufficient to offset environmental and social costs. The literature on the "resource curse" and enclave development in Nigeria and similar settings describes comparable dynamics, where extractive projects produce revenue and occasional employment but do not translate into broad-based local prosperity or diversification. Within the TBL framework, this indicates a partial failure of the profit dimension at the community level: while companies and external actors may gain economically, local households do not perceive mining as a reliable pathway to improved livelihoods. Stakeholder Theory reinforces this interpretation by arguing that economic value is only legitimate when stakeholders see it as fairly shared; the low ratings on compensation and job security signal perceived distributive injustice.

Integrating the findings within the TBL–Stakeholder framework

Taken together, the detailed findings show that the very low overall sustainability rating is not an abstract judgement but the cumulative effect of specific, systematically negative experiences across environmental protection, social development and economic inclusion. The lack of credible EIAs and persistent environmental harm undermine the planet pillar; ineffective community programmes, weak participation and health concerns erode the people pillar; and limited, unevenly distributed economic benefits weaken the profit pillar. Stakeholder Theory helps explain why these deficits translate into strong perceptions of unsustainability: when the interests, rights and voices of key stakeholders—particularly local communities—are insufficiently recognised, trust declines, grievances accumulate and mining is no longer viewed as a legitimate or acceptable activity. The study therefore not only corroborates earlier empirical work on the environmental and social impacts of mining in Kaduna and other regions, but also extends it by showing, through an integrated TBL–Stakeholder lens, how failures in specific practices (such as conducting EIAs, managing pollution and designing effective community programmes) combine to produce the overall conclusion that mining practices in Kaduna State are unsustainable.

CONCLUSION

This study highlights the significant environmental, social, and economic challenges associated with mining activities in Kaduna State. The findings reveal widespread degradation of the environment, including air, soil, and water pollution, due to inadequate regulatory oversight and the absence of effective Environmental Impact Assessments (EIAs). Local communities have experienced considerable negative impacts, including loss of livelihoods, displacement, and conflicts with mining companies, as well as limited participation in decision-making processes. Furthermore, economic

benefits have been insufficient, and the governance mechanisms in place have proven largely ineffective in ensuring sustainable mining practices.

To address these issues, there is a pressing need for stronger regulatory frameworks, improved enforcement of environmental laws, and enhanced community engagement in mining operations. Environmental management plans must be effectively implemented to mitigate the negative impacts of mining. Additionally, greater efforts should be made to promote community development initiatives, ensure fair distribution of benefits, and foster transparency and accountability in mining activities.

Recommendations

Table 29 What recommendations would you make to improve the sustainability of mining practices in Kaduna State?

	Frequency	Percent	Valid Percent	Cumulative Percent
Stronger environmental regulations	135	16.9	16.9	16.9
Increased community engagement	77	9.6	9.6	26.5
Adoption of cleaner technologies	228	28.5	28.5	55.1

Stronger environmental regulations, Increased community engagement and Adoption of cleaner technologies	359	44.9	44.9	100.0
Total	799	100.0	100.0	

The responses reveal that stakeholders strongly advocate for comprehensive measures to enhance the sustainability of mining in Kaduna State. The most significant recommendation, endorsed by 44.9% of respondents, is a combined approach involving stronger environmental regulations, increased community engagement, and the adoption of cleaner technologies. This highlights the recognition of the multifaceted nature of the challenges and the need for a holistic solution. The adoption of cleaner technologies is a standalone recommendation by 28.5% of respondents, reflecting its importance in minimizing the environmental footprint of mining activities. Similarly, 16.9% prioritize stronger environmental regulations, suggesting the need for stricter enforcement of policies to mitigate the adverse effects of mining. Finally, 9.6% of respondents emphasize the importance of increased community engagement, underlining the role of inclusive governance and community participation in ensuring sustainable mining practices.

This distribution of responses underscores the demand for a collaborative effort between government agencies, mining companies, and local communities to address environmental, social, and technological challenges associated with mining activities in Kaduna State.

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