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Geospatial Identification of Sand Mining Sites and Assessment of Land Cover Change Along the New Calabar River, Rivers State, Nigeria (1986–2022)

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***Abstract*—Sand mining along Nigeria's riverine systems continues to expand in response to rising construction demand, yet the spatial footprint of extraction and its cumulative effect on land cover are rarely quantified at the local channel scale. This paper draws on a broader dissertation study of anthropogenic change along the New Calabar River to address two of its objectives: (i) identifying and mapping the locations of sand mining activity along the river channel from Omuechi in Ikwerre Local Government Area (LGA) through Iwofe in Obio-Akpor LGA, and (ii) analysing the extent of land cover change across the same corridor as a consequence of that mining. Ground positions of active mining locations were captured with handheld GPS and mapped in a GIS environment, while Landsat TM imagery (30 m resolution) for 1986, 2006 and 2022 was geo-referenced and classified using a supervised maximum likelihood classifier to derive six land cover classes. The spatial mapping showed a marked concentration of mining sites in the northern reach of the study corridor, with the swampier and less accessible southern reach far less affected. Land cover analysis showed primary forest falling from 61.2% of the study area in 1986 to 16.2% by 2022, while built-up area rose from 10.1% to 49.6% over the same period, with the sharpest transitions recorded within a 1000 m buffer of active mining points. The findings confirm that sand mining is a measurable driver of forest loss and urban encroachment along the New Calabar River and support the case for zoned mining licences, buffer protection and routine remote-sensing based monitoring.**

***Index Terms*—sand mining; land cover change; GIS; remote sensing; New Calabar River; Niger Delta**

I. INTRODUCTION

Sand and gravel remain the material basis of the construction industry, underpinning the buildings, roads and other infrastructure on which urban expansion depends. The extraction of this material from river channels, however, carries well-documented geomorphic costs, including channel incision, bank destabilisation and the disruption of riparian and aquatic habitat. Along Nigeria's Niger Delta waterways, informal and semi-formal dredging has intensified over the last three decades in step with the construction boom in Port Harcourt and its satellite towns, and the New Calabar River — which threads through Ikwerre, Emuoha, Obio-Akpor, Asari-Toru and Degema Local Government Areas of Rivers State — has become one of the more heavily mined channels in the region.

Despite the visibility of dredging activity along the river, there remains a shortage of quantitative, site-specific evidence linking the locations of extraction to the pattern and pace of land cover change around them. Anecdotal reports of bank erosion, turbidity and vegetation loss are common, but without georeferenced mapping of mining locations and multi-temporal classification of the surrounding land cover, regulators lack the evidence base needed to zone mining activity, enforce buffer protections, or plan restoration. This paper responds to that gap by isolating two of the four objectives pursued in the parent dissertation study: mapping where sand mining occurs along the New Calabar River channel, and quantifying how land cover in the surrounding corridor has changed between 1986 and 2022 as a result.

Specifically, the study set out to:

i. identify and map the locations of sand mining along the New Calabar River channel from Omuechi in Ikwerre LGA through Iwofe in Obio-Akpor LGA; and

ii. analyse the extent of land cover change across the study corridor as a consequence of that sand mining.

II. STUDY AREA

The study corridor lies along the New Calabar River between Omuechi in Ikwerre LGA and Iwofe in Obio-Akpor LGA, Rivers State, Nigeria, spanning approximately longitudes 6°50′E to 7°30′E and latitudes 4°45′N to 5°00′N. Drainage across the corridor empties into the Atlantic Ocean, with lowland elevations generally below 30 m, an alluvial sedimentary basement, and soils dominated by tertiary sandy and clayey deposits that are, in places, over 100 m thick. The area experiences a humid tropical climate with high rainfall and temperatures that promote rapid chemical weathering. Riverbank communities within the corridor — including Omuechi, Omuoko, Adanta Isiokpo, Ogbodo Isiokpo, Choba, Ogbogoro, Mgbuodoha, Ozuoba, Rumumalogo, Ogbakiri, Iwofe, Elioparanwo and Rumuparali — together host a resident population exceeding 200,000 persons, most engaged in fishing, farming and small-scale trade, alongside a growing sand-mining economy.

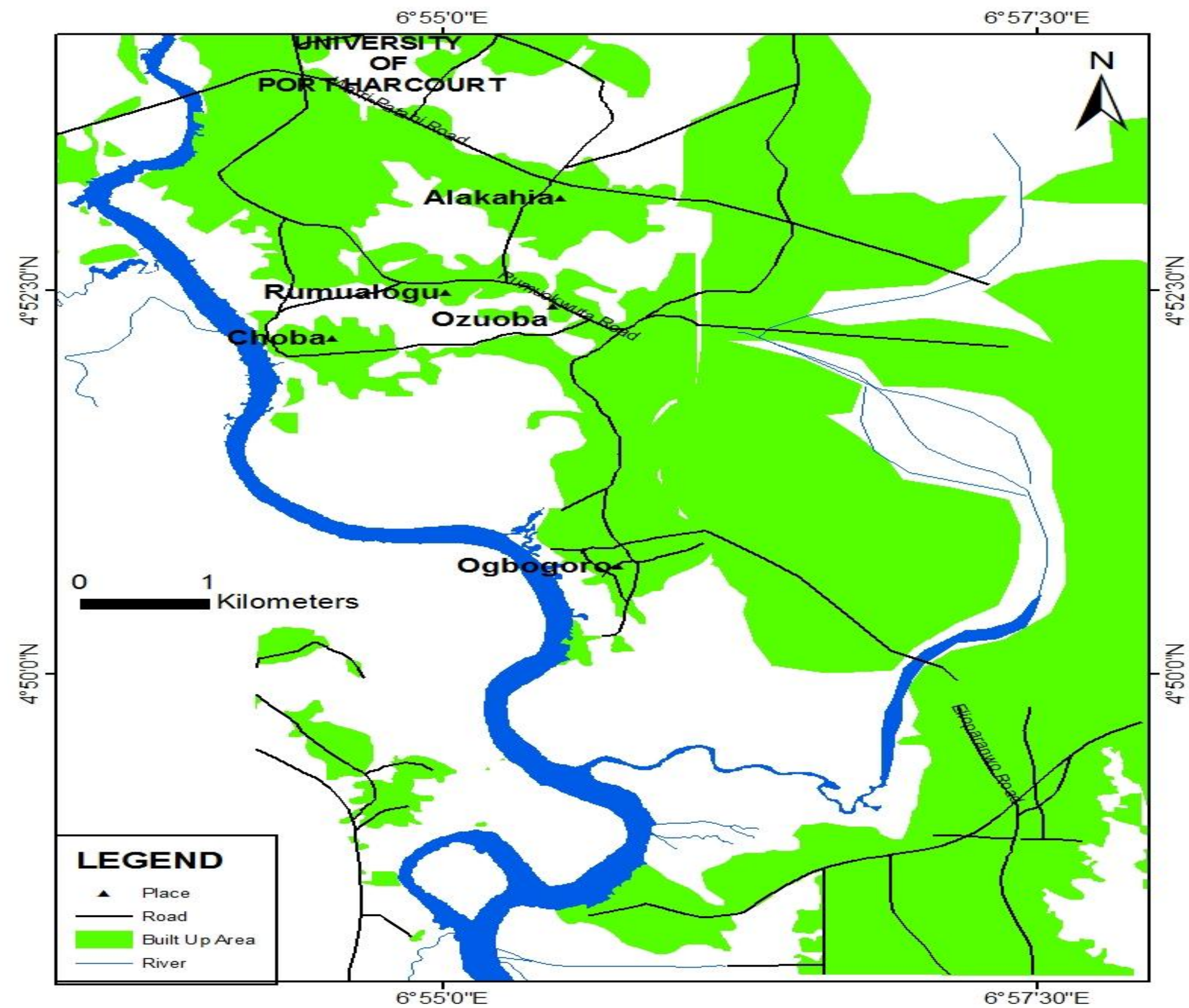

Figure 1: Study Area Showing the New Calabar River Corridor

Source: Base map, Rivers State Ministry of Lands and Survey, adapted by authors, 2026

III. MATERIALS AND METHODS

3.1 Research Design

The study adopted a quantitative, longitudinal (time-series) design, comparing conditions across three reference years — 1986, 2006 and 2022 — to capture the cumulative and cause-effect character of change along the river corridor over an extended period. A longitudinal design was preferred because bank and land cover modification driven by sand dredging accrues gradually and is best understood through repeated observation rather than a single cross-section in time.

3.2 Mapping of Sand Mining Locations

The location of active mining points along the river was established using a handheld Global Positioning System (GPS) receiver, which recorded the x, y and z coordinates of each identifiable mining site during field visits along the corridor. Simple, stable landmarks — road crossings, bridge ends and building corners — were used as reference points to support consistent positioning. The resulting point data were imported into an Esri ArcGIS environment (ArcGIS 9.3/10.2) and overlaid on a georeferenced base map of the study area sourced from the Rivers State Ministry of Lands and Survey, producing a corridor-wide map of mining locations.

3.3 Satellite Data and Geo-referencing

Landsat Thematic Mapper (TM) imagery at 30 m × 30 m spatial resolution for 1986, 2006 and 2022 was acquired to support land cover analysis. Each scene was geo-referenced in ArcGIS using ground control points collected in the field, following standard procedures for preparing multi-date imagery for change detection (Tardie & Congalton, 2001). Red, green and blue bands were composited in ERDAS IMAGINE to generate false-colour composites that improved visual discrimination between land cover types.

3.4 Image Classification and Change Detection

Land cover was extracted from each scene using supervised classification with the Maximum Likelihood Classification (MLC) algorithm, which assigns each pixel to the land cover class with the highest statistical likelihood based on training samples of known identity (Jensen, 2005; Campbell, 2002). Six land cover classes were defined for the study: water bodies, built-up area, bare surfaces, swamp forest, primary forest and secondary forest. Post-classification comparison was then used to detect change between successive dates (Eastman & McKendry, 1991), and river bank lines were digitised from each classified image and overlaid across years to visualise the corridor's changing footprint.

3.5 Buffer Zone Analysis

To isolate the influence of mining activity specifically, a 1000 m radial buffer was generated in ArcGIS around each mapped mining location, and the land cover composition within each buffer was tabulated separately for 1986, 2006 and 2022. This buffer-scale analysis complements the corridor-wide land cover statistics by showing how change is concentrated in the immediate vicinity of extraction points.

3.6 Method of Data Analysis

Land cover area and percentage cover were computed for each class and year, and percentage change was derived between successive dates (1986–2006 and 2006–2022) and across the full study period. Trends were summarised descriptively using tables and charts to characterise the direction and magnitude of change across the corridor and within mining buffers.

IV. RESULTS

4.1 Spatial Distribution of Sand Mining Locations

GPS-based mapping of active dredging points showed a distinct spatial imbalance along the New Calabar River corridor: mining locations were heavily concentrated in the northern reach of the study area, close to communities such as Choba, Ogbogoro, Ogbakiri, Emohua and Aluu, while the southern reach — nearer Iwofe — recorded markedly fewer sites. This pattern is consistent with differences in accessibility: the southern section of the corridor is dominated by swamp terrain that constrains vehicular and equipment access, whereas the northern reach offers firmer ground and closer road connections that make extraction and haulage more viable.

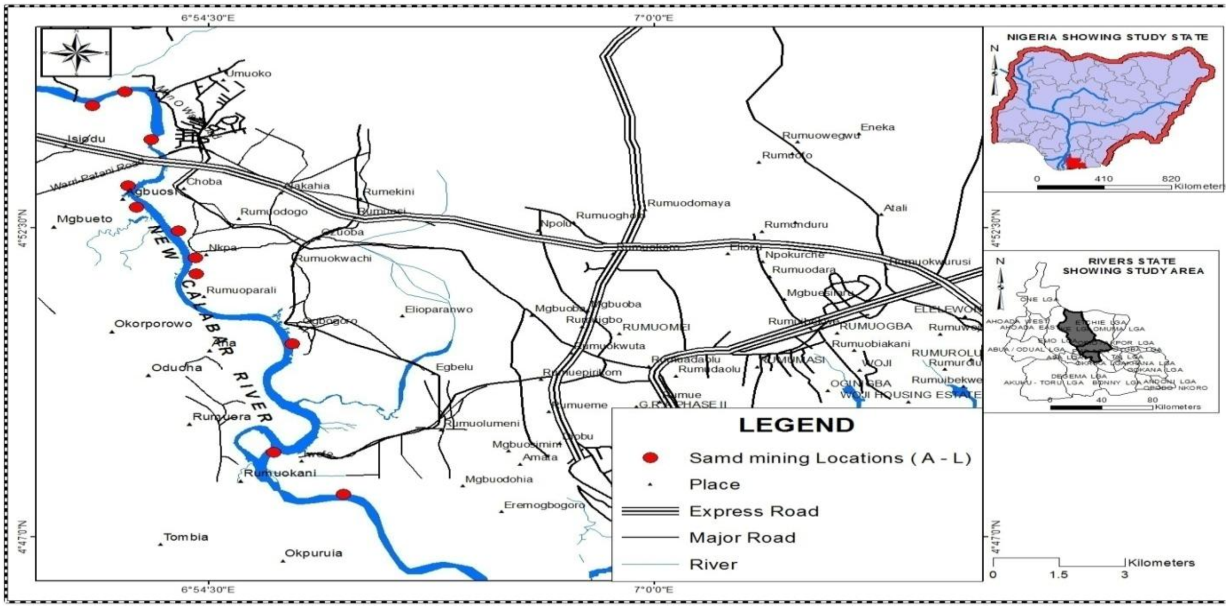

Figure 2: Mapped Sand Mining Locations Along the New Calabar River
Source: Field GPS survey and GIS mapping by authors, 2026

4.2 Land Cover Change Across the Study Corridor, 1986–2022

Baseline classification in 1986 showed the New Calabar River corridor still dominated by natural vegetation, with primary forest alone accounting for 61.2% of the study area (Table 1). Built-up area and bare surfaces were confined to scattered pockets around existing settlements.

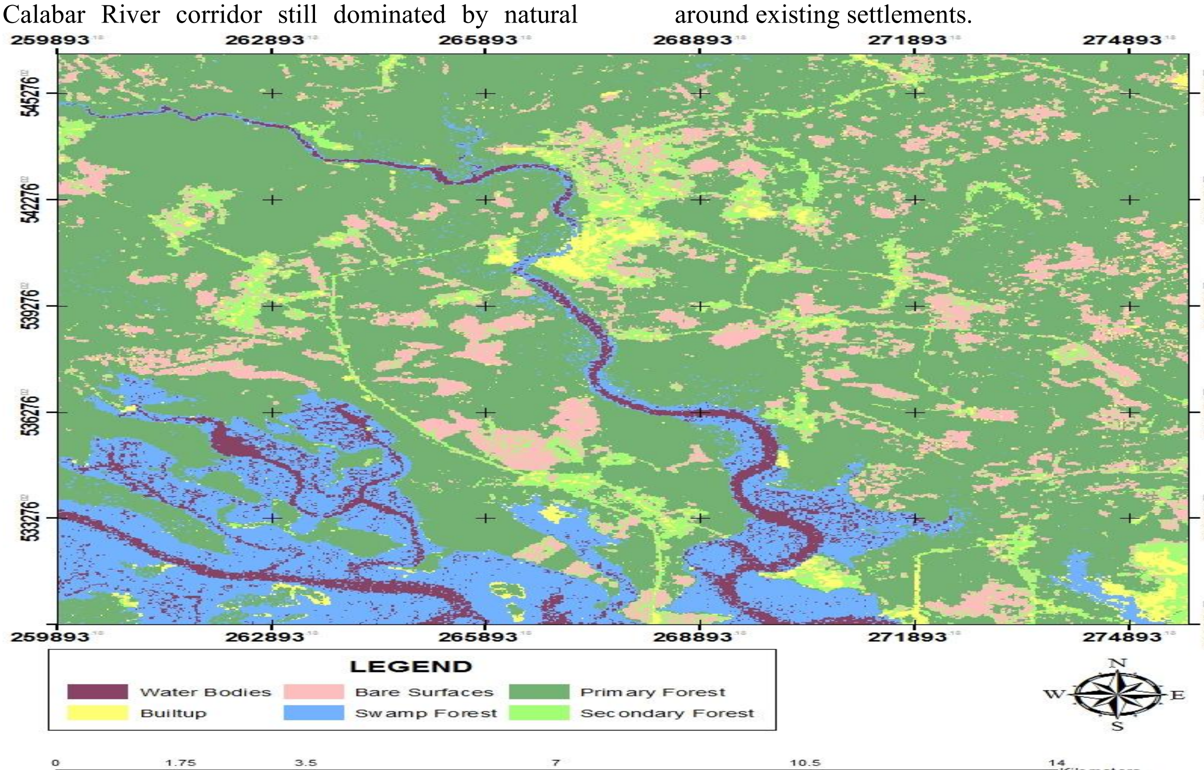

Figure 3: Classified Land Cover of the Study Area, 1986
Source: Classified Landsat TM imagery, authors' analysis, 2026

Table 1: Land Cover Classification and Percentage Cover, 1986

Land Cover Class	Area (sq. km)	Percentage Cover (%)
Water Bodies	1,315,441	3.8
Built-up Area	3,450,606	10.1
Bare Surfaces	1,411,563	4.1
Swamp Forest	3,477,054	10.2
Primary Forest	20,930,532	61.2
Secondary Forest	3,618,234	10.6
Total	34,203,430	100.0

Source: Field and satellite image analysis, 2026

By 2006, the corridor had shifted markedly toward a human-modified state. Built-up area nearly tripled to 30.4% of the corridor, while primary forest fell to 29.9% and swamp forest contracted to just 3.3%, with bare surfaces disappearing entirely as they were absorbed into either built-up or vegetated classes (Table 2).

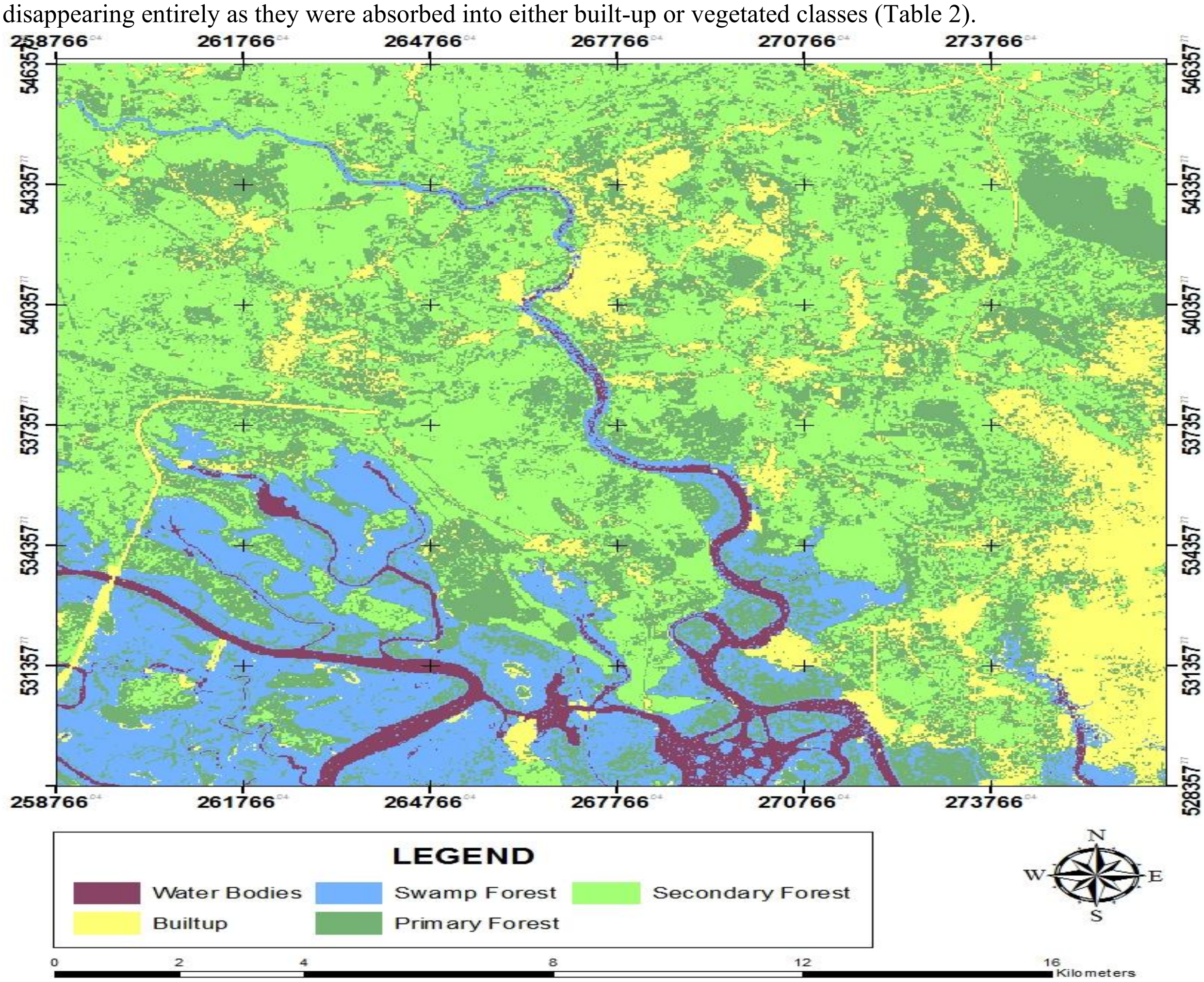

Figure 4: Classified Land Cover of the Study Area, 2006

Source: Classified Landsat TM imagery, authors' analysis, 2026

Table 2: Land Cover Classification and Direction of Change, 1986–2006

Land Cover Class	1986 (sq. km)	1986 (%)	2006 (sq. km)	2006 (%)	Change (%)
Water Bodies	1,315,441	3.8	1,143,260	3.3	-13.0
Built-up Area	3,450,606	10.1	10,394,046	30.4	+201.0
Bare Surfaces	1,411,563	4.1	0	0.0	-100.0
Swamp Forest	3,477,054	10.2	1,120,969	3.3	-67.0
Primary Forest	20,930,532	61.2	10,231,354	29.9	-51.0
Secondary Forest	3,618,234	10.6	11,313,801	33.1	+213.0

Source: Field and satellite image analysis, 2026

By 2022, built-up area had become the single most dominant land cover class in the corridor, accounting for 49.6% of the area, while primary forest had fallen further to 16.2% and swamp forest had almost disappeared at 0.2% (Table 3). Water bodies expanded moderately, reflecting channel widening in previously mined reaches.

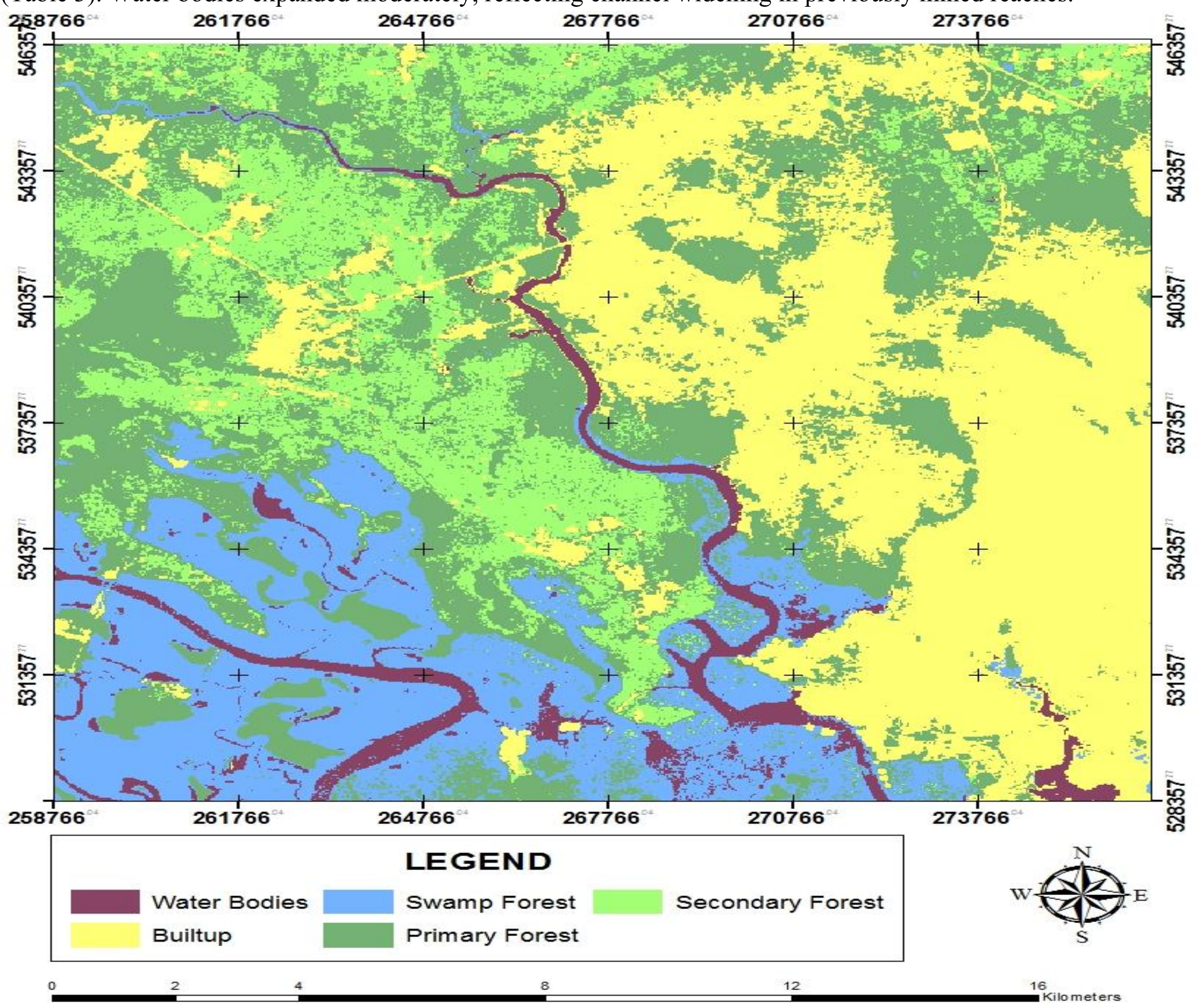

Figure 5: Classified Land Cover of the Study Area, 2022

Source: Classified Landsat TM imagery, authors' analysis, 2026

Table 3: Land Cover Classification and Direction of Change, 2006–2022

Land Cover Class	2006 (%)	2022 (sq. km)	2022 (%)	Change 2006–2022 (%)	Change 1986–2022 (%)
Water Bodies	3.3	2,200,950	6.4	+92.5	+67.4
Built-up Area	30.4	16,966,860	49.6	+63.2	+391.1
Bare Surfaces	0.0	0	0.0	0.0	-100.0
Swamp Forest	3.3	51,336	0.2	-95.4	-98.5
Primary Forest	29.9	5,536,299	16.2	-45.8	-73.5
Secondary Forest	33.1	9,447,985	27.6	-16.4	+161.2

Source: Field and satellite image analysis, 2026

4.3 Land Cover Dynamics Within 1000 m Sand Mining Buffer Zones

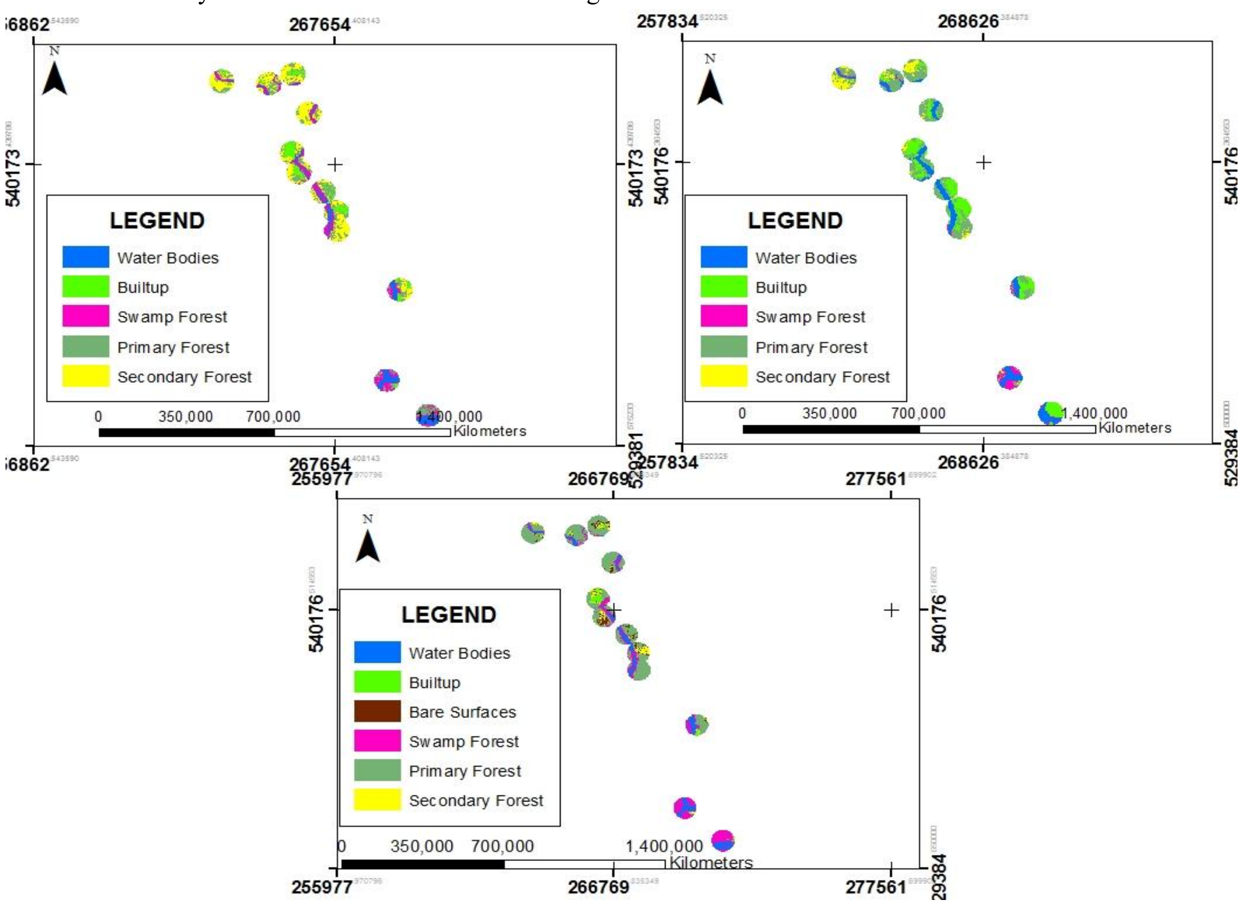

Figure 6: Land Cover Change Within 1000 m Sand Mining Buffer Zones Across the Study Area

Source: GIS buffer analysis of classified Landsat imagery, authors' analysis, 2026

Restricting the analysis to a 1000 m buffer around mapped mining points sharpened these corridor-wide trends. Individual buffer sites — traced through the same three reference years at locations near Ogbogoro, Ogbakiri, Choba, Emohua and Aluu — showed a broadly recurring cycle: primary forest dominance in 1986, displacement by secondary forest and anthropogenically altered surfaces by 2006 as extraction intensified, and a mixed outcome by 2022 in which some buffers showed continued built-up expansion while others showed partial forest recovery consistent with a local decline or relocation of active mining. At one representative buffer site, water body and swamp forest cover fell from a combined 48% of the buffer area in 1986 to a combined 22% in 2006 before recovering somewhat by 2022, while anthropogenically altered surface cover rose from 11% in 1986 to 13% in 2006, before contracting again as mining moved elsewhere within the corridor. This site-level variability indicates that mining pressure is not static: it shifts along the channel over time, producing localised recovery in previously mined buffers even as the corridor-wide trend continues toward net forest loss and built-up expansion.

V. DISCUSSION

Taken together, the mapping and land cover results describe a coherent process: sand mining is spatially concentrated where access is easiest, and the land cover surrounding those access points has been progressively cleared and built over across the 1986–2022 study period. The near-total loss of bare surfaces and swamp forest by 2006, alongside a 201% increase in built-up area, points to a rapid early phase of clearance and settlement consolidation around mining nodes, consistent with the general pattern by which sand mining drives channel and bank instability that in turn displaces riparian vegetation (Kondolf, 1994; Rinaldi, Wyżga & Surian, 2005). The subsequent rise of secondary forest by 2006, followed by continued built-up expansion to 2022, suggests a pattern of vegetation regrowth on abandoned or fallow land being repeatedly overtaken by renewed clearance and construction — a cycle that has previously been documented on other Niger Delta channels affected by dredging, including reported changes in cross-sectional form on the New Calabar River itself (Mmom & Chukwu-Okeah, 2012).

The concentration of mining activity in the northern, more accessible reach of the corridor, and its relative absence in the swampier southern reach, illustrates how terrain and infrastructure — rather than resource availability alone — govern where extraction pressure and its land cover consequences accumulate. This has a direct implication for monitoring and enforcement: regulatory attention and buffer protection need not be spread evenly along the river but can be prioritised toward the specific reaches where GPS-based mapping shows extraction is concentrated. More broadly, the findings support the wider literature linking unregulated sand extraction to bank instability, sediment starvation and habitat loss in alluvial river systems (Koehnken et al., 2020; Hackney et al., 2020; Bisht, 2021), while demonstrating that multi-temporal Landsat classification, paired with GPS mapping of extraction points, offers a practical and replicable method for quantifying that impact at the scale of an individual river corridor.

VI. CONCLUSION AND RECOMMENDATIONS

This study mapped the spatial distribution of sand mining locations along the New Calabar River between Omuechi and Iwofe and quantified the land cover change that has accompanied that activity between 1986 and 2022. Mining locations were found to concentrate heavily in the northern, more accessible reach of the corridor, while corridor-wide land cover shifted from a primary-forest-dominated landscape in 1986 (61.2%) to a built-up-dominated landscape in 2022 (49.6%), with the sharpest transitions recorded within 1000 m of active mining points. These findings confirm that sand mining is a measurable and spatially identifiable driver of land cover change along the river, rather than a diffuse or incidental influence.

Based on these findings, the study recommends that:

i. regulatory agencies prioritise licensing, monitoring and enforcement in the northern reach of the corridor identified here as the primary concentration of mining activity;

ii. a buffer zone of at least 1000 m be maintained around active or recently active mining points, within which further clearance or construction is restricted to allow vegetation recovery;

iii. periodic Landsat-based land cover classification, following the method demonstrated here, be institutionalised as a low-cost monitoring tool for tracking future mining-induced change along the corridor; and

iv. afforestation be prioritised within buffers that have already lost primary forest cover, to consolidate the partial recovery observed at some previously mined sites.

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