

Environmental Features and Spatial Dynamics of Sand Mining in South-Western Nigeria: Field Measurements Perspectives from Ile-Ife

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ABSTRACT

Sand is one of the most widely consumed construction materials globally, second only to water, and its extraction has become a pressing environmental concern. This study investigates environmental features and spatial dynamics of sand mining in South-western Nigeria: field measurements perspectives from Ile-Ife focusing on systematic identification, spatial mapping, and environmental characterisation of mining sites. Primary data were collected through field surveys, GPS measurements, and direct observation of land use, vegetation, and topography, while secondary data were sourced from GRID3 archives and Google Earth imagery. Twelve mining sites were identified across five major road corridors (Ilesa, Ede, Ibadan, Ondo, and Modakeke), with varying levels of activity and abandonment. Results reveal distinct differences between pit sand (coarse, red-orange deposits) and riverine sand (fine, white-grey deposits), each serving different construction purposes. Field measurements show significant expansion of pits over time, with volumes exceeding one million cubic metres in some sites, underscoring the scale of extraction. Environmental attributes around the mines include altered vegetation cover, conversion of farmland, and emerging settlement pressures. The findings highlight the spatial extent and environmental implications of sand mining in Ile-Ife, providing critical insights for sustainable resource management, land use planning, and policy interventions in Nigeria.

Keywords: Sand mining, spatial mapping, environmental attributes, topography and remote sensing

INTRODUCTION

One of the most widely used basic materials for construction is sand. It is consequently the most consumed raw material after water, (Leal, Hunt, Lingos, Platje, Vieira, Will and Gavriletea, 2021). According to the Oxford English Dictionary, sand is a substance that consists of very small fine grains of rock which are 0.06 mm to 2.00 mm in sizes (<https://www.oxfordreference.com>). It is largely a natural aggregate formed from weathering processes over a long period of time. It is usually found large deposits in deposits and mined in pits. It is abundant along most low-lying coasts and are found in many river valleys around the world. Like any other resource, sand deposits are finite and are known to have been exhausted in many parts of the world (Draggan, 2008; Beiser 2017).

Many valuable products are made from sand. For example, high-quality mortar is obtained when sand is mixed with water and cement (Barbieri, 2022). Mortar is a paste that when dry binds building blocks such as stones and sand blocks together to form units. Because the significance- of mortar in constructions, the demand for sand is ever-increasing everywhere, in the world, particularly around major urban centres where the growing population is swelling the demand for housing and other infrastructure that require mortar. For example, Lagos probably has the highest demand for sand in Nigeria, and in Africa in recent times especially with the development of the World Bank-financed Lagos Mega City project, the Eko Atlantic City and large number of residential and industrial estates development going on (Oyalowo 2022). But the demand is growing in other parts of the country as well, and open trucks move ceaselessly on urban and sub-urban roads in many parts of

Nigeria. Sand mining was hitherto not a challenge in most communities when population pressure was low. Today it is already a cause for concern

Sand mining is commonly located where large deposits are found. Unlike most other minerals, sand deposits in workable quantities can be determined by mere observation of the ground surface. However, deposits vary in volume from one location to the other and may be deeper along the lower part of slopes and in valleys. Mineral aggregates and sand are probably the most mined materials in the world, with extraction sites located virtually every city and town. Between 32 and 50 billion tonnes of aggregate (sand and gravel) are extracted globally each year (Mette et al, 2021; UNEP 2014). Due to the widespread availability of aggregate deposits, and the inexpensive methods required for extraction, transport is typically the limiting factor of use, thus requiring a large number of sources located close to markets. The objectives of this research are to systematically identify and spatially map the locations of sand mining activities within the study area and characterise the identified sand mines based on their environmental attributes and features.

Study Area

The study area is Ile-Ife region which is made up of Ife Central and Ife East Local Government Area, located in Osun east senatorial district in Osun State, South-western Nigeria (Figure 1.1). It lies between Longitude 04° 27' 09" and 04° 38' 42" E, and Latitude 007° 26' 31" and 007° 29' 50" N at 215m above the Sea Level. It is bounded by Ife South Local Government Area in the South; Atakumosa west in the East; Ede South Local Government Area in the North; and Ife North Local Government Area in the West, (Figure 1).

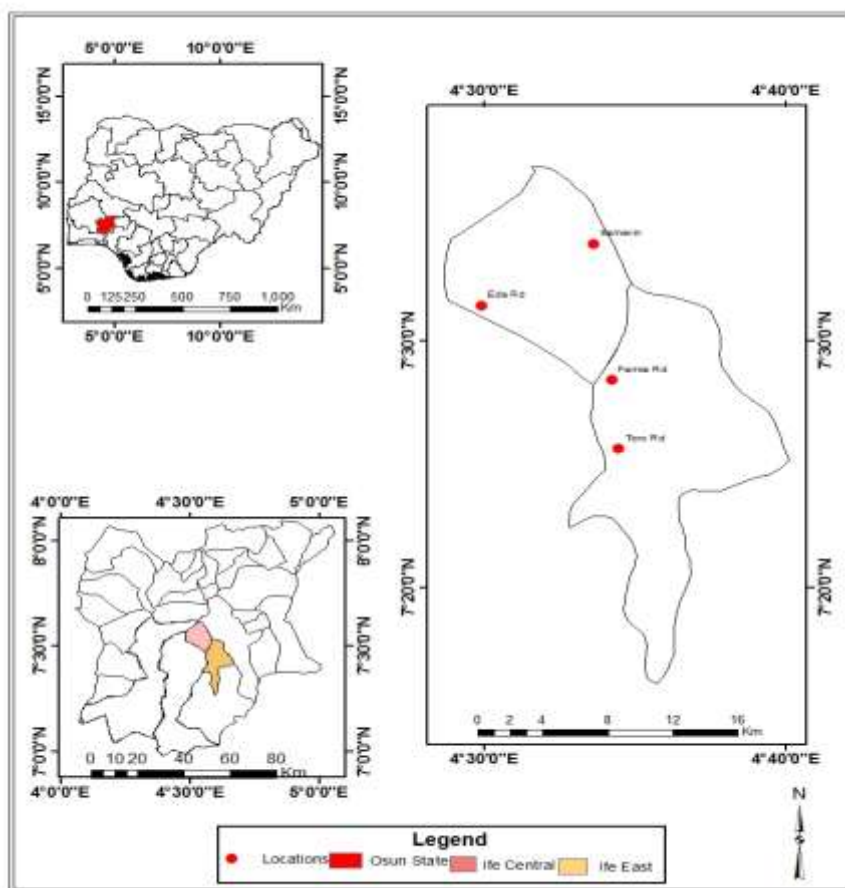


Figure 1: Study Area

METHODOLOGY

This research used primary and secondary sources of data collection. A primary source contains new pieces of information which can be turned into data sets that are not result from the interpretation or analyses of work

already done by someone else (e.g. Ajayi, 2023; Prada-Ramallal et al., 2018). They are gathered directly by a researcher for a specific set of objectives. Thus, the primary data for this study are those that were collected directly by the researchers. They were from the fieldwork carried out in the different parts of the study area. It comprises relevant geographic coordinates of the sand mines collected by hand held GPS device. The secondary data was from the archive of Geo-referenced Infrastructure and Demographic Data for Development (GRID3) for the base map and roads in the study area. Google earth map was used to validate the aerial view of the sand mines.

Locations where sand is mined were physically located, the coordinates for each of them were taken and their perimeter as well as the depths were captured. The remotes sensing data covering these sites were acquire to aid the mapping of the area. To assist image to ground concordance, five points around each sand mine were taken. These were used to estimate the average sizes of the sand mines and for classifying the Landsat imageries. Additionally, the characteristics of the features around the mines were recorded by examining vegetation characteristics, land use types as well as topography of the sites. This was done by direct field observation, measurement and recording.

On the basis of socioeconomic significance, functional level, level of environmental sensitivity, and location distribution, all the twelve (12) mining sites in Ile-Ife were chosen for this research in order to give a wholistic representation. The analysis takes into consideration local variation and allows for the comparison of ongoing mining activity impacts to residual consequences by incorporating both active and abandoned sites across various geographical locations. Additionally, topography variation allows for the assessment of geomorphological factors.

RESULTS

Systematic Identification and Spatial Mapping of the Locations of Sand Mining activities within the Study Area.

Figure 2 shows the locations of sand mining areas that were studied in the study area. Their coordinates are contained in Table 1. These are Ilesa Road, Ede Road, Ibadan Road, Ondo Road and Modakeke areas. At Ilesa Road area, there are five mining sites. Out of these, four are active i.e., they are still being regularly mined, while the fifth has been abandoned because the sand deposit has been completely exhausted and the underlying hardpan or rocky layer exposed. The active sites are labeled S1 to S4 and the abandoned, S5 in Figure 1. The sand from here is pit sand and is mined from deep trenches. The sand is coarse and is red-orange colour. Hence, it is used globally for a broad range of construction purposes such as plastering.

In other locations including Erefe in Ondo road, Molodo in Toro road, Modakeke and Awosun in Ibadan road, white sand is common. This is a type of sand with fine grains. It is formed by the corrosion from water current and is obtained from river streams and banks. It can also be found in low lying areas that experience occasional flooding by which the sand is deposited. The sand is generally white-grey. Unlike pit sand, the grains of this type of sand is smooth, rounded and of fine quality. It is usually required for a wide range of construction work including plastering.

The two mining sites in the Ede Road area, i.e., S6 and S7 in Figure 2 are already abandoned. This was also due to the fact that the sand deposit has exhausted and their apparent move to use some of the sites for other purposes such as settlement. The sand gotten from here is red-orange in colour with fairly large grains. It is in a high demand for block making and other construction works.

On the Ibadan road area which is to the Northern part of the study area, only one mine is identified and is active (S8) and it is white-grey colour type of sand. In Ondo Road and Modakeke areas two active sites re found. These are S9, S10 and S11, S12 with the same nature of sand with S8 respectively.

Comparison Between Active and Abandoned Mining Sites

The comparison of active and abandoned sand mining sites in Ile-Ife reveals that, although their mean geographic locations do not vary significantly, their geographic distribution and patterns are different (Figure 2). Active

sites are more numerous, scattered, and frequently located close to nearby communities, reflecting ongoing demand and accessibility, whereas abandoned sites are fewer and concentrated in the central zone, suggesting localised resource depletion and ecological restrictions (Awoyelu & Mebo, 2022; Balogun, Ojo, Aluko, & Alage, 2024). These findings are consistent with earlier research that highlights environmental hazards associated with unregulated sand mining, such as vegetation loss, farmland conversion, and erosion. Overall, the results underline the need for stronger zoning, reclamation initiatives, and regular monitoring to combine economic gains with sustainable land use.

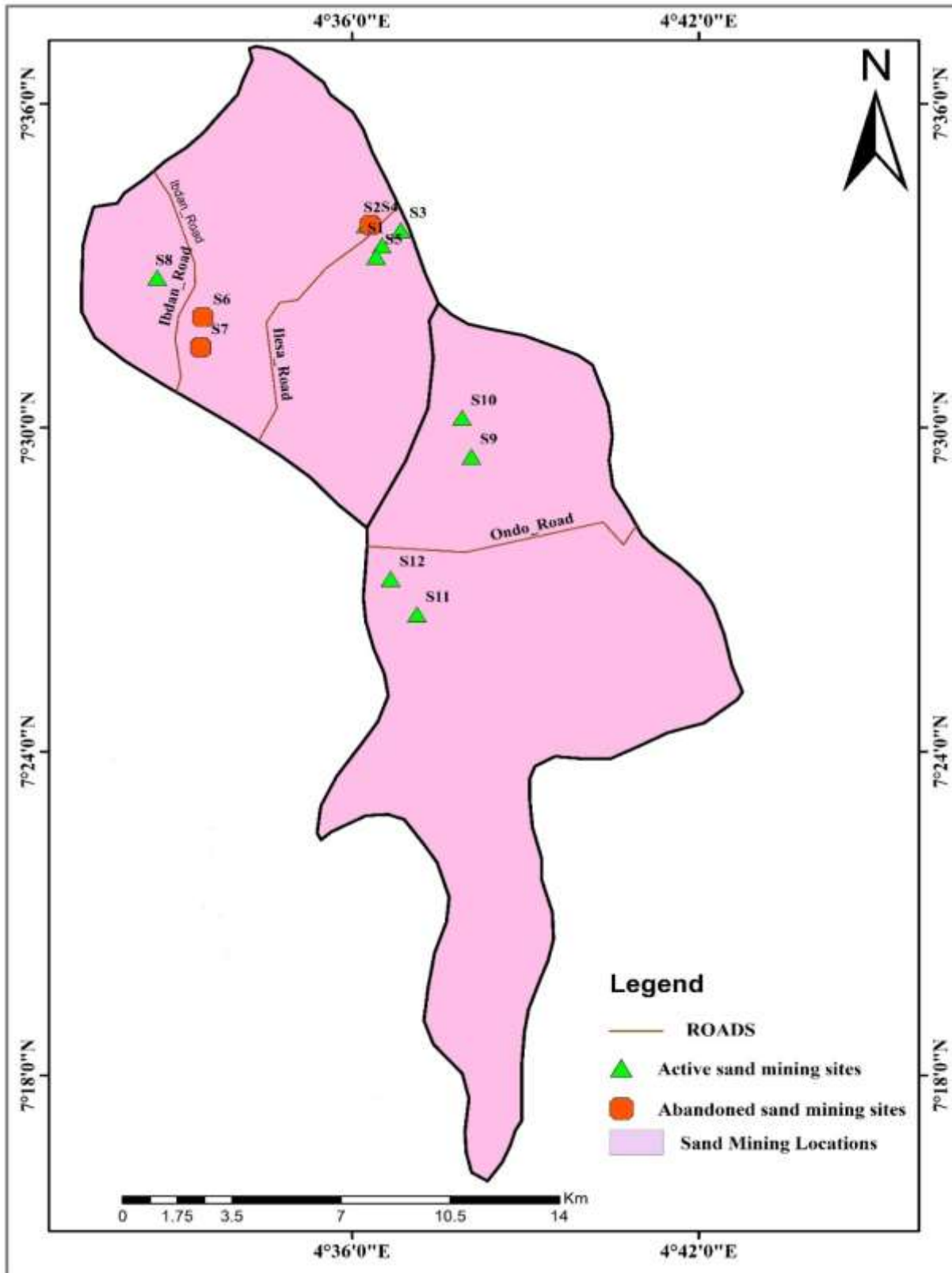


Figure 2: Sand Mining Site Locations

Table 1: Location of the sand Mining.

SN	Latitude	Longitude	Site	Status
1	7.556229	4.608604	S1	Active
2	7.562587	4.603933	S2	Active
3	7.560982	4.614072	S3	Active
4	7.562611	4.605304	S4	Abandoned
5	7.552841	4.606948	S5	Active
6	7.512893	4.49281	S6	Abandoned
7	7.509356	4.503075	S7	Abandoned
8	7.486593	4.46539	S8	Active
9	7.477	4.4947	S9	Active
10	7.442924	4.465758	S10	Active
11	7.441829	4.556465	S11	Active
12	7.39656	4.557192	S12	Active

Source: Researchers’ Field observation 2026

Statistical Test Comparing Mean Latitudes and Longitudes between Active and Abandoned Sand Mining Sites

The mean latitudes of active and abandoned sites did not differ statistically significantly ($p > 0.05$) according to a two-sample t-test, suggesting that the latitudinal ranges of both groups are generally similar (Table 2). Similarly, there was no discernible difference in longitude comparisons ($p > 0.05$). However, compared to abandoned sites (latitude range: 7.51–7.56; longitude range: 4.49–4.61), the range of coordinates shows more spatial dispersion among active sites (latitude range: 7.39–7.56; longitude range: 4.46–4.61). While abandoned sites seem more localized, the broader dispersion of active sites indicates continued exploitation across a variety of terrains.

Table 2: Statistical Comparison of Active and Abandoned Sand Mining Sites

Parameter	Active Sites (n=9)	Abandoned Sites (n=3)	t-value	p-value	95% Confidence Interval (Difference)
Latitude (°N)	7.49 ± 0.05	7.53 ± 0.03	-1.34	0.21	-0.11 to 0.03
Longitude (°E)	4.55 ± 0.05	4.54 ± 0.06	0.32	0.76	-0.06 to 0.08

Satellite Imagery Time-Series of Sand Mining Site

Figure 3 shows the spatial distribution of all the mining sites in the five different locations in the study area. This is a typical view of the various mining sites as at the time of the research and it correctly validates the fieldwork.

Serial satellite images show the extraction ditches at Site S1 for instance, expanding quickly between 2024 and 2026 (Figures 4, 5 and 6). Disturbed areas are clearly getting bigger, vegetation is gradually disappearing, and agriculture is being converted. The prolonged exposure of subsurface layers and growing vulnerability to erosion and other ecological disturbances are made clear by the imagery. In just two years, more than a million cubic meters of sand (Table 3) were extracted, highlighting the severity of mining and the unsustainable rate of resource loss. This time-series study highlights how important geospatial monitoring is for tracking environmental change and directing sustainable land-use planning.

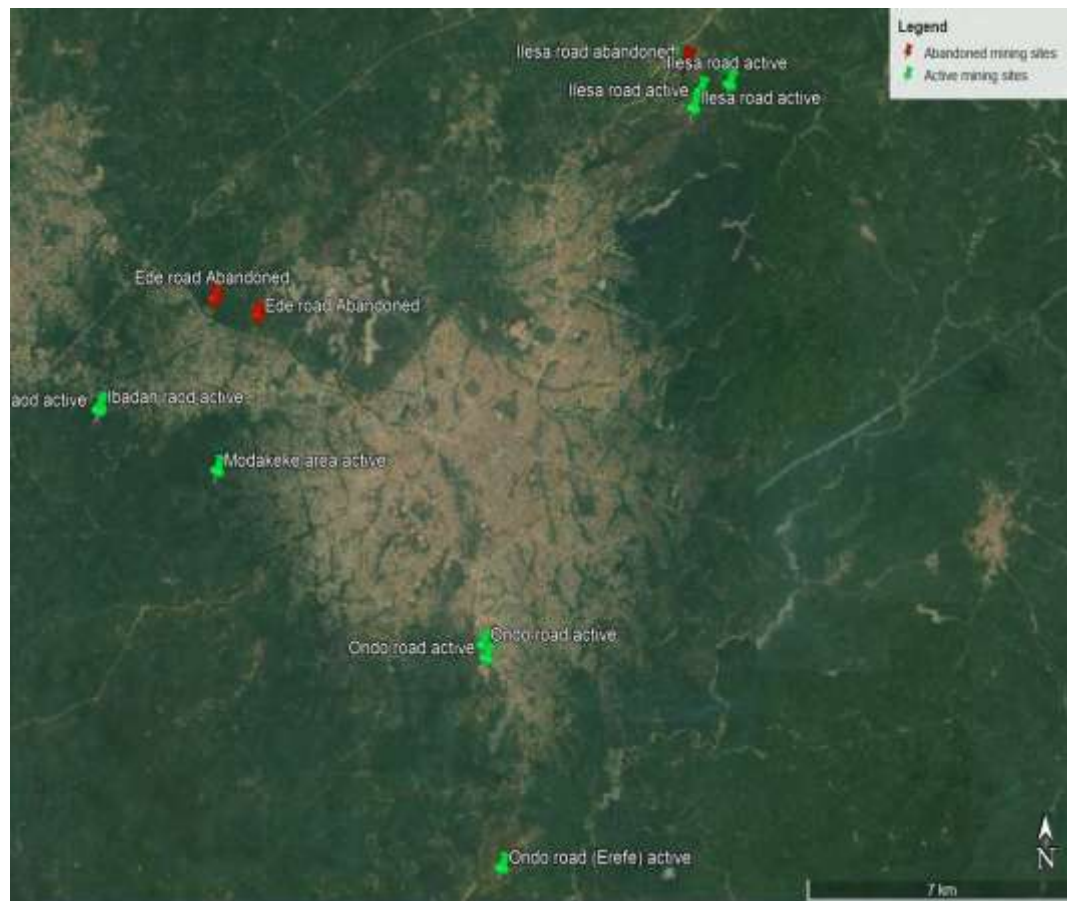


Figure 3: Spatial Extent of the Sand Mining Locations (Source: Google Earth, 2026; Fieldwork, 2026)



Figure 4: Spatial Extent of the Sand Mining Site S1 2024 (Source: Google Earth, 2026)



Figure 5: Spatial Extent of the Sand Mining Site S1 2025 (Source: Google Earth, 2026)



Figure 6: Spatial Extent of the Sand Mining Site S1 2026 (Source: Google Earth, 2026)

Characterising the Identified Sand Mines based on their Environmental Attributes and Features.

The sand mining sites were visited, sampled and the researchers and team members recorded observations within three visits. The first visit was in the month of January 2024, a year after there was another visitation to the sites and the last one was in March 2026. For all the mining locations, (Ilesa road, Ede road, Ibadan road, Ondo road and Modakeke area) twelve mining sites were visited as S1 to S12. Measurements in Table 3 shown that the length, width and depth of S1-S12 pits. During the first site visitation at S1 for instance, 390m was recorded as the length and this increased to 542.6m in three (3) visits, while the width of the pit increased from 200m to 300m and the depth from 5.9m to 10m. The estimated volume of sand mined from the site considering the measurements obtained in the first visit was 4500,000 cubic metres. This increased to 1,627,800 cubic metres by the third visit, showing that an approximate 1,627,800 cubic metres of sand had been removed from the site. Results showed that mining was still going on though.

Table 3: Field measurement from Site S1-S12

Location	Ilesa Road					Ede Road		Ibadan Road	Modakeke		Ondo Road	
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Length	390	322	305	245	190	826	300	410.78	765.2	670	225	379
Width	200	220	120	75	105	105	25.5	45.9	56	95	89	12.5
Depth(m)	5.9	4.8	3.5	1.25	12.5	10.5	5	4.6	6.75	12.5	1.25	11
Area (m ²)	78,000	70,840	36,600	18,375	19,950	86,730	7,650	18,854.8	42,851.2	63,650	20,025	4,737.5
Volume(m ³)	450,000	340,032	126,000	22,968.75	249,375	910,665	38,250	86,732.08	289,245.25	795,625	25,031.25	52,112.5
Miner/Truck present	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Used as Waste Dump?	No	No	No	yes	No	yes	yes	No	No	No	No	No
Vegetation Cover	Yes	Yes	Yes	No	No	No	No	Yes	No	No	No	No
Sand Type	Coarse sand and is red-orange colour	Coarse sand and is red-orange colour	Coarse sand and is red-orange colour	Coarse sand and is red-orange colour	Coarse sand and is red-orange colour	white sand and fine grains	white sand and fine grains	white sand and fine grains	white sand and fine grains	white sand and fine grains	white sand and fine grains	white sand and fine grains
Dominant Landuse around the mine	Arable farming	Arable farming	Arable farming	Arable farming	Arable farming	Light vegetation and Tick plantation	Light vegetation	Cash crop farming	Light forest	Light forest	Farming and settlement	Grazing land and fish farming
Mining is active, Partial, or closed	Active	Partial	Partial	Closed	Active	Active	Partial	Closed	Active	Active	Active	Active

Source: Researchers Field Observation and Measurements 2024, 2025 and 2026.

DISCUSSION

Twelve sand mining locations, representing both active and abandoned sites, were found throughout Ile-Ife. In line with earlier research showing that urban demand drives sand mining, their spatial arrangement along important road corridors emphasizes accessibility and closeness to construction markets (Awoyelu & Mebo, 2022). The unsustainable rate of resource depletion and related land degradation is demonstrated by the quick growth of pits, especially at site S1 where more than one million cubic meters of sand were mined in just two years (Balogun et al, 2024). The ecological damage documented in previous studies is confirmed by environmental observations, such as plant loss, cropland conversion, and erosion-prone abandoned areas (Balogun et al, 2024).

The lack of control and remediation efforts puts agriculture, biodiversity, and long-term land-use sustainability at serious risk, even if sand mining is still commercially important. These results highlight the critical need for

more stringent zoning regulations, reclamation initiatives, and ongoing oversight to strike a balance between environmental protection and economic development.

CONCLUSION

This research systematically mapped and characterised sand mining sites in Ile-Ife, South-western Nigeria, revealing twelve locations with distinct environmental attributes. The results demonstrate that sand mining is extensive, with significant extraction volumes and observable impacts on vegetation, land use, and soil integrity. The study underscores the urgent need for sustainable management strategies to balance economic demand with ecological preservation.

By integrating geospatial tools with field observations, the research provides a replicable framework for monitoring sand mining activities in other regions. Ultimately, while sand remains indispensable for construction and development, unchecked extraction poses serious risks to environmental integrity and community livelihoods. Sustainable policies and practices are therefore essential to safeguard both resources and ecosystems.

Nevertheless, there are some limitations to this study. It did not include measures of water quality, air quality, or biodiversity impacts, despite methodically mapping and characterizing sand mining locations. Given that mining operations frequently impact river systems, contribute to dust emissions, and disturb local plant and animal life, these features are essential for a comprehensive knowledge of the ecological effects of sand mining (Draggan, 2008; UNEP, 2014). The environmental implications discussed here are incomplete and may understate the wider ecological impact of sand extraction due to the lack of such data. In order to provide a more thorough assessment of the sustainability of sand mining, future research should incorporate hydrological, atmospheric, and biological assessments.

RECOMMENDATIONS

The findings of this study point to the urgent need for a more sustainable approach to sand mining in Ile-Ife and similar regions. Government agencies should strengthen regulatory oversight by introducing clear guidelines on licensing, monitoring, and enforcement to ensure that extraction rates remain within environmentally safe limits. Abandoned mining sites must not be left unattended; instead, they should be rehabilitated through reforestation, soil stabilization, or conversion into productive land uses such as agriculture or settlement.

Local communities should be actively engaged in monitoring mining activities, as their livelihoods are directly affected by land degradation and resource depletion. Community participation will also foster accountability and encourage miners to adopt practices that minimize ecological damage. Furthermore, the adoption of sustainable extraction techniques, including controlled removal of sand and the exploration of alternative construction materials, will help reduce pressure on natural deposits.

The integration of geospatial technologies such as GIS and remote sensing into routine monitoring is essential for tracking changes in mining sites over time. This will provide accurate data for policymakers and planners, enabling them to make informed decisions about land use and resource management. Finally, sand mining policies should be aligned with broader sustainable development goals, ensuring that economic growth does not come at the expense of environmental integrity and community well-being.

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