



Assessing the Impact of Unsustainable Sand Mining on the Morphology of Kanawa Stream, Gombe State, Nigeria

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ABSTRACT

Kanawa stream is ephemeral and carry a significant load of sand and sediment during flow. The sediment sand is of high quality for construction, and therefore exploited heavily for sand extraction. This study assessed the impacts of unsustainable sand mining on stream morphology in Kanawa Stream, Gombe State, Nigeria. The research combined field surveys, participatory observations, and administered structured questionnaire to 200 respondents across five mining villages. Likert scaling quantified perceptions of morphological impacts, while chi-square analysis tested relationships between mining activities and stream degradation. Findings revealed extensive morphological alterations with an overall mean Likert score of 3.78, exceeding the criterion mean of 3.0. The most pronounced effects included increased depth and width (mean=3.91), channel incision (mean=3.83), desiltation (mean=3.79), temporary sandpit formation (mean=3.79), altered flow direction (mean=3.74), and riparian vegetation destruction (mean=3.64). Statistical analysis revealed a significant relationship between unsustainable mining and morphological degradation ($\chi^2 = 41.96 > 31.40$, $df = 20$, $p < 0.05$). The study concludes that extraction rates far exceed natural replenishment, triggering channel instability, sediment imbalance, habitat destruction, and compromised water quality. These impacts threaten aquatic biodiversity and community livelihoods dependent on the stream for irrigation and domestic water. Persistent illegal mining and weak regulatory enforcement perpetuate the crisis. Recommended interventions include enforcing a 1.6-meter extraction limit using GPS/drone surveillance, riparian restoration, promoting manufactured sand alternatives, community-managed cooperatives, continuous monitoring, and public awareness campaigns. Without urgent action, ecological collapse endangers biodiversity and riparian community well-being.

Keywords: Sand mining, stream morphology, channel incision, riparian vegetation, Kanawa Stream, Gombe State, Nigeria

1. INTRODUCTION

The practice of mining began as far back as the time of human evolution. Early humans dug up flint and rock fragments to craft hunting weapons, shape raw materials, and defend themselves from wild animals. Continuous global population growth and increasing urbanization rates will

pose pressure on governments and companies regarding how they deal with urban development. Although aggregate demand for stream sand is very high, as concrete is commonly used in the construction industry, the demand for sand is expected to rise with the world population (Crow, 2008).

Nigeria has one of the largest construction industries in Africa, driven by rapid urbanization and infrastructure development. Sand is a resource in high demand from the construction sector. According to the Nigeria Bureau of Statistics (NBS), the average per capita cement consumption in Nigeria has been rising steadily. The average per capita sand consumption, using the standard construction factor of 2.5, is correspondingly high. In Nigeria, an estimated thousands of loads of stream sand are illegally mined from various streams daily, with Gombe State being one of the significant hotspots in the North-East region. Sand mining, especially illegal sand mining in Gombe State, is conducted on stream beds, basins, and floodplains. It has been on the increase since the beginning of the 1990s following a construction boom in Gombe area after it gain the status of a State. Kanawa stream is one of the major streams affected by unsustainable sand extraction in the State.

Several studies such as Koehnken (2020) summarized the results of a structured literature review addressing the question of what evidence exists of impacts of sand mining on ecosystem structure, process, and biodiversity in streams, floodplains, and estuaries. Ecosystem features affected include macroinvertebrate drift, fish movements, and food web dynamics. The study emphasized that sand mining impacts extend beyond immediate mining sites to affect the entire stream systems. Rupesh, Rastogi Virendra, & Kumar (2017) presented an outline of the environmental impact of river sand mining and possible means of minimizing impacts. They noted that extraction higher than natural replenishment has caused irreparable damage to land, water, biotic, and social environments of many rivers. Excessive in-stream sand and gravel mining ruins river systems. Usman et al. (2016) conducted a geochemical assessment of toxic metal stocking in topsoil within the area of a limestone quarry in Gombe State, North-Eastern Nigeria. Their research found elevated concentrations of heavy metals including Fe, Mn, Zn, Ni, Cu, Cr, Cd, and Pb, indicating that mining activities contribute to environmental contamination. The geoaccumulation index assessment showed moderate contamination by hazardous metals. Aliyu, Garba, Victor, Gital, & Mado, (2021) conducted research assessing the impact of sand mining on river channel physical changes and morphological characteristics along river channels in Nigeria. Their study, found that river channels have a sustainable threshold of 1.6 meters for sand extraction, beyond which environmental problems begin to manifest. The study reported that sand accounts for 72.08 percent of sediment in the channel, while silt and clay account for 16.86 and 11.06 percent respectively. The average daily sand transport into mining sites was 106.6 tons.

Institutionally, the Nigeria Security and Civil Defence Corps (NSCDC) and Gombe State Ministry of Energy and Mineral Resources have documented increasing cases of illegal sand mining. In October 2023, three suspects were arrested in Gamawa community, Akko LGA, operating without proper clearance. The State government subsequently announced the suspension of all mining activities pending screening and clearance of all operators. Additionally, the Gombe State Urban Planning and Development Authority (GOSUPDA) has warned against illegal sand excavation in Shehu Abubakar district, where heavy trucks are used daily to extract and sell sand. Therefore, the present study assessed the impacts on stream

morphology due to sand mining in Kanawa stream, seeking to identify ways of achieving an efficient balance between stream sand mining for development and environmental conservation.

2. MATERIALS AND METHODS

This study was carried out along the entire stretch of Kanawa stream, from the upstream reaches near the Gombe Hills to the downstream sections flowing southeast toward River Gongola. The stream basin drainage is part of the larger Upper Benue Basin, underlain by the Gombe Sandstone, Bima and Kerri-Kerri Formations. The Stream covers a distance of approximately 120km and is located in Yamaltu/Deba Local Government Area of Gombe State, Nigeria. It lies in the Northern part of the Sudan Savanna between latitude $10^{\circ}16'N - 10^{\circ}18'30''N$ longitude $11^{\circ}18'10''E - 11^{\circ}22'09''E$ (Figure 1). The climate of the study area is part of the tropical continental type of climate in Nigeria. One of the basic characteristics of this climate zone is relatively short rainy season and a comparatively long dry season which fluctuates from year to year. Rainfall usually begins in late April or early May and ends in early October. The rainfall last between five (5) to six (6) months. The maximum rainfall is usually experienced in the months of July and August. The annual rainfall amount ranges between 800 - 1000mm³. The dry season last between October to late May. The mean annual temperature of the study area is about 30°C, with highest temperature experienced in the month of April. It has an altitude of 336-390m (Abba, Sawa, Gani, & Abdul, 2015) and located about 5km from the State capital on Gombe – Biu road. The major economic activity in the area is farming which is the mainly subsistence and sand minig. Most of the people engage in irrigation farming along the Kanawa Stream valley. Farm produce include maize, sorghum, groundnut, millet, vegetables and beans. Other activities include livestock grazing, poultry and fishing.

The present study also covers villages located near active sand mining spots along the Kanawa Stream. It targets people permanently residing in these villages, farmers, village heads, local government officials, sand loaders, and truck drivers, government officials from the Ministry of Environment and Mineral Resources, office bearers of NGOs, and other stakeholders either directly or indirectly involved in or affected by sand mining activities.



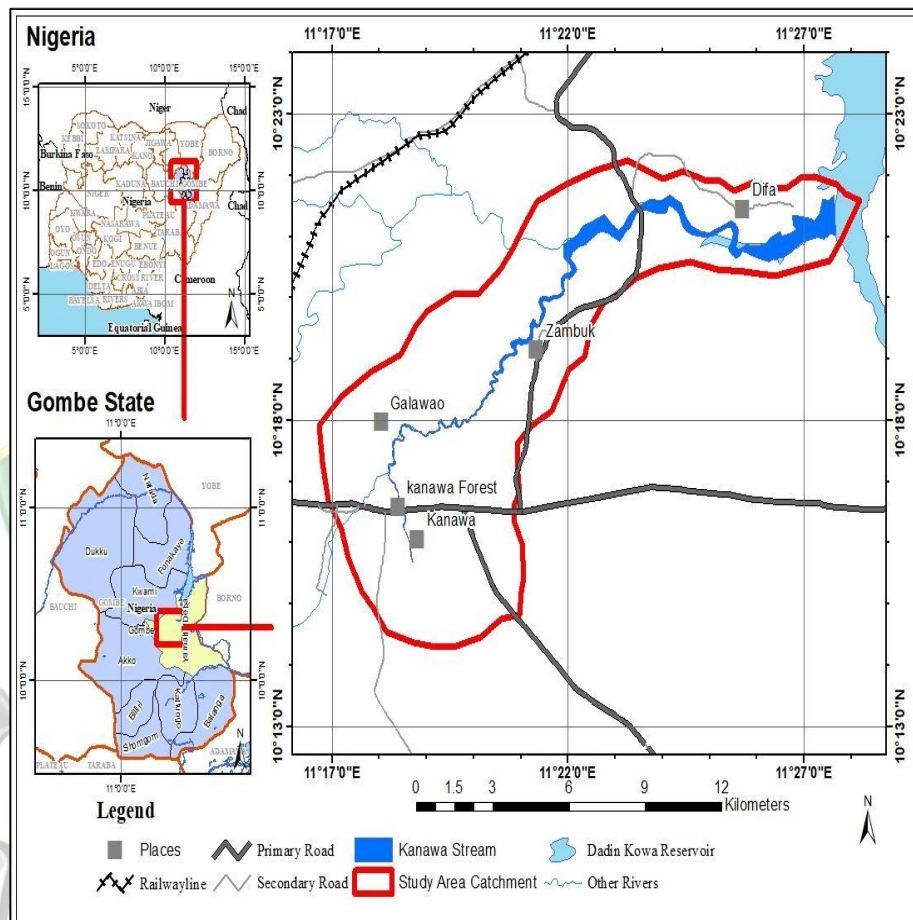


Figure 1: Kanawa Stream, Gombe State

This study mainly used primary data sourced through reconnaissance survey and structured questionnaire. A non-probability sampling technique was adopted and utilized. Kanawa stream within Yamaltu-Deba Local Government Area flows through a cluster of villages including Kanawa, Kundulum, Wuro Tale, Wajari, Tudun Wada Isa, Wajari Pillam, Dangar Tera, Wajari Lakau etc. The researcher purposely identified one hot spot mining center in five villges based on size, and the nearest neighboring village to the stream as shown in Figure 2 was selected. Snowball sampling was adopted to select 40 sample respondents from each sample village. The total sample size was 200. A pre-tested interview schedule was used to obtain primary data. In addition to the above, participatory observation techniques and informal discussions were held with various stakeholders, including government officials from the Ministry of Environment, Village administrative officials, nearby villagers, NGOs, and the general public. The researcher formulated null hypotheses and used the chi-square test to study the significance of the hypotheses. To supplement the above, the researcher used the Rensis Likert scaling technique as an appropriate method for opinion study.

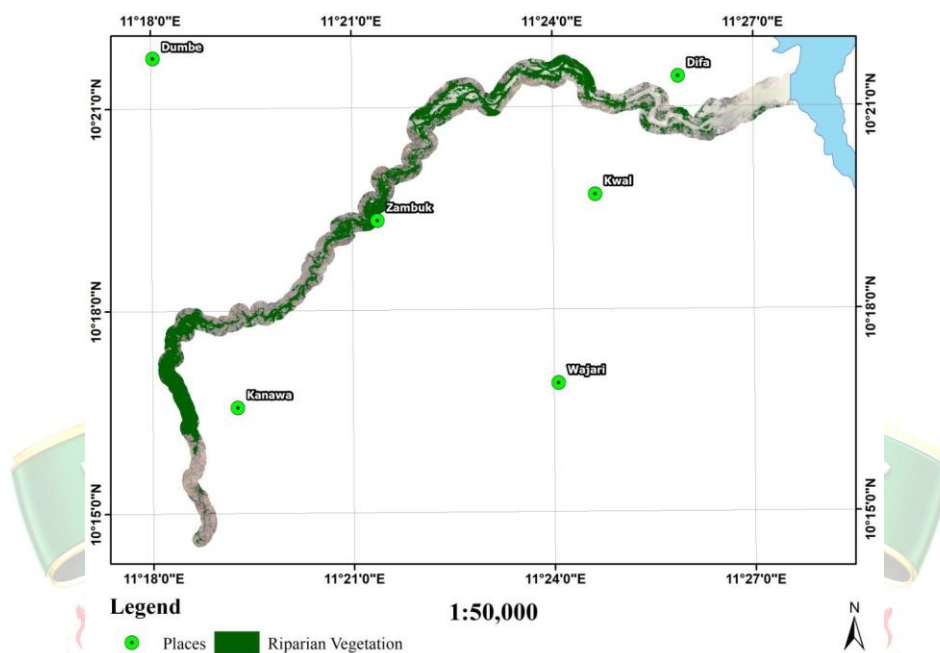


Figure 2: Sampled Sand mining hot spot centers in the study area

3. RESULTS AND DISCUSSION

3.1 Impacts of Sand Mining on Kanawa stream Morphology

The respondents' opinions about impacts on stream morphology in Kanawa stream are presented in Table 1. The field observations and respondents opinions identified channel incision, increase in depth and width of the stream, direction of stream change, desiltation, destruction of riparian vegetation and temporary sandpits as the main sand mining impacting Kanawa stream morphology. Statistical information was observed from primary data, and after calculation, it was observed that the mean value of the Likert scale technique for each item, and the overall mean value, was 3.78. The overall mean value was greater than the criterion mean value of 3.0. This revealed that sand mining operations led to numerous negative impacts on river morphology. Based on the table, about 38.0 percent of respondents strongly agreed about the impacts of stream mining on stream morphology in Kanawa stream. The next 30.0 percent of respondents agreed, 12.9 percent neither agreed nor disagreed, 10.3 percent disagreed, and the remaining 8.7 percent strongly disagreed about the impacts of stream sand mining on stream morphology.

Table 1: Impact of sand mining on stream morphology of Kanawa stream

S/No	Impacts	No. of Respondents					Total	Mean score
		SA	A	NAD	D	SD		
1.	Channel Incision	87	46	30	20	17	100	3.83
2.	Increases in depth/width of the stream	73	56	32	24	15	100	3.74
3.	Direction of stream change	78	67	26	17	12	100	3.91
4.	Desiltation	92	45	18	18	27	100	3.79
5.	Destruction of Riparian vegetation	60	68	31	22	19	100	3.64
6.	Temporary sand pits	66	78	18	23	15	100	3.79
	Total	38	30	12.9	10.3	8.7	100	3.78

Changes to channel morphology, alterations to the composition and movement of sediment, changes to larger-scale stream features, alterations to the flow regime, and impacts on water quality are the major abiotic impacts (Koehnken, 2020). Simply put, stream morphology means the shape and direction of stream channels. Stream channel morphology is a combination of many processes and environmental conditions that erode and deposit material on the bed and banks, including sand, stone, and boulder. Erosion by natural and anthropogenic activity affects the formation of the river path. The extensive removal of streambed resources, mining and dredging beneath the existing streambed (Figure 3), and the modification of channel-bed form and shape cause several impacts, such as erosion of channel bed and banks, increase in channel slope, and change in channel morphology (Virendra, 2017). Mining on or near stream-beds has a direct impact on the stream's physical characteristics, such as channel geometry, bed elevation, substratum composition and stability, in-stream roughness of the bed, flow velocity, discharge capacity, sediment transport capacity, turbidity, and temperature (Aliyu, Garba, Victor, Gital, & Mado, 2021). Alteration or modification of the above attributes may cause an impact on the ecological equilibrium of the riverine regime, disturbance in channel configuration, and flow paths (Enforcement and Monitoring Guidelines for Sand Mining, Federal Ministry of Environment, Nigeria).



Figure 3: Sand Mining in the study area

The physical habitat characteristics of the stream directly impact groundwater, water quality, channel geometry, bed elevation, substrate composition and stability, in-stream roughness elements, depth, velocity, turbidity, sediment transport, stream discharge, and temperature. These geologically impact channel morphology, increase suspended sediments and their load, create unsuitable aquatic conditions, reduce light penetration, cause loss of photosynthesis in micro and macrophytes, reduce food availability for plant biomass, damage infrastructure, cause riverbank erosion, cause loss of cultivable land, and lead to loss of biodiversity (Basavarajappa, 2014). The stream is highly dynamic, characterized by rapid changes in channel locations. Unsustainable and illegal stream sand mining activities cause environmental problems at the mine site. The effect of sand mining not only degrades the water quality of the stream (Figure 3) but also changes the physical quality of the stream, such as causing stream bank erosion, stream bank slump, changes in stream flow, and decreasing stream flow. These physical impacts result from mining of stream-beds, causing alteration of channel slope and changes in channel morphology. The present study identified many harmful morphological parameters likely to create impacts along the Kanawa stream, such as channel incision/affecting river banks; change in stream direction; increased depth/width/slope of the stream desiltation; destruction of riparian vegetation; and creation of temporary sandpits.

3.2 Channel Incision/affected banks

Results in Table 1 on channel incision as an impact on stream morphology indicated that about 43.5 percent of respondents in the study area strongly agreed, 23.0 percent agreed, and 15.0 percent neither agreed nor disagreed. The next 10.0 percent disagreed, and 8.5 percent strongly disagreed about the impact of channel incision streambanks. It was noticed by the researcher during the investigation that degradation of the stream was more pronounced in the alluvial reaches of the midland compared to the lowlands. In communities near the Gombe Hills, streambanks themselves were scooped for sand extraction. The Likert mean value regarding channel incision/affected stream banks in Kanawa stream was 3.83, greater than the criterion mean value of 3.00. Hence, the data analysis concluded that stream sand mining has affected channel incision and stream banks. Channel incision is the most commonly reported impact

linked with in-stream mining. The degree of channel incision in streams has been quantified in several studies, with reported ranges including 0.5 to 3.5m over 40 years in the Tedor River in Japan (DMinh Hai et al., 2011); 2 to 4m in an ephemeral streams in Spain since the 1970s (KoeHNken, 2018); 3.5m in montane rivers in Southern Poland (Skalski et al., 2016); up to 5m in the Brenta River in Southern Italy (Moretto et al., 2014) and 10m in the Panaro River in Northern Italy (Gumiero et al., 2015). Substantial channel incision was generally associated with channel narrowing. Incision and channel narrowing were linked to bank erosion due to oversteepening and destabilization of banks (Campana et al., 2014; Ortega-Becerril et al., 2016).

3.3 The Direction of River Change

About 36.0 percent of respondents strongly agreed, 28.0 percent agreed, 16.0 percent neither agreed nor disagreed, 12.0 percent disagreed, and 7.5 percent strongly disagreed about the impact on the direction of river change (Table 1). The Likert mean value regarding the direction of change of stream was 3.74, greater than the criterion mean value of 3.00. Thus, it was concluded that stream sand mining has affected the direction of stream change, particularly the water flow path. Excessive stream sand mining can significantly alter river channels, leading to changes in stream direction, increased erosion, and potential for flooding. This occurs because removing sediment from the riverbed disrupts the natural balance of erosion and deposition, forcing the stream to adjust its course. Aliyu et al. (2021) found that in Nigerian streams, the undisturbed areas of stream channels became shallower and wider as a result of deposition, while disturbed streams became deep and narrow due to significant sand mining operations, causing erosion both upstream and downstream of mining sites.

3.4 Increase of Depth/Width of streams

From Table 1, it is depicted that 39.0 percent of respondents strongly agreed, 33.5 percent agreed, 13.0 percent neither agreed nor disagreed, 8.5 percent disagreed, and 6.0 percent strongly disagreed about the impact of increased depth/width and slope of Kanawa stream. The Likert mean value regarding this impact was 3.91, greater than the criterion mean value of 3.00. Hence, the analysis concluded that stream sand mining has a major impact on increasing the depth, width, and slope of the stream in the study area. The width ranges of several streams in the Piedmont and Tuscany regions of Italy decreased by over 50 percent as a result of incision (Surian & Rinaldi, 2002). This effect was viewed as advantageous in the past as it allowed the former floodplain to be mined and developed for agriculture and infrastructure; however, it also fundamentally altered the character of streams from braided to single channel. Shallowing and widening of the channel also increase stream temperature extremes, and channel instability increases the transport of sediments downstream. Mining-induced bed degradation and other channel changes may not develop for several years until major channel-adjustment flows occur, and adjustments may continue long after extraction has ended.

3.5 Desiltation at Kanawa stream

Results in Table 1 on desiltation shows that about 46.0 percent of respondents strongly agreed, 22.5 percent agreed, 13.5 percent strongly disagreed, 9.0 percent neither agreed nor disagreed, and another 9.0 percent disagreed about the impact of desiltation. The Likert mean value regarding desiltation of Kanawa stream was 3.79, greater than the criterion mean value of 3.00. The study concluded that stream sand mining has a major impact on desiltation processes. Stream sand mining can significantly impact stream desiltation by disrupting the natural

sediment balance (Abubakar et al., 2022), leading to channel adjustments like incision, and potentially increasing the need for desilting efforts, which are costly and pose disposal challenges. A multidisciplinary committee in India (Mittal Committee, 2001) identified causes and extent of siltation in streams and suggested measures to minimize siltation. In the Nigerian context, the Federal Ministry of Environment has raised similar concerns about siltation and sediment imbalance in streams affected by sand mining.

3.6 Destruction of Riparian Vegetation

The findings of this study as displayed in Table 1 revealed that about 34.0 percent of respondents agreed, 30.0 percent strongly agreed, 10.5 percent neither agreed nor disagreed, 11.5 percent strongly disagreed, and 9.5 percent disagreed about the impact of destruction of riparian vegetation. The Likert mean value regarding this impact was 3.64, greater than the criterion mean value of 3.00. According to the analysis, it was concluded that stream sand mining has a major impact on riparian vegetation destruction (Figure 4). Stream sand mining significantly impacts riparian vegetation by causing habitat destruction, reducing bank stability, intensifying erosion, and modifying stream morphology, ultimately leading to degradation of the stream ecosystem. The riparian zone contains stream banks, riparian vegetation, and vegetative cover. It serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and nutrient input into the stream (Wohl & Carline, 1996; Rimtip, Wuyep & Mark, 2026). Destruction of the riparian zone during sand/gravel extraction activities can have manifold deleterious effects on in-stream habitat. Destruction of any of these elements can cause stream bank destabilization, resulting in increased erosion, sediment and nutrient inputs, and reduced covering and bank cover leading to increased stream temperatures (Roth, 1996; Rimtip, Wuyep & Mark, 2026).

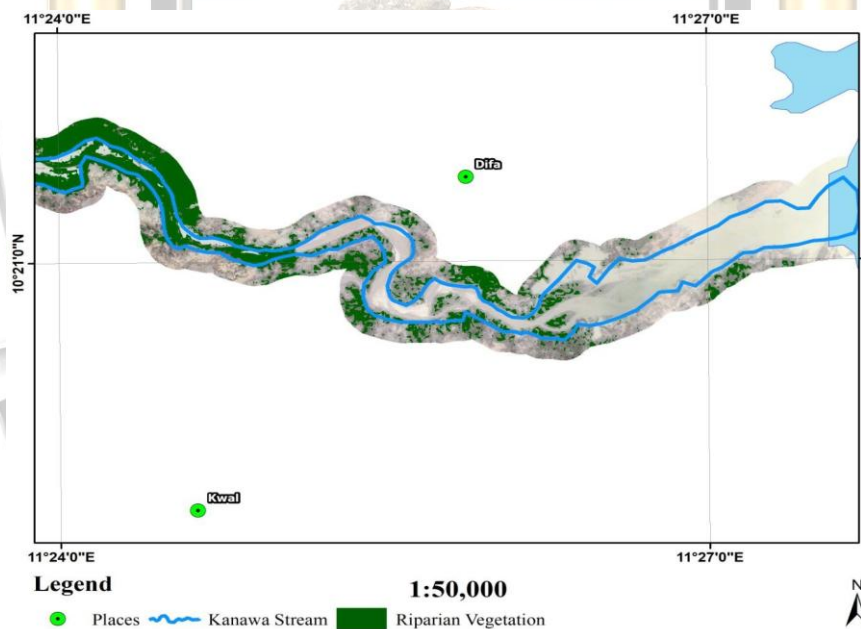


Figure 4: Shrinking Riparian Vegetation

3.7 Temporary Sandpits

The results in Table 1 depicts about 39.0 percent of respondents agreed, 33.0 percent strongly agreed, 11.5 percent disagreed, 9.0 percent neither agreed nor disagreed, and 8.5 percent strongly agreed about the impact of artificial creation of water reservoirs and pits. The Likert mean value regarding temporary sandpits in Kanawa stream was 3.79, greater than the criterion mean value of 3.00. Thus, the analysis concluded that river sand mining has created temporary sandpits in the study area. River sand mining, especially when it creates temporary sandpits, can lead to significant environmental impacts, including riverbed degradation, habitat destruction, and changes in river morphology, potentially impacting aquatic life, water quality, and local ecosystems. In Gombe Metropolis, reports from GOSUPDA have documented the creation of temporary sandpits in areas such as Shehu Abubakar district, where illegal sand excavation continues despite government warnings.

Testing of Hypothesis

The null hypothesis (H_0) was formulated: "There is no significant relationship between unsustainable stream sand mining and impact on stream morphology." The calculated value of the Chi-Square test (41.96) is greater than the table value (31.40) at the 5 percent level of significance with 20 degrees of freedom. Thus, the formulated null hypothesis (H_0) was rejected and the alternative hypothesis was accepted. The researcher concluded that there is a significant relationship between unsustainable stream sand mining and impact on stream morphology in the study area.

4. CONCLUSION

The study concludes that unsustainable sand mining in Kanawa Stream has caused severe morphological degradation, with a mean Likert score of 3.78 and statistically validated impacts ($\chi^2 = 41.96 > 31.40$) including channel incision, increased depth and width, altered flow direction, desiltation, vegetation loss, and sandpit formation, all disrupting ecological balance. Despite the stream's importance for local development, extraction exceeds natural replenishment, especially in alluvial zones near Gombe Hills, while riparian vegetation loss intensifies erosion and environmental feedback loops. Persistent illegal mining, weak enforcement by regulatory agencies, and limited community engagement perpetuate the crisis, and without urgent intervention, the stream faces ecological collapse, endangering biodiversity and community livelihoods dependent on its water resources.

5. RECOMMENDATIONS

Based on the study's findings, addressing unsustainable sand mining in Kanawa Stream requires an integrated strategy combining institutional regulation, environmental restoration, livelihood support, research, and public engagement. The Gombe State Government should establish a multi-stakeholder regulatory committee to enforce a 1.6-meter extraction limit GPS and drone surveillance, backed by strong penalties and a whistle-blower reward system. Concurrently, riparian restoration and morphological rehabilitation including check dams and controlled back filling should be implemented, alongside promotion of manufactured sand and community managed mining cooperatives that direct partial revenues to community development and alternative livelihoods. Long-term sustainability depends on continuous

monitoring by local universities, hydrological studies to set science based extraction limits, and public awareness campaigns led by traditional and religious leaders, while partnerships with research institutions build local capacity and ensure adaptive management under changing environmental conditions.

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