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Socio-Economic and Environmental Impact of Sand Mining on the Floodplains of River Benue, Makurdi Town, Benue State, Nigeria

Atser, Timothy Iorwuese., Daniel Peverga Dam., Monday Akpegi Onah., and Johnson Orfega Mage

Department of Geography, Benue State University, Makurdi

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ABSTRACT

This study assesses the socio-economic contributions and environmental impact of sand mining along the floodplains of River Benue in Makurdi, Nigeria. The study adopted a survey/questionnaire approach with a sample size of 380 respondents from ten (10) selected mining sites. Descriptive analytical techniques were used to analyze the data. The findings reveal that sand mining is a male-dominated activity, with 90.5% of respondents being men, while only 9.5% are women. The majority (37.1%) of miners fall within the 26–35-year age range, followed by 32.1% in the 36–45-year category. Income distribution analysis shows that 38% of miners earn ₦36,000 or more monthly, while 25.1% earn between ₦16,000–₦25,000. The study identifies manual in-stream mining as the predominant method (62.2%), followed by manual surface mining (26.3%) and mechanized dredging (11.5%). Sharp sand constitutes the majority (68%) of mined materials, primarily due to its demand in construction. Environmental issues such as flooding, erosion, and riverbed destabilization are significant concerns, particularly at North Bank under Bridge Right and Tse Kpam, where high levels of extraction have exacerbated land degradation. The study concludes that while sand mining plays a vital economic role, it has severe environmental consequences that necessitate urgent intervention. Therefore, it is recommended that the government enforce stricter regulations on sand mining operations to control excessive extraction, ensure compliance with environmental standards, and prevent further ecological degradation. This policy intervention will help balance economic benefits with environmental sustainability in the study area.

Keywords: Sand, Mining, socio-economic, environmental impact; floodplain, River Benue

INTRODUCTION

Sand mining is an activity that deals with the process of harvesting sand from an open pit or areas where it can be found in larger quantities such as rivers, streams, and lakes. Sand mining is also the removal of sand from its natural configuration or a place of its occurrence (Ashraf et al, 2010; Gavriletea, 2017). Sand mining, the extraction of sand from various environments such as beaches, inland dunes, riverbeds, and ocean floors, is a practice integral to numerous sectors, including construction, manufacturing, and infrastructure development. Sand is a loose, incoherent mass of mineral materials and also a product of natural processes (weathering and abrasion) and has become a very important material for our society due to its wide range of uses. The material's versatility makes it a cornerstone in making concrete, filling roads, building sites, brick-making, making glass, sandpapers, and reclamations, among many other vital uses.

Torres et al. (2017) report that sand, gravel, and laterite constitute the largest proportion of mined solid resources in the world, accounting for an estimated 50 billion tonnes annually. Pereira (2020) corroborates its economic value to include the making of fracking, glass, paints, computer chips, land reclamation, sports and leisure, water filtration, horticulture, and beach nourishment. However, the vast documented use of sand is for the construction of infrastructural facilities (Koehnken et al., 2020). The ideal sand, useful for industrial purposes, is mined from rivers, marine, and terrestrial deposits by dredging with bulldozers, excavators, and manually with shovels. As a result of the numerous uses of sand, the demand for it has placed rivers all over the world under immense pressure due to various kinds of anthropogenic activities. Among indiscriminate sand mining is the most disastrous, as the activity threatens the very existence of river ecosystems (Kondolf, 1998). However, the escalating demand for sand has precipitated significant socioeconomic and environmental challenges, particularly concerning its extraction from river floodplains. Torres et al. (2017) maintained that infrastructural development to match the housing and other urban infrastructural needs of the growing urban population has imposed an ever-increasing demand for sand at an unsustainable rate in many countries.

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Globally, sand mining has been linked to a myriad of environmental issues. The removal of sand from river systems can lead to the lowering of riverbeds, which in turn imposes severe damage to the physical and biological environments of these river systems. Consequences include loss of biodiversity, changes to hydrological functions, and increased erosion. Sand mining can also lead to salinization and water loss, generating areas of infertile soil and making it difficult for plants and crops to grow (Gavriletea, 2017). The socioeconomic ramifications are equally profound. While sand mining can provide economic benefits such as employment opportunities and infrastructure development, it often triggers tensions among government authorities, private individuals involved in mining, and local communities, leading to conflicts over resource control and environmental degradation (WIT Press, 2016).

In Nigeria, sand mining is a prevalent activity, especially along river floodplains, driven by the country's rapid urbanization and infrastructural demands. As society grows with increasing population growth, human settlements, industrialisation, urbanization, and associated developments, the rivers are widely exploited for river bed materials like sand. In the past few decades, the demand for construction-grade sand has increased in many parts of Nigeria due to economic development and the subsequent growth of building activities. This, on many occasions, has resulted in indiscriminate in-stream sand mining and floodplain areas, leading to severe damage to the river basin environment. The fast pace of economic developments, rise in foreign remittances, and liberalized housing schemes for building constructions, mainly from the banking sector, are some of the causative factors responsible for unabated in-stream sand mining from river beds (Padmalal et al., 2014; WIT Press, 2016). However, the practice has been encumbered with rudimentary and unsustainable techniques in its mining, which has led to seriously poor ecological conditions of the ecosystem of the mining sites and the adjoining environment. This has resulted in inequity and the misplaced priority of the miners and owners of those sites, which causes more harm than good to all concerned (Johnbull and Brown, 2017; RePEc, 2024).

Sand mining on the floodplains of River Benue has significant socioeconomic effects, impacting livelihoods, the local economy, and environmental stability. The extraction of sand from riverbeds and floodplains is a lucrative industry, providing raw materials for the construction sector, which drives urban expansion and infrastructural development. However, the activity also disrupts riverine ecosystems, contributes to land degradation, and exacerbates flood risks (Ezekwe and Angbas, 2021). The socio-economic consequences of sand mining manifest in both positive and negative dimensions, influencing employment, income distribution, agricultural productivity, and settlement patterns in communities along the river. One of the key socio-economic benefits of sand mining is employment generation. The industry provides direct jobs for labourers, truck drivers, and site operators while indirectly supporting businesses involved in equipment leasing, transportation, and construction (Okafor et al., 2020). Many residents, particularly unskilled workers, rely on sand mining as a primary source of income. This has contributed to poverty alleviation in some communities where alternative employment opportunities are scarce. In the same vein, government revenues increase through taxation and levies imposed on licensed sand mining operations, which, in turn, contribute to local infrastructure development (Akinola and Adeyemo, 2019).

Despite its economic benefits, unregulated sand mining has detrimental consequences for livelihoods and environmental sustainability. One of the most critical effects is the alteration of river morphology, leading to increased channel instability, erosion, and sedimentation (Agbo et al., 2021). The removal of sand from floodplains weakens the natural embankments of the River Benue, making adjacent farmlands and settlements more susceptible to seasonal floods. Farmers who rely on the fertile floodplains for crop cultivation experience declining agricultural yields due to soil degradation and loss of arable land. This contributes to food insecurity and increased rural poverty as farmers struggle to find alternative means of sustenance (Chukwuma and Eze, 2022). Another socio-economic challenge associated with sand mining is the displacement of communities. As flood risks intensify due to the excavation of riverbanks, residents living near sand mining sites are often forced to relocate, leading to loss of homes, social disintegration, and economic displacement (Aliyu et al., 2020). The cost of resettlement further strains household incomes, while informal settlements emerge in urban areas as displaced individuals seek alternative shelter. Additionally, infrastructure such as roads and bridges near sand mining sites often deteriorates rapidly due to the continuous movement of heavy trucks, increasing maintenance costs for local authorities (Ezeudu and Nwosu, 2018).

The health implications of sand mining also pose socio-economic concerns. Workers in sand mines are exposed to respiratory illnesses caused by prolonged inhalation of dust particles. In addition, water pollution

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from excessive sand extraction affects local drinking water sources, increasing the prevalence of waterborne diseases (Oladipo and Adebayo, 2021). Increased health expenditures place an economic burden on affected families, diverting income from productive uses to medical care. Furthermore, conflicts often arise between sand miners and local communities, especially when mining activities encroach on communal lands or disrupt traditional fishing practices. This tension sometimes leads to violent confrontations, disrupting social harmony and economic stability in affected areas (Nwafor et al., 2020).

In the Makurdi section of the floodplains of River Benue, the extent to which sand mining contributes to employment and revenue generation, its adverse effects on livelihoods, environmental stability, and public health have not received the desired attention. Similarly, there is also a knowledge gap on the effect of uncontrolled sand extraction on the environment. Consequently, this study seeks to assess the socio-economic and environmental impact of sand mining on the floodplains of River Benue in Makurdi town.

MATERIAL AND METHODS

Study Area

Makurdi is the capital of Benue State and doubles as the Headquarters of the Makurdi Local Government Area. Makurdi was established in the 20th century and became prominent in 1976 when it was named the state capital. As of the 2006 census, the population was 300,377, projected to reach 405,500 by 2021. It is located at the bank of River Benue in the plain of Benue trough of middle belt region of Nigeria. The area is located between latitude 7º36' 00" N and 7º48' 00" N; and longitude 8º 29' 00" E and 8º 39' 00" E with a mean elevation of 92 meters above sea level (Fig.1).

Its geology consists of fluvio-deltaic sediments with thick sandstone deposits, and alluvial soils dominate the floodplains. The town experiences a tropical wet and dry climate, influenced by southwesterly and northeasterly air masses, with a unimodal rainfall pattern peaking in August or September. Annual rainfall averages 1,200 mm, and temperatures remain high, averaging around 32°C. Makurdi's vegetation falls within the Guinea Savannah, characterized by tall grasses and deciduous trees. It is prone to flooding due to its low-lying relief and is drained primarily by River Benue and smaller tributaries like Idye and Urudu. The town is predominantly inhabited by the Tiv ethnic group, with minority groups such as Idoma, Igede, and Jukum, alongside Hausa, Igbo, and Yoruba traders. The economy revolves around agriculture, sand mining, and fishing, with commercial transport and petty trading also significant. Makurdi has a well-planned road network and moderate environmental standards. The town's hospitable and diverse population engages in various socio-economic activities, making it a dynamic administrative and commercial hub.

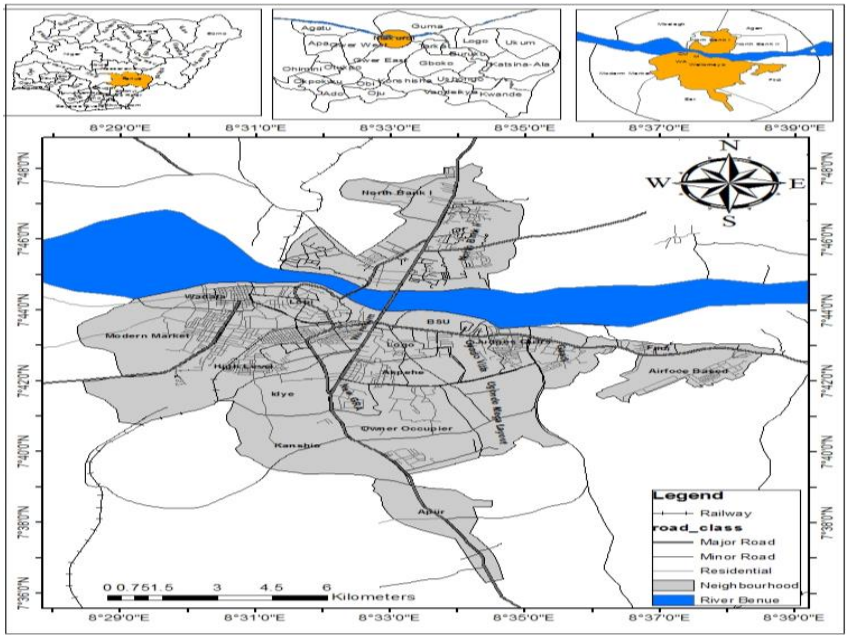

Figure 1: Makurdi Town.

Source: Benue State University GIS Lab (2021)

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Methods

In this study, Cochran formula (equation 1) was used to estimate a representative sample size in the study area (Cochran, 1977) because the study population was unknown. The equation is expressed as:

$$n_o = \frac{z^2 pq}{e^2} \quad (1)$$

where, n_o is the sample size, z is the selected critical value of desired confidence level, p is the estimated proportion of an attribute that is present in the population,

$q = 1 - p$ and e is the desired level of precision

To calculate a sample size of the target population of the study area whose degree of variability is not known, we assumed that the maximum variability is 50% (p =0.5) and considering the 95% confidence level with ±5% precision, the calculation for required sample size was done as follows: p = 0.5 and hence q =1-0.5 = 0.5; e = 0.05; z =1.96, then:

$$n_o = \frac{1.96^2(0.5)(0.5)}{(0.05)^2} = 384.16 = 384$$

Thus, for the purpose of this study, a sample size of 380 was adopted. Therefore 380 questionnaires were distributed among the sand miners, sand sellers, transporters (Truck drivers), loaders, farmers, fishermen, traders in 10 (ten) mining sites purposefully selected for the study. The ten (10) selected mining sites are Ityo-Mu, Gaadi back of Brewery, Terwase Agbadu, Wurukum under Bridge behind Abattoir, Wurukum under Bridge behind Tipper garage, Clerk Market back of John Holt, Ujamatu Agbough, North Bank under Bridge Hausa Quarters, North Bank under Bridge behind Filling station and Tse Kpam (Figure 2). The questionnaires were distributed following convenience sampling which allowed the researcher to administer the questionnaire to the respondents that were readily available and had the acumen to answer the questions in the questionnaire. The questionnaire designed to address the following objective: socioeconomic and demographic characteristics of respondents; contribution of sand mining on the socio-economic/livelihood of the miners; and the environmental effects of sand mining. Field observations and photographs were also employed in data collection:

The study used Statistical Package for Social Sciences (SPSS) software (Version 21) to analyze the data collected from the study. Descriptive statistic such as cross tabulation, charts and percentages were used in data analysis.

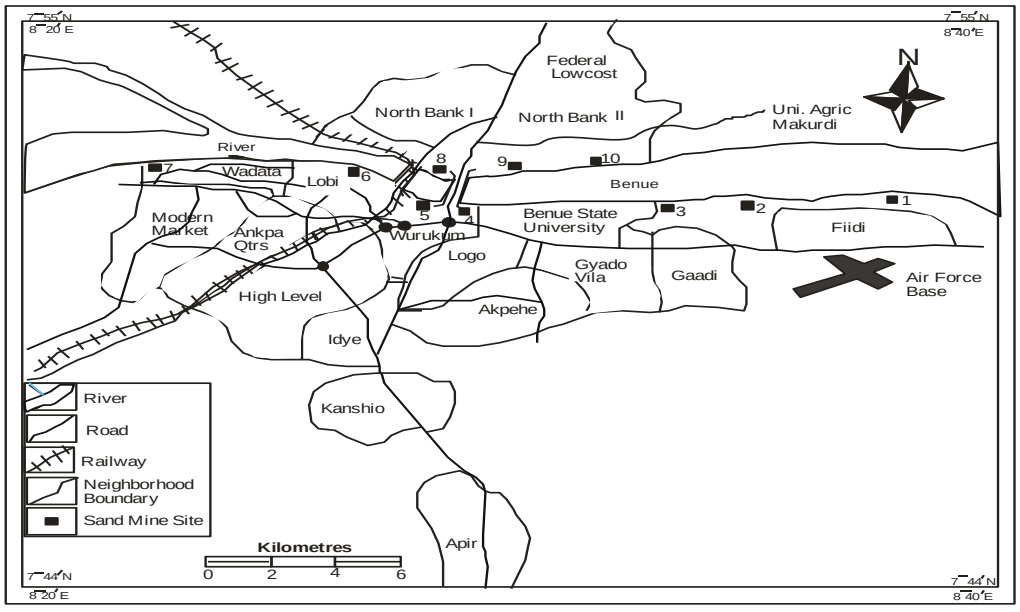

Figure 2: Makurdi town showing Sand Mining Sites

Source: Extracted from Ministry of Lands, Survey and Solid Minerals, Makurdi (2019)

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RESULTS AND DISCUSSION

Socio-demographic Characteristics of Respondents

The socio-demographic characteristics of the respondents examined in this study encompass age distribution, sex, marital status, occupation, and educational qualifications. A detailed analysis of these variables and their implications for the study population is presented in the subsequent sub-sections.

Table 1 presents the distribution of respondents based on sex and age.

Table 1: Distribution of Respondents by Age and Sex

Age (Years)	**Male**		**Female**		**Total**	
	Frequency	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
0 – 25	53	16.9	6	1.8	59	18.7
26 – 35	102	32.6	15	4.5	117	37.1
36 – 45	94	29.7	7	2.4	101	32.1
46 and above	36	11.3	2	0.8	38	12.1
Total	**285**	**90.5**	**30**	**9.5**	**315**	**100**

Source: Data Analysis, 2019

The study reveals a significant male dominance in sand mining, with 90.5% of respondents being men and only 9.5% women. This disparity is attributed to the physically demanding nature of the work and cultural or religious norms. The majority of workers (37.1%) are aged 26–35, followed by 32.1% aged 36–45, indicating that sand mining is primarily undertaken by individuals in their economically active years. Younger individuals (below 25 years) participate less, likely due to education or lack of experience, while older individuals (46 years and above) are underrepresented, possibly due to the strenuous nature of the work. Understanding the age and sex composition is essential for analyzing workforce sustainability and socio-economic impacts. These findings align with those of Farahani and Bayazidi (2018), who studied sand mining in an Iranian village. The study highlights the socio-economic and environmental effects of sand mining on the floodplains of River Benue in Makurdi.

The marital status of the respondents was classified into four categories: married, single, divorced, and widowed, as presented in Table 2.

Table 2: Marital Status of the Respondents

Marital Status	**Frequency**	**Percentage**
Married	168	53
Single	134	43
Divorced	5	1.5
Widowed	8	2.5
Total	**315**	**100**

Source: Data Analysis 2019

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The analysis indicates that the majority of respondents (53%) were married, followed by 43% who were single, while 2.5% were widowed. Only 1.5% (5 respondents) were divorced. The predominance of married individuals suggests that sand mining is a primary livelihood for those with family responsibilities. Additionally, a significant number of single respondents, primarily aged 26–35 years, were engaged in labor-intensive roles such as loading and offloading sand, highlighting the physically demanding nature of sand mining.

The result of the occupational distribution of the respondents is presented in Table 3.

Table 3: Occupation of Respondents

Occupation	**Frequency**	**Percentage**
Mining	211	67
Fishing	29	9.2
Farming	61	19.4
Trading	14	4.4
Total	**315**	**100**

Source: Data Analysis 2019

The result revealed that 67% of respondents were involved in sand mining, making it the dominant economic activity. Farming followed at 19.4%, while fishing and trading accounted for 9.2% and 4.4%, respectively. These figures underscore sand mining as a major source of income for residents in the floodplains of the River Benue in Makurdi. However, the reliance on sand mining raises environmental concerns, including riverbank erosion, habitat degradation, and increased flood risks. The unregulated nature of the practice necessitates urgent policy interventions and sustainable management strategies. Similar observations have been reported in previous studies (Madyisa, 2013; Farahani & Bayazidi, 2018).

The result of respondents' distribution by educational qualification is presented in Table 4.

Table 4: Educational Level of the Respondents

Educational Level	**Frequency**	**Percentage**
Non-Formal	52	16.5
Primary	101	32.1
Secondary	146	46.3
Tertiary	16	5.1
Total	**315**	**100**

Source: Data Analysis 2019

The data indicates that 46.3% of respondents had completed secondary education, indicating a moderate level of basic education. Meanwhile, 32.1% had attained only primary education, and 16.5% had no formal education. A smaller proportion (5.1%) had post-secondary qualifications. These results suggest that while formal education is present, lower educational attainment levels may impact socio-economic development and decision-making capacities.

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Income Level

The result of respondents' distribution by income level is presented in Figure 3.

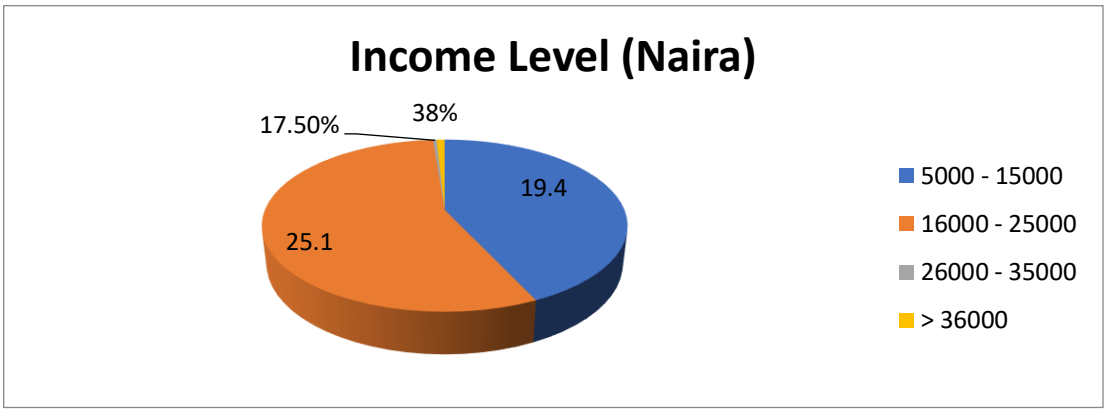

Figure 3: Income Levels of respondents

Income distribution within the study area revealed that 38% of respondents earned ₦36,000 or more per month, followed by 25.1% earning ₦16,000–₦25,000. Additionally, 19.4% earned ₦5,000–₦15,000, while 17.5% fell within the ₦26,000–₦35,000 range. The findings suggest that most respondents belong to low- to middle-income groups, aligning with existing studies that indicate sand miners often originate from economically disadvantaged backgrounds.

Sand Mining Methods in the Study Area

Table 5 presents the distribution of sand mining methods across various mining sites within the study area.

Table 5: Mining Techniques used in the Study Area

Mining Site	**Frequency**	**Sand Mining Method**		
		Manual In-stream	**Manual Surface Mining**	**Mechanized Dredging**
Tyo Mu	32	0	32	0
Gaadi Back of Brewery	36	30	6	0
Terwase Agbadu	34	29	5	0
Wurukum Behind Abattoir	29	24	5	0
Wurukum Behind Tipper Garage	33	27	6	0
Clerk Market Back of John Holt	28	25	3	0
Ujamatyu Agbough	30	20	10	0
North Bank Behind Hausa Quarters	31	3	2	26
North Bank Behind Olando Filing Station	34	18	6	10
Tse Kpam	28	20	8	0
Total	**315**	**196 (62.2 %)**	**83 (26.3 %)**	**36 (11.5 %)**

Source: Data Analysis 2019

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The study identifies three primary sand mining methods: manual in-stream mining, manual surface mining, and mechanised dredging. Manual in-stream mining is the most dominant, accounting for 62.2% of all mining activities. It is widely practiced in Gaadi Back of Brewery, Terwase Agbadu, Wurukum Behind Abattoir, Wurukum Behind Tipper Garage, Clerk Market Back of John Holt, Ujamatyu Agbough, and Tse Kpam, reflecting a strong reliance on labour-intensive techniques. Manual surface mining constitutes 26.3% of mining activities. While less prevalent than in-stream mining, it remains significant, particularly at Ujamatyu Agbough and Tse Kpam, where its proportion is relatively higher than in other locations. This suggests that mining preferences vary based on site conditions. Mechanised dredging, the least employed method, accounts for only 11.5% of mining activities. It is exclusively observed at North Bank Behind Hausa Quarters (26%) and North Bank Behind Olando Filling Station (10%), where the presence of mechanised operations is likely influenced by the availability of infrastructure and financial investment in dredging equipment.

The predominance of manual in-stream mining raises concerns about socio-economic and environmental impacts. While it provides employment opportunities, it also leads to riverbed destabilisation, habitat destruction, and increased sedimentation. Manual surface mining, though less environmentally invasive, contributes to land degradation and vegetation loss. The low adoption of mechanised dredging suggests financial constraints as a major barrier. Findings indicate that sand mining in the area is largely informal and reliant on traditional techniques, with minimal technological advancements. The dominance of manual in-stream mining heightens the risk of environmental degradation, erosion, and flooding. To mitigate these risks, regulatory oversight and sustainable mining practices, such as controlled extraction and site rehabilitation, should be implemented. The potential for mechanised mining exists but requires financial support and policy incentives to facilitate adoption. Similar concerns and recommendations were noted by Farahani and Bayazidi (2018).

Categories of Sand Mined in the Study Area

Table 6 presents the distribution of sand types mined across various sites in the study area, which generally indicate the predominance of sharp sand extraction.

Table 6: Types of Sand Mined in the Study Area

Mining Site	**Frequency**	**Type of Sand Mined**			
		Smooth	**Sharp**	**Quartz**	**All Types**
Tyo Mu	32	0	12	20	0
Gaadi Back of Brewery	36	5	24	24	3
Terwase Agbadu	34	2	27	3	2
Wurukum Behind Abattoir	29	7	20	1	1
Wurukum Behind Tipper Garage	33	0	29	4	0
Clerk Market Back of John Holt	28	3	20	3	2
Ujamatyu Agbough	30	5	21	1	3
North Bank Behind Hausa Quarters	31	0	25	6	0
North Bank Behind Olando Filing Station	34	0	20	14	0
Tse Kpam	28	7	16	2	3
Total	**315**	**29(9.2 %)**	**214(68 %)**	**58(18.4 %)**	**14(4.4 %)**

Source: Data Analysis 2019

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The study also examines the types of sand extracted, with findings presented in Table 6. Sharp sand is the most frequently mined type, constituting 68% of total extraction. Its dominance reflects its high demand in construction, particularly for concrete production due to its superior binding properties. Quartz sand represents 18.4% of the total extraction, highlighting its role in industrial applications, including glassmaking and specialized construction. Smooth sand, accounting for 9.2%, is the least extracted type, primarily used for plastering and minor construction projects. Additionally, 4.4% of miners extract all sand types, indicating a preference for resource diversification at certain locations. Site-specific data reveal that sharp sand is the most extracted type across all locations, with particularly high proportions at Wurukum Behind Tipper Garage (88%) and Terwase Agbadu (79%), suggesting strong construction demand. Quartz sand extraction is highest at Tyo Mu (20%), North Bank Behind Olando Filling Station (41%), and Gaadi Back of Brewery (24%), indicating significant geological deposits suitable for industrial applications. However, the overall lower proportion suggests that local market demand for quartz sand is not as high as sharp sand. Smooth sand mining is relatively minimal, with the highest proportions recorded at Tse Kpam (25%) and Wurukum Behind Abattoir (24%), suggesting the presence of finer sediment deposits. However, limited large-scale construction demand contributes to its lower extraction rates.

A small fraction (4.4%) of miners extracts all sand types, particularly in Gaadi Back of Brewery and Ujamatyu Agbough, reflecting a market diversification strategy aimed at maximizing profitability. This may also indicate a lack of strict resource segregation, allowing miners to extract multiple sand types within the same site. Overall, findings confirm that sharp sand is the most valuable and widely mined resource, driven by construction demand. Quartz and smooth sand extraction is relatively lower due to more specialized applications. The existence of mixed-extraction sites suggests a flexible approach to resource utilization, influenced by economic and environmental considerations.

Reasons for Sand Mining in the Study Area

Figures 5 and 6 present the factors (reasons) influencing sand mining activities at different sites within the study area. A tabulated distribution of respondents' reasons for increased sand mining activity in the study area is given in Table S2 in Appendix.

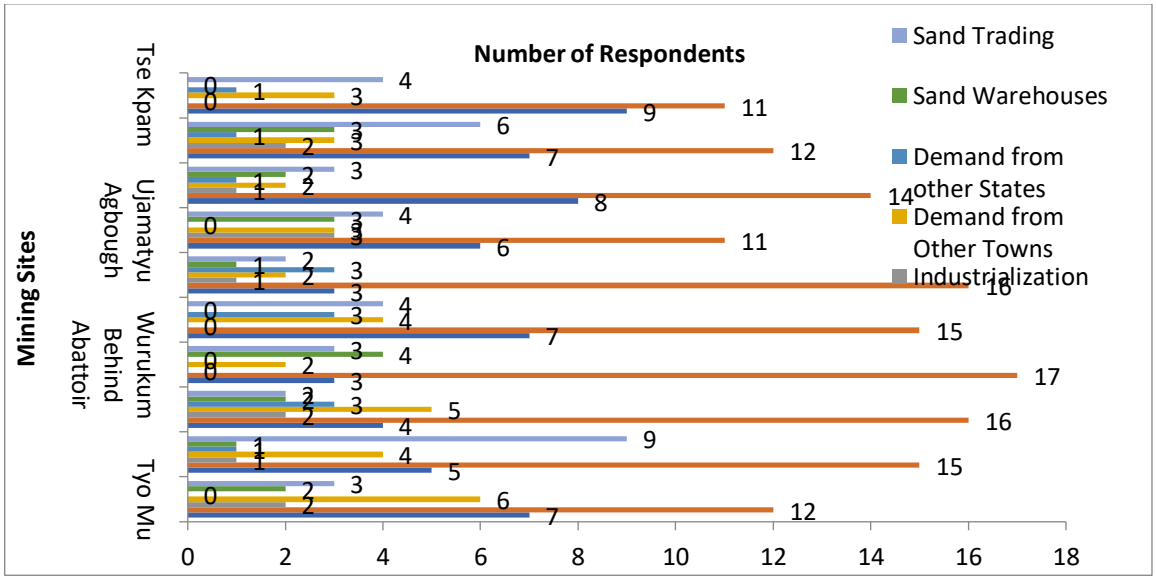

Figure 5: Site- Specific Reasons for Sand Mining in the Study Area

At Terwase Agbadu, urban development accounts for 30% of responses, the highest recorded, while Wurukum Behind Tipper Garage and Tyo Mu report 29% and 23%, respectively. This highlights the significant role of infrastructure expansion, road construction, and housing in driving sand mining activities. Population pressure follows closely, with notable figures at Wurukum Behind Tipper Garage (27%), Terwase Agbadu (28%), and Tyo Mu (21%), emphasizing that rising population growth increases the demand for sand resources for residential and commercial development. The strong connection between population expansion and construction suggests that sand mining will continue unless effective regulations are implemented.

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Demand from other states, although a lesser factor compared to urbanization and population growth, contributes to mining activities, accounting for 9% at Terwase Agbadu and 10% at Tyo Mu. This inter-state demand indicates that sand mining has economic significance beyond local use, potentially fostering regional trade while posing risks of environmental degradation. Similarly, demand from other towns contributes between 5% and 8%, with North Bank Behind Olando Filing Station reporting the highest at 8%, reflecting the influence of external markets in sustaining sand extraction. Sand trading as a driver of mining records lower percentages, with the highest values at Tyo Mu (16%) and Terwase Agbadu (14%). This suggests the presence of commercial sand trading networks that support employment and income generation but remain secondary to urban development and population pressure. Sand warehousing contributes marginally, with the highest percentage at Terwase Agbadu (6%) and North Bank Behind Olando Filing Station (5%), indicating some degree of supply chain management but limited long-term stockpiling. Industrialization plays the smallest role, with the highest percentage recorded at Ujamatyu Agbough (4%), suggesting that large-scale industrial demand for sand is minimal in the study area. Instead, sand mining is largely driven by urban and residential construction needs rather than by industrial-scale extraction.

Overall, urban development (30%) and population growth (28%) emerge as the primary drivers of sand mining, with additional contributions from inter-state (10%) and inter-town (8%) demand. While sand trading (16%) and warehousing (6%) play a role, their impact remains secondary. The findings indicate that mining activities are more responsive to immediate construction needs rather than speculative storage or trading.

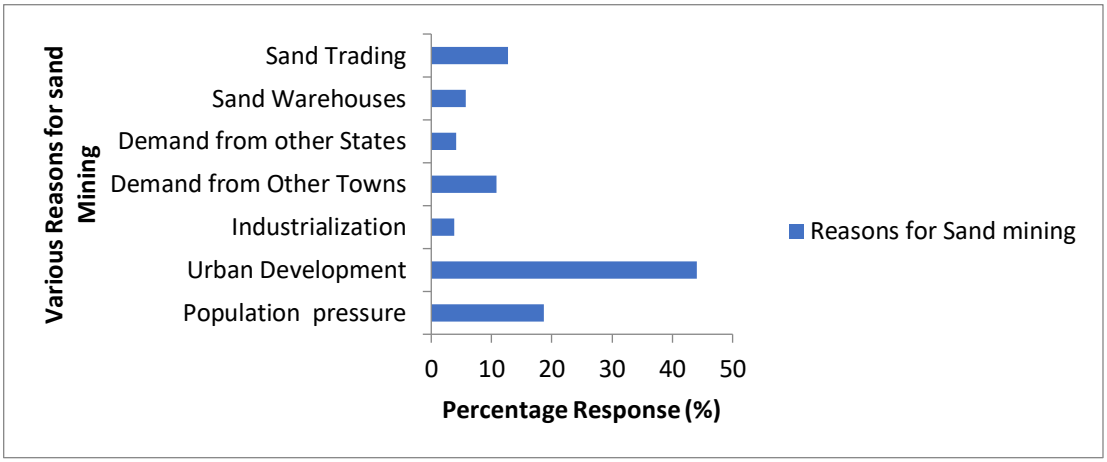

Figure 6: Overall Reasons for Sand Mining in Makurdi Town

Contributions of Sand Mining to Socio-Economic Livelihood

In this study, the sampled respondents identified the contributions of sand mining to their welfare and livelihood to include income generation, job creation, construction, tax revenue, and reclamation. The study revealed the significant contributions of sand mining on the socio-economic/livelihood of the miners.

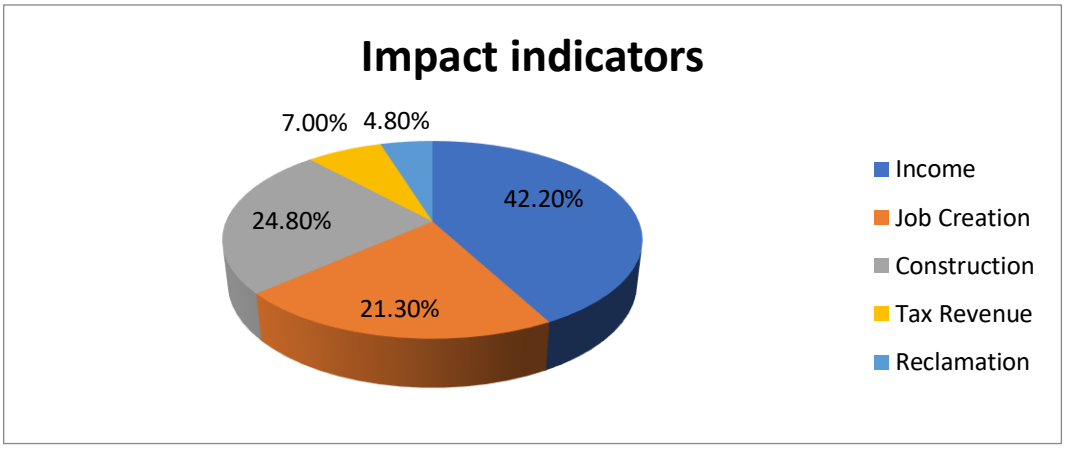

Figure 7: Effects of Sand Mining on Socio-Economic Attributes of Respondents

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Figure 7 presents the socio-economic contributions of sand mining to miners' livelihoods. The most significant impact is income generation, which accounts for 42.2% of responses, indicating that many individuals depend on sand mining for their livelihood, particularly in extraction, transportation, and sales. Job creation follows as the second most significant impact, contributing 21.3%, highlighting the sector's role in providing employment opportunities for skilled and unskilled labor. However, the lower percentage compared to income generation suggests that job security and structured employment remain limited. Construction activities account for 24.8% of responses, reinforcing the essential role of sand mining in urban growth. The high percentage reflects its necessity in supporting housing, road infrastructure, and commercial development, aligning with trends of urban expansion and increasing construction demand. Tax revenue generated from sand mining accounts for 7.0%, indicating that while the industry contributes to government earnings, its financial impact remains relatively low. The lower percentage could be attributed to informal mining operations and inadequate tax collection mechanisms. Enhancing regulatory frameworks and enforcing taxation policies could improve government revenue from the sector. Reclamation, or land restoration efforts after mining, is the least acknowledged impact, accounting for only 4.8%. This suggests that little attention is given to mitigating the environmental consequences of sand mining, raising concerns about land degradation and ecological disruption. The low percentage highlights the need for policy interventions to integrate sustainable mining practices, including mandatory reclamation efforts.

The dominance of income generation (42.2%) suggests that many individuals rely on sand mining for daily sustenance, but its long-term sustainability remains uncertain due to environmental degradation. Job creation (21.3%) is significant but appears secondary to income, reflecting informal employment structures with limited security benefits. Government intervention through skill development and alternative employment opportunities could improve long-term socio-economic benefits. The relatively high contribution of sand mining to construction (24.8%) confirms its indispensable role in urban development. As cities expand, demand for sand is likely to increase, necessitating sustainable extraction practices to prevent resource depletion. Policy frameworks should balance construction demands with responsible mining to mitigate environmental hazards. Tax revenue generation (7.0%) is an area for improvement, as strengthening tax compliance mechanisms within the sand mining sector could provide additional government funding for infrastructure and social services. Proper documentation and monitoring of mining activities would enhance taxation processes. The minimal focus on reclamation (4.8%) raises environmental concerns. Without adequate restoration, mined areas may become unproductive, leading to long-term ecological damage. Government regulations should enforce land rehabilitation policies to ensure that mined areas are restored for future use.

Overall, the findings from Figure 7 indicate that while sand mining significantly contributes to income and employment, its socio-economic benefits are unevenly distributed. The imbalance between economic gains and environmental sustainability presents challenges that require policy interventions. Sustainable mining practices, improved regulatory frameworks, and community involvement in land reclamation could enhance the long-term viability of the sector.

Plate 1: Youths loading river sand into a tipper using shovels

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Plate 2: Sand Deposits on the Floodplain of River Benue that caused soil degradation at Ityo – Mu Mine Site

Daily Quantity of Sand Mined Per Tipper Truck

The variables for sand mining are the quantity of sand mined daily with the number of tippers load per day, shown along the ten (10) sand mining sites. Data on the quantity of sand mined daily per tipper load at each mine site in the study area is shown in Figure 8, while the overall percentage contributions are presented in Figure 9.

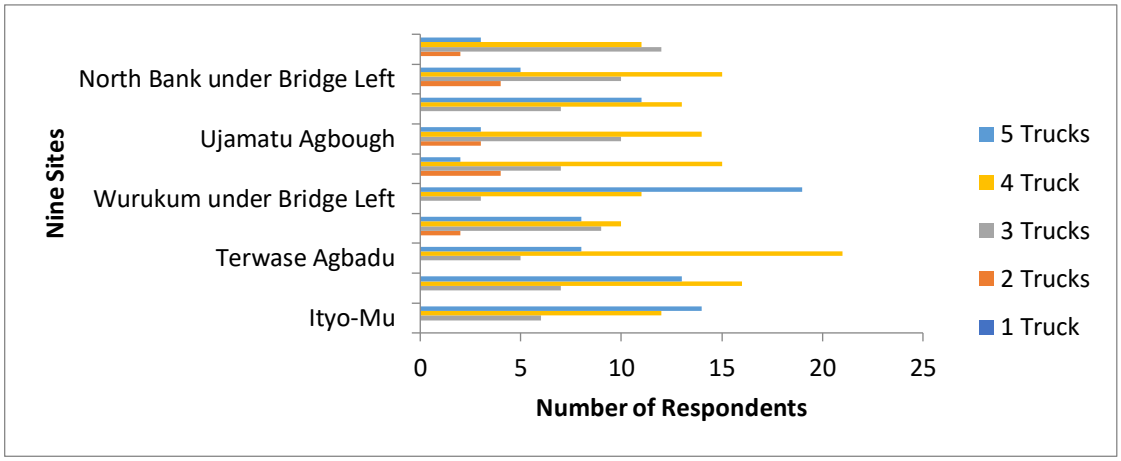

Figure 8: Daily Quantity of Sand Mined in the Various Mines Site

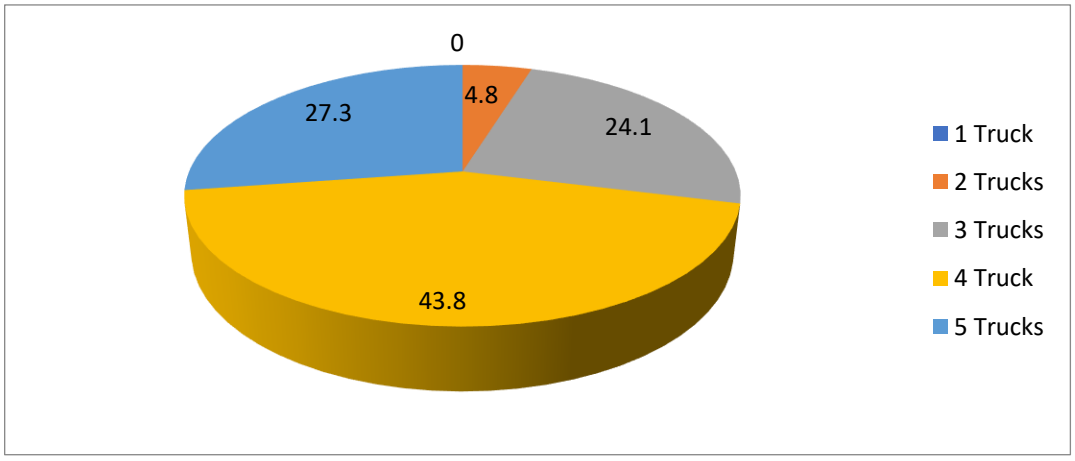

Figure 9: Overall Quantity of Sand Mined in the Study Area

The study examines sand mining activities across ten (10) sites, focusing on the daily quantity of sand extracted per tipper truck. Figures 8 and 9 illustrate these variations. The highest percentage of respondents mine four trucks of sand daily, suggesting that medium-scale extraction is the dominant form of sand mining in the area. This extraction level underscores sand mining's role as a crucial economic activity. At Wurukum

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under Bridge Left, the highest percentage of respondents extract five trucks of sand daily, making it a highly active site. This suggests significant sand deposits and high market demand, potentially contributing substantially to urban construction. Similarly, Terwase Agbadu records a high percentage of respondents mining four trucks daily, reinforcing its status as a major extraction point. The high extraction rate here may be due to favorable mining conditions and accessibility, necessitating sustainable mining practices to prevent resource depletion.

Conversely, Tse Kpam records the lowest percentage of respondents mining five trucks daily, suggesting lower extraction levels due to factors such as limited deposits, accessibility challenges, or regulatory constraints. A geospatial analysis is needed to assess sustainability at this site. Meanwhile, North Bank under Bridge Right and Ujamu Agbough have a significant percentage of respondents extracting four trucks of sand daily, indicating substantial sand deposits that contribute significantly to the local construction sector. However, this high extraction rate raises concerns about environmental degradation and resource depletion.

The percentage of respondents mining three trucks daily is relatively high at Gaadi Back of Brewery and Ityo-Mu, demonstrating moderate contributions to the overall sand supply. Proper regulation is required to balance economic benefits with sustainability. At Clerk Market Back of John Holt, a notable percentage of respondents mine only two trucks daily, indicating lower sand mining activity due to limited deposits or market preferences. Further research is required to determine factors influencing lower extraction at this site. The presence of respondents mining only one truck daily across multiple sites suggests a mix of small-scale and subsistence-level mining operations. These may be influenced by market demand, site accessibility, and labor availability. Encouraging organized mining cooperatives could enhance efficiency and profitability for small-scale miners.

The dominance of four-truck and five-truck extractions suggests that sand mining is primarily commercial rather than subsistence-based, highlighting its economic significance and employment generation role. However, large-scale extraction raises sustainability concerns, requiring regulatory oversight. Variations in extraction levels may result from differences in deposit distribution, regulatory enforcement, and transportation accessibility. Sites with higher extraction levels may require stricter monitoring to prevent over-extraction and land degradation. Given the high percentage of respondents mining large quantities of sand daily, sustainable resource management strategies are necessary. Over-reliance on sand extraction without restoration efforts could lead to severe ecological consequences such as erosion and habitat loss. Government intervention through controlled mining policies is crucial to mitigating these risks.

Environmental Problems of Sand Mining

The results of environmental problems of sand mining in the study area based on the respondents' perceptions and practical experiences is presented in Figure 10 and 11.

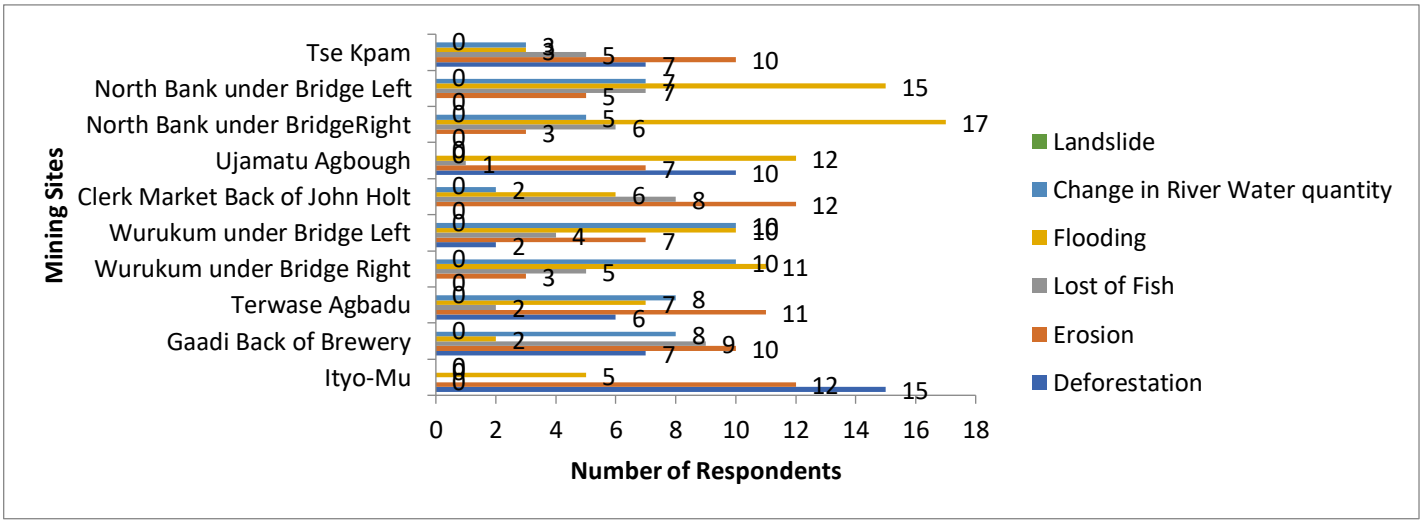

Figure 10: Effects of Sand Mining on the Environment Based on Mining Sites

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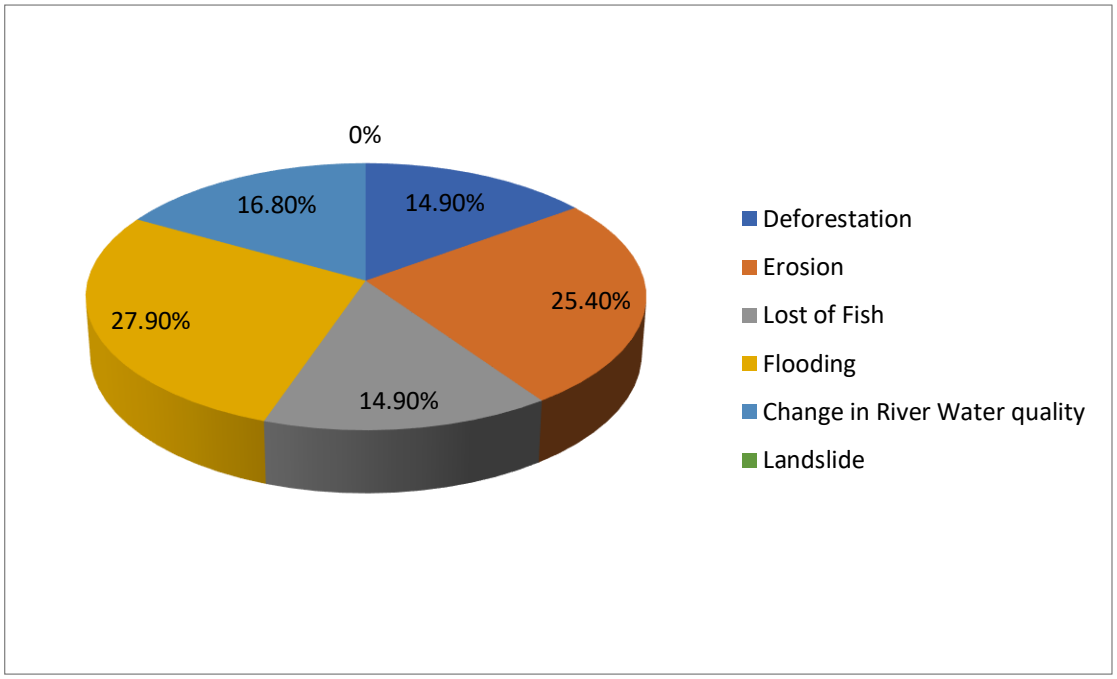

Figure 11: Overall Effects of Sand Mining on the Environment

The environmental impact of sand mining was assessed based on respondents' perceptions and experiences, as presented in Figures 10 and 11. Key concerns identified include erosion, deforestation, flooding, and changes in river water quantity. Deforestation emerges as a major environmental impact, with the highest percentage of respondents reporting its occurrence across multiple sites. This indicates significant vegetation loss, leading to habitat destruction and increased soil degradation. Flooding is another critical issue, particularly at North Bank under Bridge Right, where the highest percentage of respondents report its occurrence. Excessive sand mining alters riverbeds, reducing their capacity to contain water and increasing flood risks. This poses severe threats to infrastructure and community displacement in urban areas. Changes in river water quantity were frequently reported, particularly at North Bank under Bridge Right and Ityo-Mu, where the highest percentages of respondents noted this problem. Excessive extraction disrupts river flow, negatively affecting aquatic ecosystems and water availability for domestic and agricultural use. Sustainable mining practices are necessary to prevent severe hydrological consequences.

Erosion is another significant environmental impact, with a high percentage of respondents at Tse Kpam and Wurukum under Bridge Left identifying it as a major concern. Sand mining exposes soil surfaces and weakens riverbanks, leading to severe erosion that threatens settlements and farmlands. Urgent intervention through proper land management strategies is required to mitigate these effects. Loss of fish populations is a notable impact, with respondents at Wurukum under Bridge Right and Terwase Agbadu reporting declines. The destruction of aquatic habitats reduces fish biodiversity and affects fishing livelihoods. To address this, strict environmental protection measures are necessary. Landslides, though reported at lower percentages, remain a concern at Clerk Market Back of John Holt and Ujamu Agbough. Excessive excavation destabilizes slopes, increasing landslide risks that could lead to property damage and loss of life.

The combined impact of sand mining on flooding, erosion, and deforestation indicates severe environmental degradation across the study sites. The highest levels of deforestation were observed at Ityo-Mu and Wurukum under Bridge Right, emphasizing the need for afforestation programs to counteract deforestation's adverse effects. Flooding and erosion are closely linked, as observed at North Bank under Bridge Right and Wurukum under Bridge Left, where high percentages of respondents reported both issues. Continuous mining weakens riverbanks, increasing collapse risks. Controlling extraction rates and implementing protective measures such as buffer zones could mitigate these problems. Environmental effects of sand mining vary across sites. Urban locations like North Bank under Bridge Right and Wurukum under Bridge Left show higher vulnerability to flooding and erosion due to their geographical and hydrological conditions. Policy interventions should consider site-specific variations for effective regulation.

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Plate 3: Environmental Degradation that caused erosion on the riverbank of River Benue

DISCUSSION

The findings align with Rukmana et al. (2020), who highlight the economic benefits of sand mining, including income generation and job creation. However, while their study suggests that sand mining in the Sadang River aids in restoring hydrological function, the current study finds that sand mining in Makurdi contributes to environmental degradation, including flooding and fish population decline. Rukmana et al. (2020) focus on mechanized and large-scale mining, while this study reveals that manual in-stream and surface mining dominate in Makurdi, raising concerns about sustainability. The study also aligns with Mbaka and Rono (2022), confirming that sand mining provides socio-economic benefits while causing land degradation and water pollution. While Mbaka and Rono (2022) emphasize drug abuse, violence, and school dropouts as key social issues, this study focuses on employment distribution and tax contributions. Both studies highlight regulatory challenges, with the current study emphasizing weak tax revenue and minimal land reclamation. Similarly, Tesi et al. (2018) highlights the socio-economic and environmental impacts of sand mining, emphasizing erosion, flooding, and farmland destruction. However, while their study focuses on infrastructure damage, the current study prioritizes riverbed destabilization and water quantity reduction. Tesi et al. (2018) use ANOVA for analysis, while this study relies on descriptive statistical approaches.

The findings also correspond with Mngeni et al. (2016), which recognizes sand mining as a major livelihood source. While Mngeni et al. emphasize conflicts between communities and government officials, this study highlights weak regulatory enforcement. Additionally, the study aligns with Johnbull and Brown (2017), confirming that sand mining contributes to income generation and job creation while causing environmental degradation, including river course alteration and flooding. In conclusion, sand mining in Makurdi is primarily commercial, with most respondents extracting four to five trucks daily. The activity significantly contributes to the local economy but poses severe environmental threats. Sustainable management strategies, stricter regulations, and afforestation programs are essential to balance economic benefits with environmental sustainability.

CONCLUSION

Based on the findings, the study concludes that sand mining plays a crucial role in the local economy, with high extraction levels observed at key sites such as Wurukum under Bridge Left and Terwase Agbadu. However, the uneven distribution of sand deposits and possible regulatory factors contribute to lower extraction levels at Tse Kpam and other less active sites. The significant environmental impacts, including deforestation, flooding, erosion, and river water reduction, highlight the urgent need for sustainable mining practices. North Bank under Bridge Right, in particular, faces severe erosion risks due to excessive sand removal, while flooding and erosion at Tse Kpam and Wurukum under Bridge Left threatens land stability and ecological sustainability.

RECOMMENDATIONS

The study therefore makes the following recommendations based on the findings: that the government should enforce stricter regulations on sand mining operations to control excessive extraction, ensure compliance with environmental standards, and prevent further ecological degradation; miners should adopt sustainable

techniques such as controlled dredging and periodic site restoration to mitigate the adverse effects of sand mining on riverbeds, water quality, and aquatic ecosystems; and mandatory land reclamation programmes should be introduced to restore degraded sites through reforestation, erosion control measures, and proper waste disposal after mining activities.

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