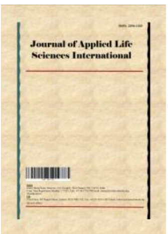

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Environmental Impacts of Sand Mining in Some Coastal Communities in Port Harcourt Metropolis Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author ODN designed the study, while author MCAO performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript managed the analyses of the study and literature searches under the strict supervision of authors ODN, SAN and AEG. All authors read and approved the final manuscript.

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ABSTRACT

Sand mining activity is one of the serious environmental problems, as the rivers are widely exploited for river bed materials like sand resulting in land and river bed degradation as well as loss of riparian habitat. The aim of this research was to assess the environmental impacts of sand mining activities in some coastal communities of Port Harcourt metropolis. Three communities namely Choba, Abuloma and Chokocho were selected for the study because of good access to waterfront and regular outcry by communities affected due to the level of environmental degradation. Formal interviews with operators of sand mining activity and stakeholders as well as the administration of questionnaire was employed. Questionnaires were designed to collect information on the characteristics of the sand mining activities in these coastal communities. The study lasted for a period of 12 months. Results obtained show that there were major impacts of sand mining namely soil erosion, road destruction, loss of vegetation, noise pollution across the coastal communities engaged in this activity. Choba recorded soil erosion with 27% as a major problem, Abuloma had noise pollution with 33% while in Chokocho, soil erosion ranked 32% as major impact of the activity. The study therefore, revealed that inspite of its economic importance,

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sand mining activity is causing more harm than good, hence it is suggested that environmental legislations regarding sand mining activities must be put in place to check and ameliorate the impacts. Community stakeholders should seek constant interface between the sand miners to resolve issues arising from the activity and to proffer intervention measures to ensure sustainability.

Keywords: Sand mining; environmental impacts; degradation of ecosystem; coastal communities; sustainability.

1. INTRODUCTION

Sand is a valuable resource and a major raw material in the construction industry in many parts of the world [1; 2]. Sand mining is an activity referring to the process of harvesting sand from an open pit or areas such as rivers, streams, and lakes. Sand mining is also the removal of sand from their natural configuration [3]. Sand mining has been one of the major environmental problems around the coastal communities, as the rivers are widely exploited for riverbed materials to satisfy his unappeasable needs. Over the years, most coastal communities in Rivers State have been inundated by the activities of sand miners with the intent of satisfying the construction needs of developers within and around the Port Harcourt metropolis. Against the backdrop, there is nonstop sand extraction without consideration of the consequences on the environment. This has degenerated into plethora of dreadful ecological consequences such as distortion of livelihood chain of communities, ecosystems, destruction of marine fauna and flora, destruction of access roads within the mining sites and the incremental deepening and widening of the rivers. The activities often result in land degradation, riverbed degradation, loss of aesthetic beauty of the land, agricultural lands and loss of riparian habitat.

Expansion due to industrialization and urbanization requires growth in infrastructure, construction of new roads, commercial malls, and residential areas [4]. Sand extraction is therefore ongoing without recourse to the impact on the environment. This results in over exploitation leaving deep pits on bare grounds while rivers are widening daily [3]. Sand mining has become a regular activity with sight of tipper trucks carrying pit sand and river sand from rivers and open fields. Unfortunately, there are no strict rules guiding these activities [5]. However, sand plays a very vital role with regards to the protection of the coastal environment. It acts as a buffer against strong tidal waves and storm surges by reducing their impacts as they reach the shoreline but when mined in larger quantities that exceed the rate at which it is being replenished, poses a threat to nearby bridges through erosion and will cause the river mouths to widen. Sand mining causes riverbed degradation and exposes buried pipelines and other infrastructure causing damage to public and private property [3]. Such excessive activities can affect the habitat of crustacean species and aquatic organisms and can pose a threat to the lives and livelihoods of other related aquatic organisms and may affect the river's water quality. Severe impacts in rivers may cause reduction of water quality, increased turbidity at the mining site due to suspension of sediment, sedimentation due to stockpiling and dumping of excess mining materials and organic particulate matter and oil spills or leakage from excavation machinery and transportation vehicles [3]. On the other hand, mining of sand and gravel in river streams causes serious damage to watersheds and is a major challenge especially in developing countries [6]. Mining activities in rivers can damage public property and private assets and aquatic habitats, threaten the stability of slopes and river bank deformation [7] and have negative consequences for the river and its surroundings [8;9].

Riverbeds widen and deepen after removing river sand, affecting aquatic life biodiversity while gravel removal destroys ecosystems, forests and agricultural lands, pollution of water bodies, vegetation losses, loss of biodiversity, erosion, changes in water table, high frequency noises and air contamination [10; 5; 11]. Sand mining has potential negative impacts on the in-stream and riparian habitats and therefore alters the ecological characteristics which include the water quality and quantity as well as physical characteristics of the river. The riverbed, riverbanks and riparian vegetation are affected, as excavation of sand and clearing of vegetation occurs during sand mining [12]. Disturbed habitat and changes in water quality in a river negatively also influence the ecology [12].

2. MATERIALS AND METHODS

2.1 Area of Study

This study was carried out in Chokocho, Choba and Abuloma coastal communities in Etche,Obio-Akpor and Port Harcourt Local Government Areas respectively. Each area in this study was chosen because of the peculiar terrain and impact experienced by the communities affected. Fig 1 shows the map of Rivers state indicating the LGAs while Fig. 2 shows the map indicating the study areas. The GPS coordinates of the various sand mining locations in the study areas are indicated in Table 1. The meteorological conditions of the study areas display climatic characteristics that could be classified as semi-hot equatorial zone. The equatorial maritime air mass characterizes the climate with high humidity and heavy rainfalls (annual ranges between 72% - 81% and 3,000mm - 4,000mm). The climatic characteristics range from the hot equatorial forest type in the southern lowlands to the humid tropics in the Northern highlands. The wet season or rainy season are relatively long lasting between seven and eight months of the year from the months of March to October. There is usually a short break around August otherwise termed the August break. The dry season begins in late November and extends to February or early March, a period of approximately three months although the atmosphere sustains adequate moisture throughout the year [13].

Rainfall is highest in July and September, 348.1mm and 357.4mm with the highest monthly average precipitation in July and August respectively [14]. Average peak temperature is 32 degrees centigrade in core dry season of January to March and in the wet season 26 degrees centigrade in the month of July [15]. Their vegetation is of the rainforest vegetation and rich in tropical biodiversity. The vegetation is a mixture of both dense and sparse species with a mixture of grass and shrubs others include a variety of tall and big trees like Mahogany, Obeche, Afara and an abundance of palm trees and several other species of economically viable plants [16].

2.2 Sample and Sampling Procedures

In order to elicit the views from the members of the community with regard to sand mining that is taking place in their areas and how they perceive the entire operation, Questionnaires and focus group discussions were used to get general views of the local people. According to Bryman [17] the focus group method represents a form of group interview where there are several participants including the interviewer. It is a means to achieve some form of collective conscience or opinion of a group of people regarding their experiences of an issue or phenomenon under investigation. The study was concerned with ascertaining the predominant feeling of the people about the activities of sand mining since it is more likely that differences may exist as to how different groups of people perceive the activities of the mining entities. The general idea was to gauge whether or not there exists a general consensus about how the communities feel about the mining operations and how these impact their livelihoods.

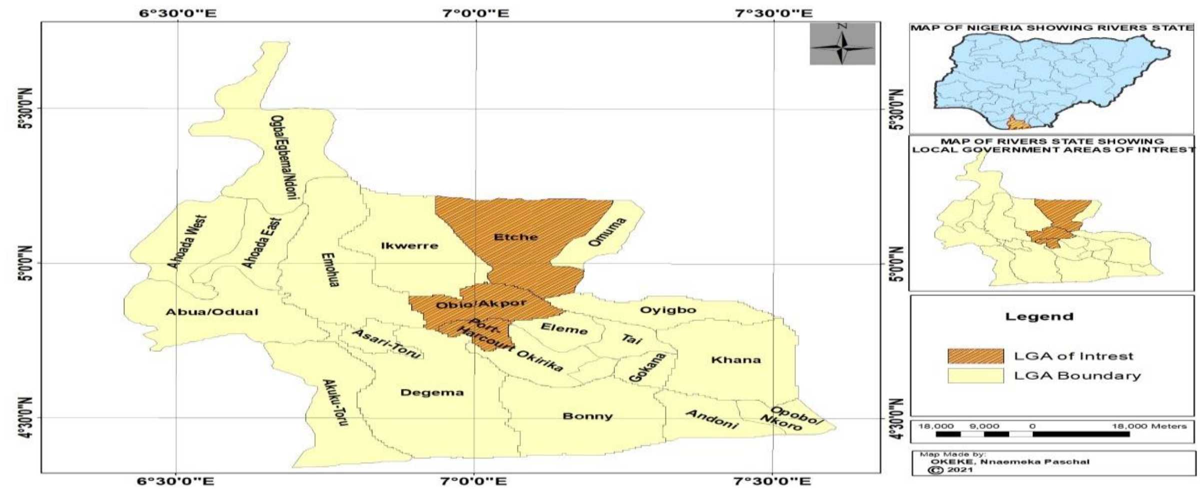

Fig. 1. Map of Rivers state showing Etche, Obio/Akpor and Okrika LGAs

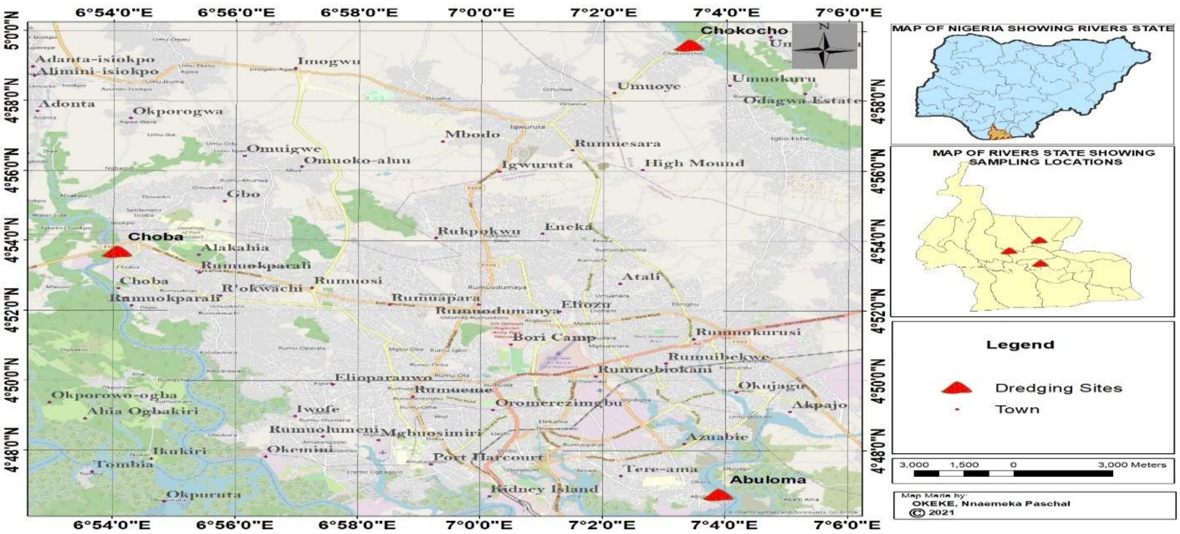

Fig. 2. Map of Rivers state showing Study Locations in the 3 LGAs

Table 1. GPS coordinates of the sand mining locations

S/N	Location	Longitude	Latitude
1	Chokocho	7° 3’14.4″	4°59’132″
2	Choba	6° 54’3.6″	4° 53’27.6″
3	Abuloma	7° 3’54″	4° 46’33.6″

Community leaders and selected indigenous people who constitute sand mining committees in communities were selected to engage in the discussion that focused on impacts, coping mechanisms and management of the impacts. It was expected that since the discussions would be engaged and that consensus was likely to be reached at the end, the final account of the impacts of the activities of the mining activities would be authentic and largely reflect the actual situation obtaining on the ground [17]. Questionnaires were also distributed to each and every individual who participated in the focus groups so as to quantify the data gathered from the focus groups. Given the fact that indigenous people tend to be suspicious of strangers who come and ask them questions about their livelihood, they may sometimes refuse to provide correct information about the questions. Questionnaire surveys were distributed as a way of substantiating the information gathered through focus group discussions as well as transect walks.

In Chokocho, Abuloma and Choba communities, 68 questionnaires each were distributed to the members of the community while 32 questionnaires were distributed to sand loaders and truck drivers. Using the Kish [18] formula $n=(Z^2pq/d^2)$ for determining adequate sample size and further correcting for population less than 10,000 using $n=N/(1+(N/n1)$ [19], a total of 300 respondents of the total population of coastal communities in a cluster was used for the study. Sampling Size for this study will be determined based on the estimation of the population. According to Mkando [20], transect walks are walks with local guides and analysts through an area, observing, asking, listening, discussing, learning about different zones, soil, land uses, vegetation, crops, livestock, local technologies, introduced technologies, seeking problems, solutions and opportunities and mapping and diagramming the zones, resources and findings. Sand miners were interviewed mainly about financial implications and mining methods. In addition, the sand loaders were requested to provide information about the amount of money charged when selling the sand to consumers.

2.3 Data Analysis Techniques

The researcher validated the data collected and ensured that data analyzed were from respondents interviewed, respondents were chosen as per the research criteria, data collection procedure was duly followed and the interviewer asked the respondents all the questions, rather than just a few.

However, Mohammed [21], affirmed that data analysis in research is the systematic application of statistical and or logical techniques to illustrate and describe, condense and recap, and evaluate data. The data was analysed using tools of descriptive statistics in the form of averages and percentages. Loss of vegetation in riparian forest and surrounding areas was assessed using change detection geospatial techniques with the aid of ArcGIS 10.3 software. Landsat and satellite imagery of the study area was acquired for the year 2003 and 2021.

3. RESULTS AND DISCUSSION

In this study, six major impacts of sand mining namely soil erosion, land depression, land alteration, loss of vegetation, noise pollution and destruction of roads were recorded in different proportions (Figs 1-3; Plates 1 - 4).

In Choba, the most conspicuous impact was soil erosion 27% (Fig. 1), while in Abuloma the impact accounted for 27% with noise pollution 33% (Fig. 2), road destruction in Choba had 26% (Fig. 3). In Chokocho respondents reported 28% loss of vegetation, while land alteration and degradation featured very low in occurrence across the study locations.

This study revealed that commercial activities along the mining sites have exploited coastal resources such as sand, indigenous forests and sea grasses indiscriminately; and the consequences are coastal erosion and indigenous vegetation loss. This could be due to

Plate 1. Heavy Erosion at Abuloma mining site.
Source: Researcher's field work (2021)

Plate 2. Heavily damaged roads at Choba mining site
Source: Researcher's field work (2021).

Plate 3. Devastated and heavily polluted land in Choba mining site.
Source: Researcher's field work (2021)

Plate 4. Abandoned mine site showing destroyed vegetaion in Chokocho mining site.
Source: Researcher's field work (2021)

the heavy vehicular traffic and lack of maintenance by miners and it accounts for these environmental concerns. The erosion caused the destruction of roads in the mining communities. The original landscape of the communities were destroyed and altered as a result of excavated pits and trenches, leaving behind unpleasant sights which renders the land unsuitable for any productive purpose [22]. During the wet season, these pits and depressions created by abandoned mine sites collect water which becomes stagnant and serves as breeding ground for mosquitoes and other water borne diseases which become a health risk to the community. Destruction of roads are mainly by heavy trucks and equipment which move in and out of the mining site. These heavy trucks cause soil compaction which increases the erodibility of the soil, reducing soil infiltration which invariably causes overland flow. Heavy vehicular traffic in the study areas have caused the destruction of access roads. In Choba, the roads are very badly damaged and often, the vehicles get stuck and damaged especially during rainy seasons, which results in seeking alternative routes to mine sites.

These impacts recorded a major environmental pollution as a major problem in sand mining communities. They usually occur in the form of land, air, noise and water pollution [23]. Noise pollution in mining sites occur from the movement of heavy trucks, tractors and other mining equipment. Sediments from mines running off into rivers and wetlands are significant sources of water pollution. Surface and ground water quality are also affected through contamination of suspended and dissolved materials. Air pollution is also one of the environmental impacts observed in the area. It results from the use of a jack hammer to facilitate drilling which aroused dust particles in the air [22; 23]. Other sources of pollution were indiscriminate waste disposal causing an environmental hazard in the villages and mine sites around coastal communities.

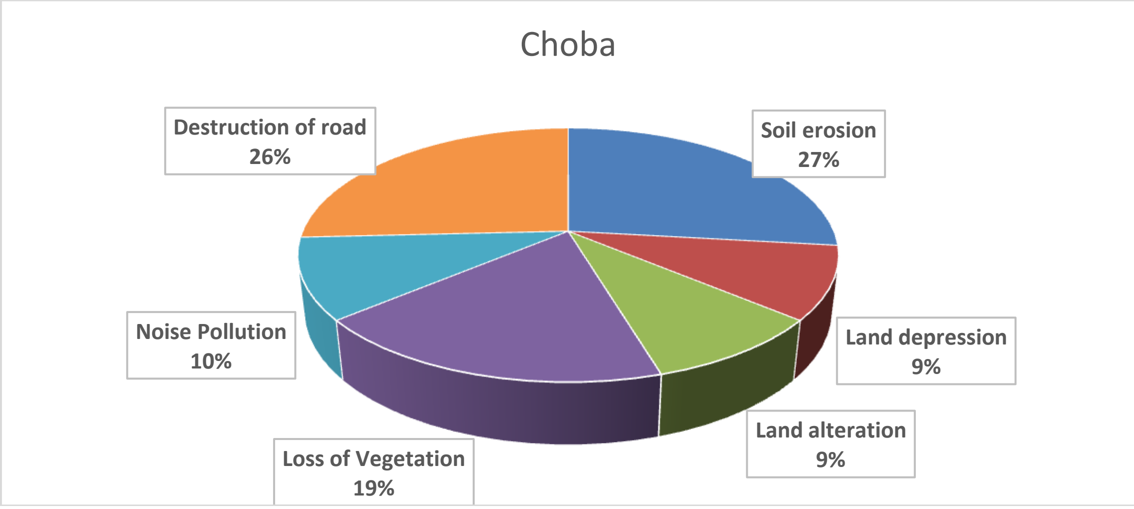

Fig. 3. Impact of Sand mining activities on the environment in Choba coastal community

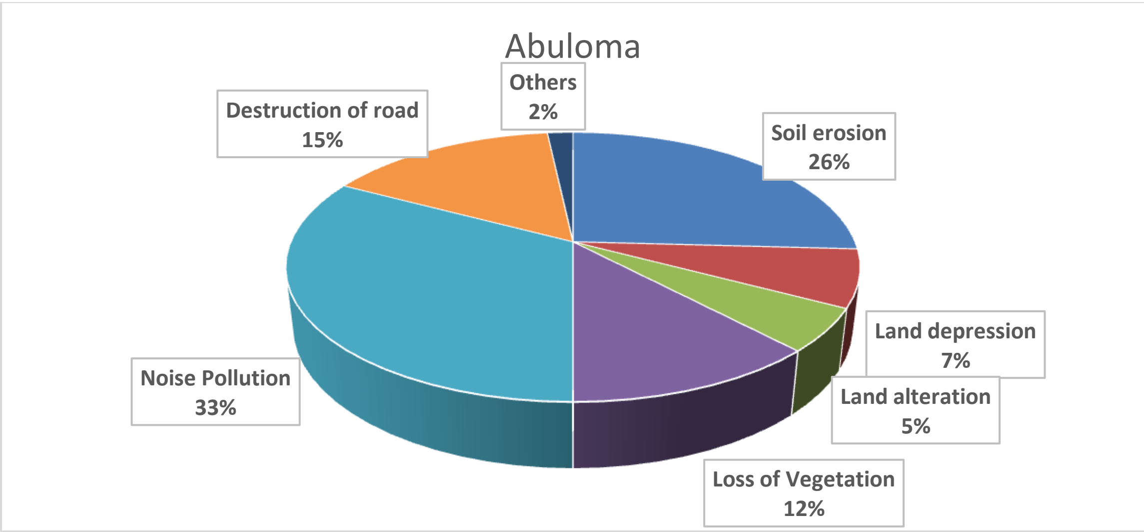

Fig. 4. Impact of Sand mining activities on the environment in Abuloma coastal community

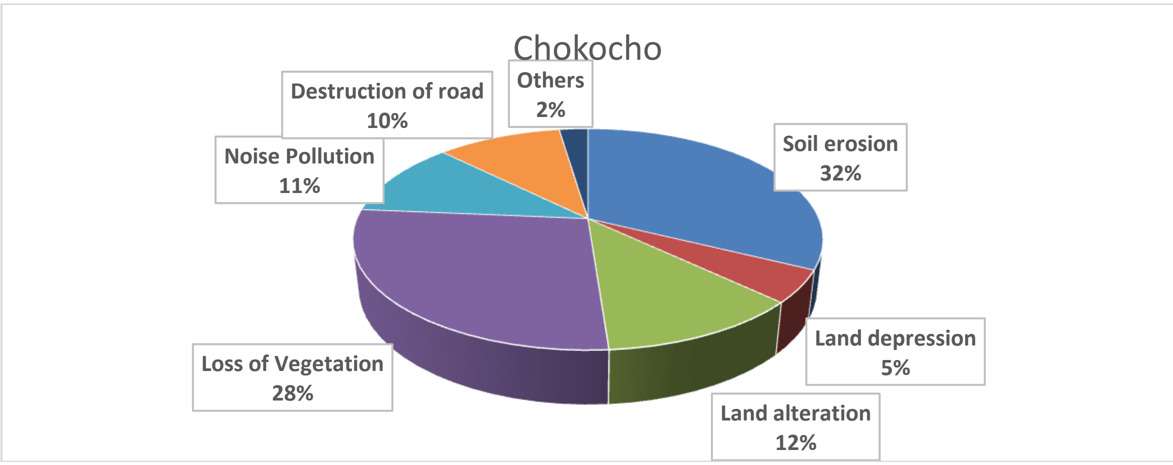

Fig. 5. Impact of Sand mining activities on the Environment in Chokocho coastal community

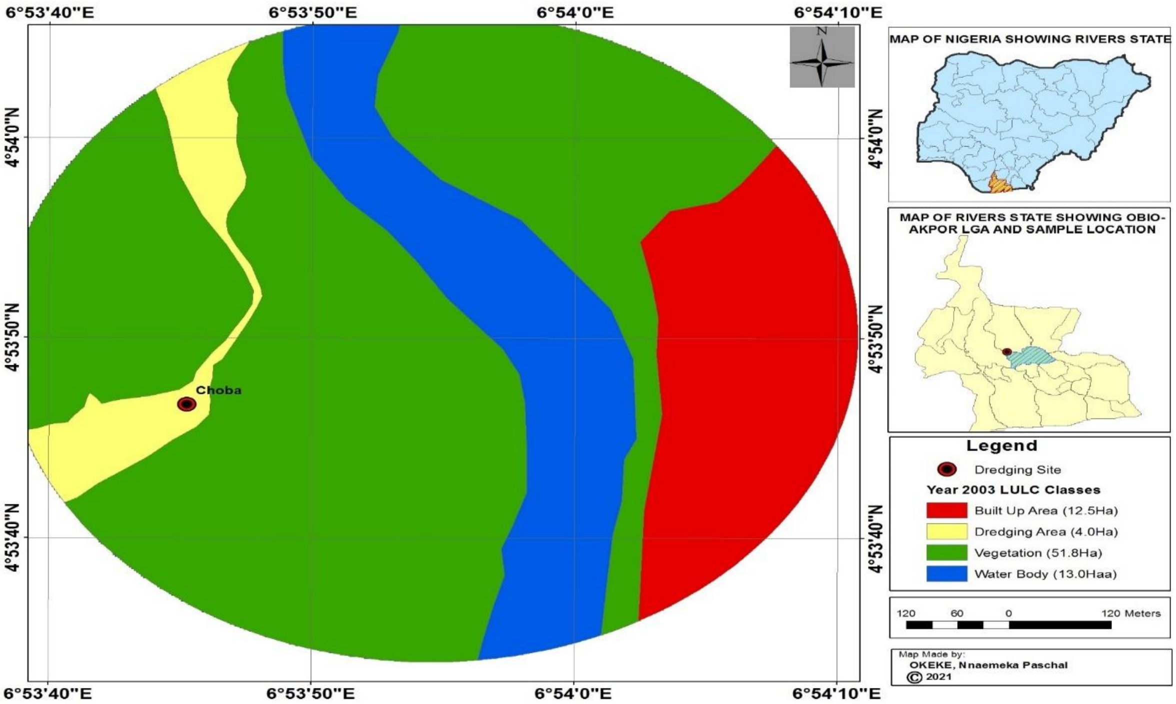

Fig. 6. Year 2003 land use/land cover map of Choba mining area

Loss of vegetation was amongst the many impacts of sand mining as evidenced in the study. This is normally associated with an increase in the human population and rapid economic development. Thousands of animals and plants are removed when vegetation is cleared. Clearing of vegetation affects species through loss of habitat. The removal of vegetation contributes to soil erosion through water and wind, and this leads to a decline in water quality. Destruction of vegetation is a serious issue given that it triggers formation of gullies as it is perceived as the major factor resulting to landslides [24]. It is noted that large scale mining activities generally continue to reduce the vegetation of most of the mining communities to levels that are dangerous to biological diversity [25]. Significant parts of the riparian vegetation have been destroyed as a result of cutting for charcoal and domestic fuels which are not related to mining. This has unsheltered most forest animals and caused them to relocate to other places [25].

Geographic information systems (GIS) plays a major role in the management of mapped or spatial data prior to, during, and after sand mining activities [26]. It can provide maps of sand mining sites showing the level of degradation and help or serve as a decision support capability [27]. GIS and remote sensing techniques have proved to be veritable tools in locating sand mining sites especially in remote areas. The techniques play important roles in monitoring and assessing the extent of damage to the environment by sand mining activities. GIS can be used to map severity of sand mining activities and plan restoration of degraded land resources. In the study, change detection of vegetation was done using GIS imagery for the sampled locations for years 2003 and 2021. High resolution imageries of the three sites were acquired for the year 2003 and 2021. The imageries were geo-referenced and orthorectified. A 500 meter buffer was established around the mining sites. The buffer was then used to clip the imageries, the clipped imageries were then vectorized. After vectorization, feature extraction was performed and all the land use/land cover (LULC) classes within each clipped imageries were extracted as map layers. The area coverage of each LULC classes was calculated in hectares. In the study, change detection of vegetation was done using GIS imagery for the sampled locations for years 2003 and 2021. The essence of this was to determine if any changes had occurred in the vegetation of the study locations. Figs. 4 and 5 showed Choba mining site land use/Land cover imagery for 2003 and 2021. The result in Choba showed that the vegetation cover which was 51.8 hectares in 2003 had reduced to 45.3 hectares in

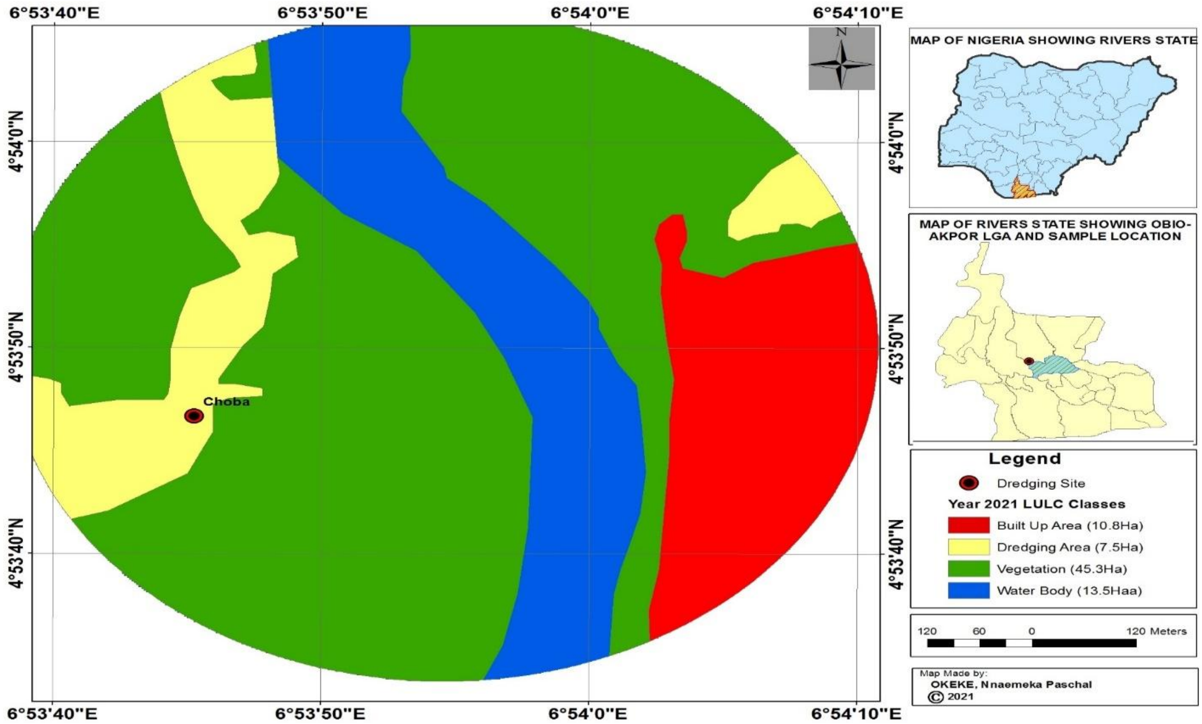

Fig. 7. Year 2021 land use/land cover map of Choba mining area

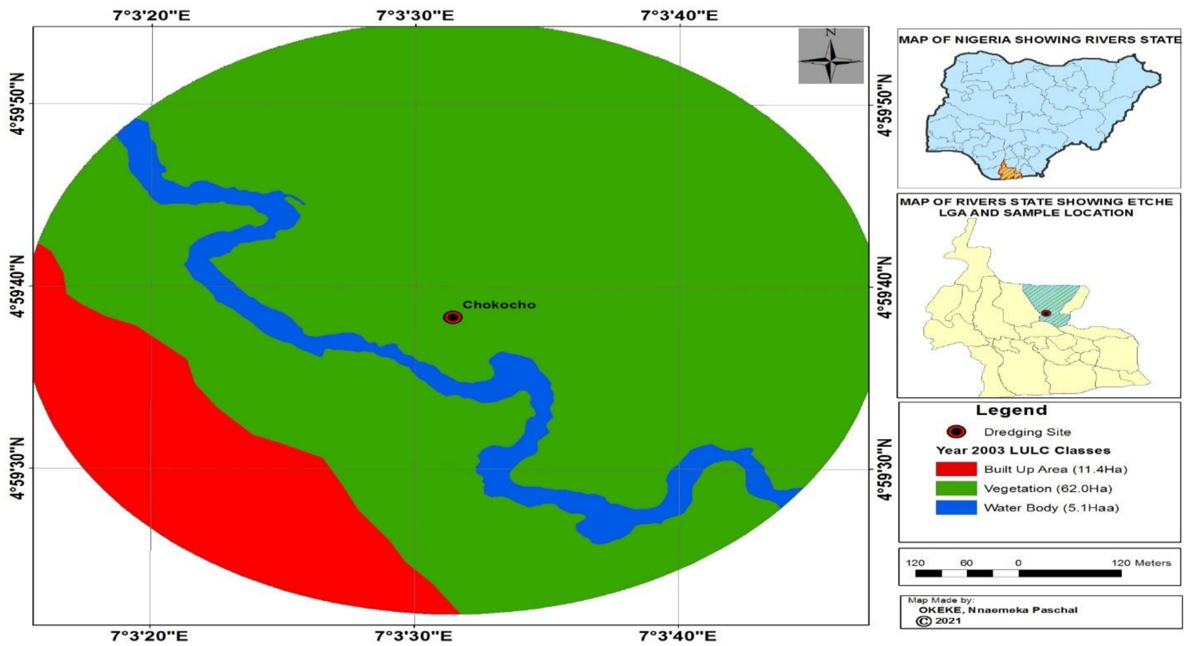

Fig. 8. Year 2003 land use/land cover map of Chokocho mining

2021(12.5%), while the dredging site in 2003 was 4.0 hectares and had increased to 7.5 hectares in 2021. Results from the imagery in Chokocho showed that as at 2003, there was no dredging activity, but by 2021, 3.2 hectares of land was used for sand mining. The vegetation cover depleted by 40% from 62.0 hectares to 37.44 hectares in 2021 (Figs. 6 and 7). In Abuloma the land use/land cover classes in 2003 showed that there was no mining activity as opposed to 2021 where extensive mining activities had commenced in the area (Figs. 8 and 9). Results show that as at 2003, the vegetation cover in the mining area was 29.9

hectares but had reduced remarkably by 2021 with only 24.0 hectares (19.7%) of land covered by vegetation. The dredging which was non-existent in 2003 had increased to 17.4 hectares of land coverage. From the results shown by the imagery, it can categorically be said that sand mining has decreased the vegetation cover in the study areas resulting in the disruption of the ecosystem balance of the area.

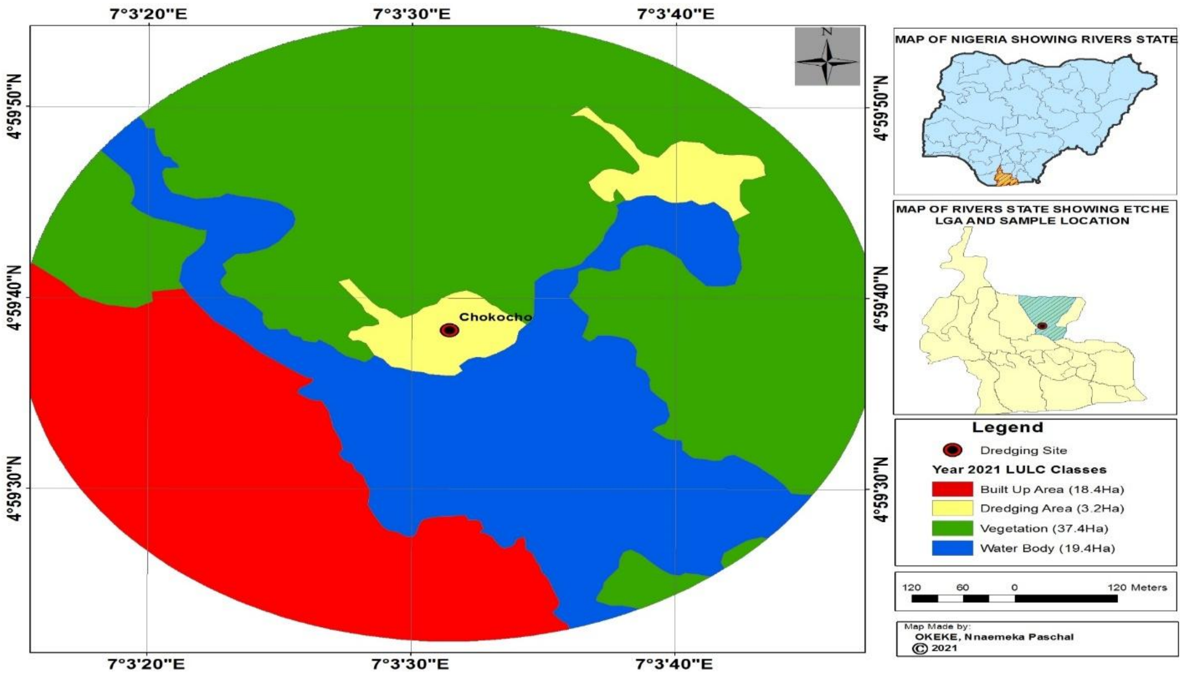

Fig. 9. Year 2021 land use/land cover map of Chokocho mining area

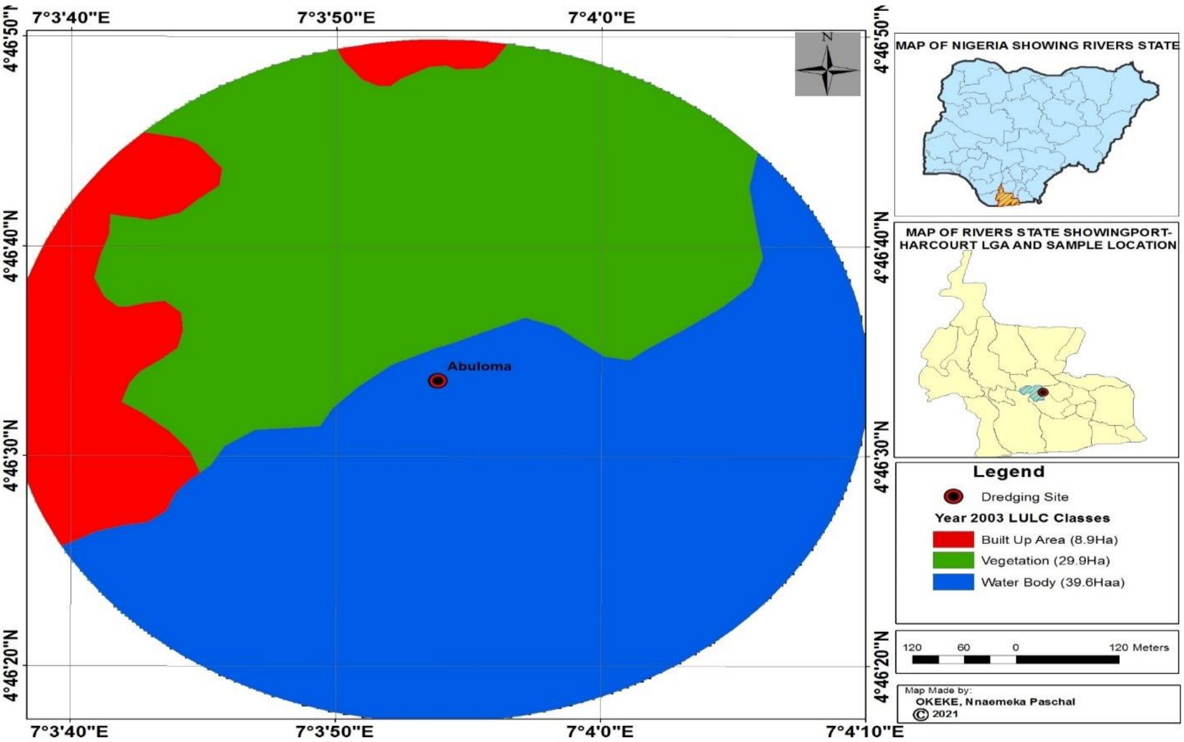

Fig. 10. Year 2003 Land use/ Land cover map of Abuloma mining area

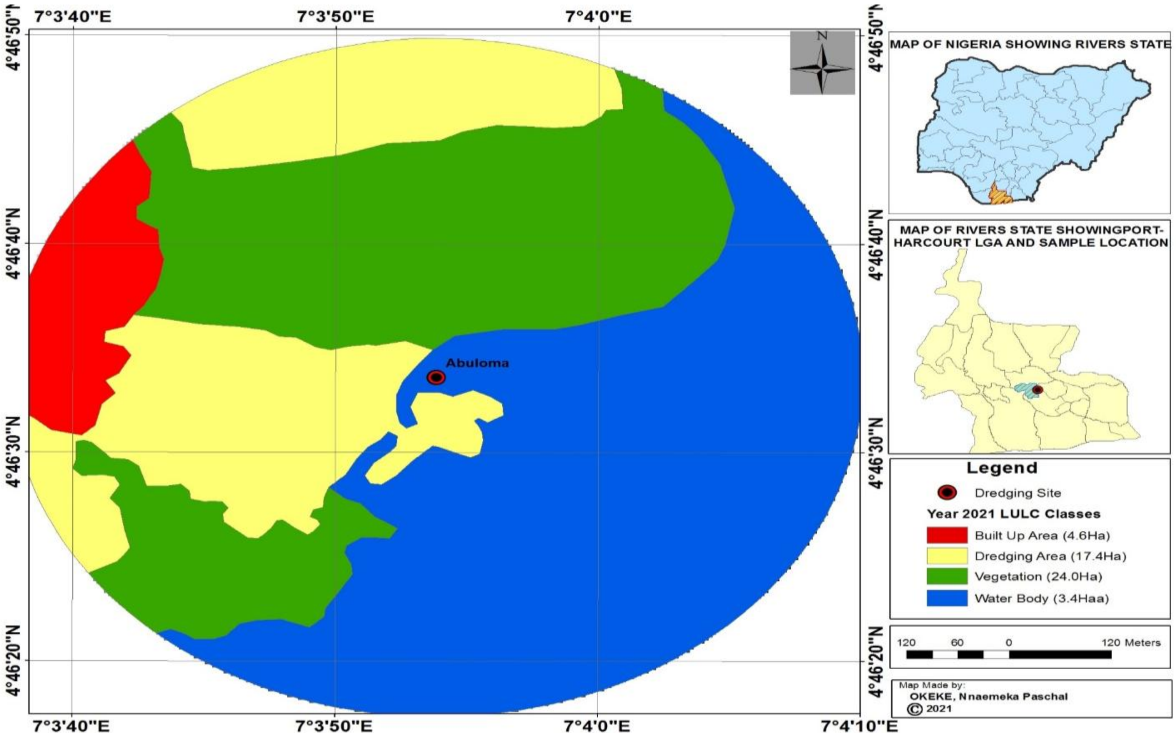

Fig. 11. Year 2021 land use/land cover map of Abuloma mining area

4. CONCLUSION AND RECOMMENDATION

The demand for uncontrolled extraction of sand for use in construction, developmental activities and for financial gains is growing at an overwhelming rate. This has resulted in multiple environmental impacts including destruction of the ecosystems, distortion of livelihood chains and loss of biodiversity in coastal communities. The study revealed six major impacts including soil erosion, land depression, land alteration, loss of vegetation, noise pollution and destruction of roads due to continuous sand mining in coastal communities. Irrespective of its economic importance, it is concluded that socially and environmentally, sand mining activity is causing more harm than good. Therefore, stakeholders should seek constant interface between themselves and the miners to keep abreast with activities and interventions where necessary and to ensure that all concerned are fairly treated. Coastal communities that host sand mining activities should encourage the establishment local monitoring teams to ensure the mining activities are performed in a sustainable manner. Government is also encouraged to establish environmental laws to oversee the activities of sand mining to prevent destruction of the ecosystem.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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