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SPATIAL DISTRIBUTION AND METHODS OF SAND MINING IN THE RIVERINE COMMUNITIES OF NEMBE LOCAL GOVERNMENT AREA, BAYELSA STATE, NIGERIA

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ABSTRACT

Sand mining has become a defining informal economic activity in the riverine communities of the Niger Delta, yet the geography and technology of extraction remain poorly documented at the local scale. This study mapped the spatial distribution of sand mining sites and documented the methods, products and measurement practices of sand miners in Nembe Local Government Area (LGA), Bayelsa State, Nigeria. A survey research design was adopted. Ten of the 32 sand-mining villages in the LGA were purposively selected; site coordinates were recorded with a handheld GPS receiver and processed in ArcMap 10.8; and 400 structured questionnaires (40 per village) were administered to site owners, tipper and canoe drivers, and site workers. Data was analysed with descriptive statistics. A total of 58 sampled sites were mapped between latitudes 4.52°N and 4.63°N and longitudes 6.16°E and 6.48°E. Sites were unevenly distributed: Ogbolomabiri (11), Bassambiri (9) and Liama (8) together held 28 sites (48.3%), whereas Mini-Ikensi and Okoroma had two each. Manual diving and scooping (43.5%) were slightly more common than mechanised dredging (38.0%), and 18.5% of respondents combined both. Sharp sand was the dominant product (45.25%), and 73.5% of respondents measured output in tons. Gravel and pebbles commanded the highest unit price (₦26,000 per ton) despite the lowest daily output. The findings describe a mixed-technology sector whose benefits and environmental burdens are spatially concentrated. Community-specific monitoring and differentiated regulations of manual and dredging operations are recommended.

Keywords: Sand Mining; Spatial Distribution; Extraction Methods; GIS; Nembe; Niger Delta; Bayelsa State

1. INTRODUCTION

Sand is the most widely extracted solid material on Earth after water and an indispensable input to concrete, glass, road bases and land reclamation (United Nations Environment Programme [UNEP], 2019).

Global demand for sand and gravel aggregates, currently estimated at about 50 billion tons a year, is projected to double by 2060 as urbanisation and construction expands (Park *et al.,* 2026). Because marine and terrestrial deposits are finite and unevenly accessible, rivers have become a principal supply source, and a growing literature warns that extraction now exceeds natural replenishment in many river systems (Bendixen *et al*., 2019; Torres *et al.,* 2017; Rentier & Cammeraat, 2022). Sand extraction has also been framed as a distinct extractive frontier, with its own political economy, informal labour arrangements and governance gaps (Bisht & Martínez-Alier, 2021).

Nigeria is part of this global pattern. Construction-grade sand sustains the building boom in cities such as Lagos, Abuja, Port Harcourt and Yenagoa, and the Nigerian Dredging Industry Report (2022) places more than 90% of dredging operations in the Niger Delta and the south-western states bordering the Atlantic. The Niger Delta's dense network of rivers, creeks and estuaries delivers high-quality sharp sand close to waterborne transport, which makes fluvial sand mining one of the region's most economically significant, and environmentally contentious, activities (Ohaeri *et al.,* 2021, Wonah & Tom, 2026). In Bayelsa State, artisanal sand diving by local youths was practised for generations on a small scale. Over the past two decades, however, the scale, technology and organisation of extraction have changed markedly, and Nembe LGA has emerged as a major centre of trade.

Despite this, evidence of where mining takes place and how sand is actually extracted in Nembe remains thin. Studies elsewhere in Nigeria have mapped mining sites and classified them by degree of damage (Adedeji *et al*., 2014; Marcus, 2016), but comparable site-level geography is scarce for the creeks of south-eastern Bayelsa. Without it, regulators cannot target monitoring, and researchers cannot interpret reported impacts in relation to the intensity and technology of extraction. This paper addresses that gap with two objectives: (i) to assess the spatial distribution of sand mining sites in Nembe LGA, and (ii) to determine the methods of sand mining, the products mined

and the units of measurement used by operators.

2. LITERATURE REVIEW

2.1 Spatial patterns of sand mining

Site-level mapping studies show that sand mining is rarely uniform in space. Mathada and Kori (2012) mapped 21 mining sites along the Nzhelele River valley in South Africa, of which 15 were active and six abandoned. In Ghana, Mensah (1997) identified 15 inland and coastal sand mining sites in the Ahanta West District. Comparable inventories in Nigeria include 27 sites in parts of Ogun State, 14 of them active and 13 abandoned (Adedeji *et al*., 2014); 10 active dredging sites in the Niger Delta (Okoyen *et al*., 2020); 16 sites in Nsit Ubium LGA of Akwa Ibom State (Benson, 2010); and 27 quarrying sites in 16 communities in Etinan LGA, where no community held more than three sites (Marcus, 2016). Such studies typically use GPS and GIS to record site attributes and then classify sites by activity status or ecological damage.

The literature points to several drivers of clustering. Extraction tends to concentrate where commercially viable deposits coincide with navigable channels and short haulage distances to markets (Nwaka, 2020; Oladele *et al*., 2021). Settlements with greater socio-economic activity and better transport connectivity attract more extractive capacity, while communities far from major waterways or with less favourable sediment conditions record fewer sites (Obinna *et al*., 2022). Spatial concentration matters beyond description: communities that host many sites carry a disproportionate share of both the livelihood benefits and the environmental costs of extraction, including bank erosion, channel change and habitat loss (Koehnken *et al*., 2020; Padmalal & Maya, 2014).

2.2 Methods of sand mining

The method adopted at a site depends on the nature and depth of the deposit, its areal extent and the intended frequency of mining (Ita, 2008). In-stream mining removes sand directly from an active channel using dredgers, canoes, shovels or other implements (Kondolf, 1997). Where capital is scarce, miners dive with buckets, drag them

along the riverbed, surface when full and empty the load into a canoe; the sand is then landed, sorted and measured, and non-diving workers are paid to clean and carry it (Benson, 2010; Marcus, 2016). Mechanised dredging mounts suction or bucket equipment on boats or barges and can extract far larger volumes at greater depth, but requires more capital and skilled operators (Padmalal & Maya, 2014). Other approaches include open-cast pit excavation on terraces and floodplains and hydraulic mining with pressurised water jets, although these are less relevant to submerged riverine deposits (Ashraf *et al*., 2011).

The balance between manual and mechanised methods is usually explained by capital access rather than preference. Artisanal mining economies have been described as undergoing a dual-technology transition, in which labour-intensive and mechanised operations coexist without either displacing the other (Adeola & Nkemdirim, 2021), and capital constraints have been identified as the main reason small-scale operators in South-South Nigeria persist with manual methods (Oyinloye *et al*., 2020). Method matters for impact: dredging reshapes channels more aggressively per unit of time, whereas manual mining employs more people per ton and exposes divers to occupational hazard (Koehnken *et al*., 2020; Rentier & Cammeraat, 2022).

3. Materials and Methods

3.1 The study area

Nembe Local Government Area (the study area) is situated in the south-eastern part of Bayelsa State, within the coastal Niger Delta, and is bounded by Brass LGA to the south and south-west and Ogbia LGA to the north and north-east (Bayelsa State Government, 2020). It lies on Latitudes $4^0\ 2^{l}\ 48.46^{ll}$ to $4^0\ 4\ 0^{l}\ 39.54^{ll}$ and longitudes $6^0\ 8^{l}\ 40.75^{ll}$ to $6^0\ 32^{l}\ 59.58^{ll}$ (Figure 1).

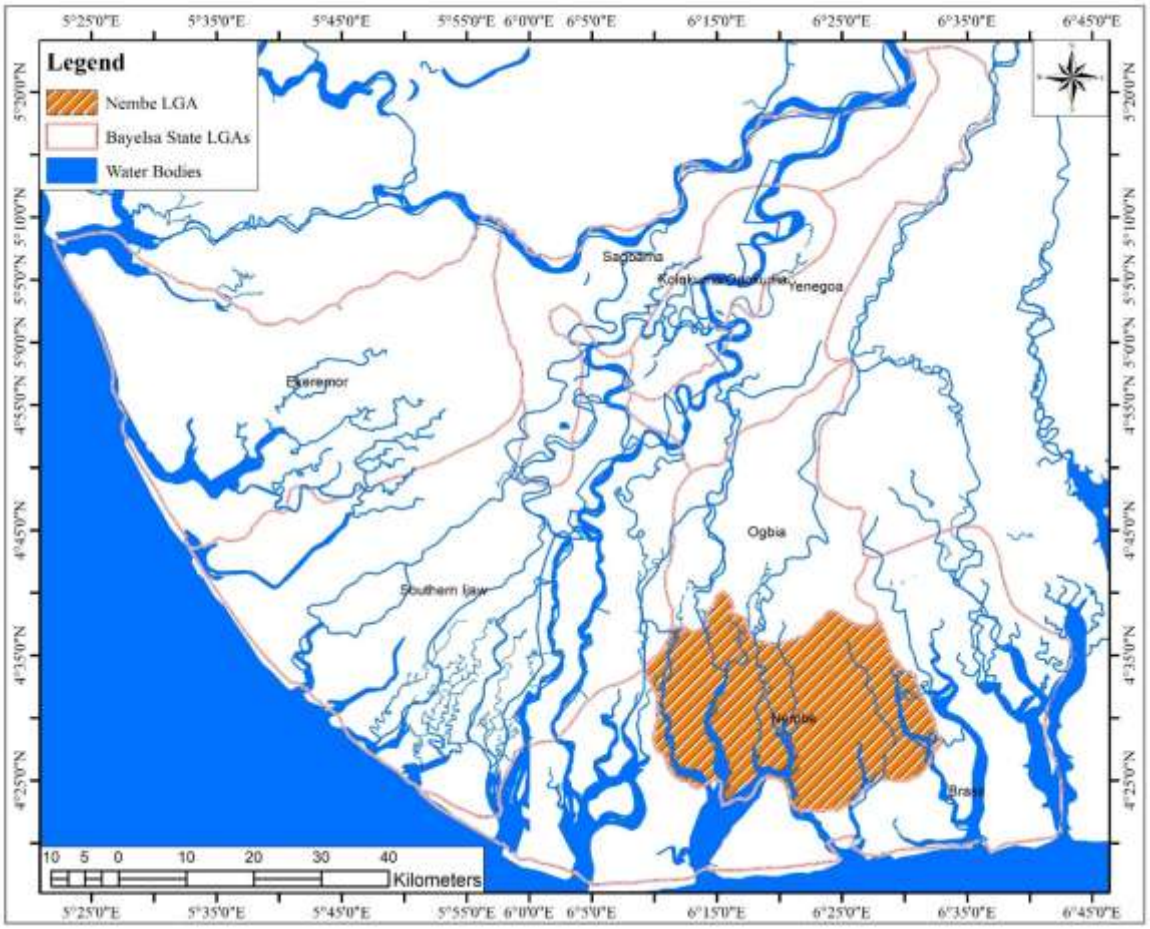

Figure 1: Location of Nembe Local Government Area on the map of Bayelsa State
Source: GIS Unit, Dept. of Geo. and Reg. Planning, Igbinedion University Okada (2026)

The climate is tropical monsoon, with high temperatures, humidity above 80% and annual rainfall of roughly 2,500-4,000 mm; the rainy season runs from March to November and the dry season from November to February (Oguntunde *et al*., 2011). The terrain is flat and low-lying, mostly one to three metres above sea level, and is dissected by creeks and distributary channels under strong tidal influence. The subsurface consists of unconsolidated Quaternary alluvial and deltaic sands, silts and clays, which constitute the resource base that sand miners exploit. Settlements are linear and riverbank-oriented, and water transport dominates movement. Fishing is the primary occupation, followed by subsistence agriculture, with sand mining a growing economic activity. The 2006 census recorded 130,966 people in the LGA (National Population Commission [NPC], 2006), which was projected to 214,784 for 2026 at an annual growth rate of 2.5%.

3.2 Research design and sampling

The study adopted a survey research design

combining field observation, GPS-based site recording and structured questionnaires. Of the 32 villages in Nembe LGA known to engage in sand mining at different scales, ten major mining villages were purposively selected: Oluasiri, Ogbolomabiri, Bassambiri, Mini-Ikensi, Okoroma, Agada, Obiata, Iseoleogono, Sabatoru and Liama. The sample size was determined from the 2026 projected population (N = 214,784) using the Taro Yamane (1967) formula, $n = N / [1 + N(e)^2]$, at a 0.05 margin of error, which gave 399.9, rounded to 400. Forty questionnaires (10% of the total) were administered in each village to site owners, tipper and canoe drivers, loaders, machine operators and other site workers, so that miners in every selected village had an equal chance of responding.

3.3 Data collection

Primary data were collected in two ways. First, a reconnaissance survey identified sand mining sites in each selected village, and a Garmin GPS receiver recorded the longitude and latitude of each site. Second, structured questionnaires captured the methods of mining, the mechanisms used, the type of sand product mined, the unit of measurement and the daily output, price and income associated with each product. Respondents were informed of the purpose of the study, participated voluntarily and were assured of confidentiality.

3.4 Data analysis

Coordinates were entered into ArcMap 10.8 to produce a map of the sampled sites by community. Methods of mining, products and measurement units were summarised as frequencies and percentages in tables and charts. Site counts were converted to shares of the total, and the three largest communities were compared with the rest to describe concentration. No inferential tests were applied in this part of the study, because the objectives are descriptive.

4. RESULTS

4.1 Profile of respondents

Of the 400 respondents, 390 (97.5%) were male and 10 (2.5%) females, reflecting the physically demanding, water-based nature of dredging, diving, loading and haulage. Site workers formed the largest group (280

respondents; 70.0%), followed by site owners (62; 15.5%) and tipper or canoe drivers (58; 14.5%). Educational attainment was low: 78.0% had primary education or less (non-formal, primary or none), and only 3.0% had tertiary education. The sample therefore represents predominantly male, lightly educated operators, and the results reflect their perspectives on methods and products.

4.2 Spatial distribution of sand mining sites

A total of 58 sand mining sites were recorded across the ten villages (Table 1). Their coordinates ranged from 4.520°N to 4.632°N and from 6.156°E to 6.478°E. The westernmost sites were at Liama (about 6.16–6.17°E), and the easternmost were at Agada and Obiata (about 6.46–6.48°E). The northernmost sites were at Okoroma and Oluasiri, and the southernmost were at Bassambiri. See detailed location coordinates on Table 2.

Table 1. Sampled sand mining sites by community, Nembe LGA

Community	Sites	Share of all sites (%)	Cumulative share (%)
Ogbolomabiri	11	19.0	19.0
Bassambiri	9	15.5	34.5
Liama	8	13.8	48.3
Iseoleogono	7	12.1	60.4
Oluasiri	7	12.1	72.5
Obiata	5	8.6	81.1
Agada	4	6.9	88.0
Sabatoru	3	5.2	93.2
Mini-Ikensi	2	3.4	96.6
Okoroma	2	3.4	100.0
Total	**58**	**100.0**	

Source: Researcher's Computation (2026)

Table 2: Sampled Communities, Site Locations and Coordinates

SN	Community	Site Number	Longitudes	Latitudes
1	Agada	1	6.477806	4.588571
2		2	6.472851	4.588021
3		3	6.471199	4.593527
4		4	6.475053	4.598482
5	Bassambiri	1	6.423849	4.543424
6		2	6.429355	4.532963

7		3	6.435411	4.525254
8		4	6.404028	4.542322
9		5	6.406781	4.546727
10		6	6.426602	4.535715
11		7	6.432108	4.528558
12		8	6.434310	4.519749
13		9	6.406780	4.546724
14	Iseoleogono	1	6.445872	4.566548
15		2	6.447524	4.572604
16		3	6.438715	4.566548
17		4	6.432658	4.567099
18		5	6.430456	4.575357
19		6	6.429905	4.583066
20		7	6.444220	4.561593
21	Liama	1	6.156265	4.561042
22		2	6.167277	4.558840
23		3	6.167828	4.552783
24		4	6.166727	4.545626
25		5	6.161771	4.551132
26		6	6.173334	4.554435
27		7	6.157917	4.566548
28		8	6.172232	4.546176
29	Mini-Ikensi	1	6.305473	4.543974
30		2	6.297765	4.534614
31	Obiata	1	6.457985	4.592976
32		2	6.456884	4.599583
33		3	6.456884	4.596280
34		4	6.459637	4.590223
35		5	6.453030	4.594077
36	Ogbolomabiri	1	6.340711	4.574807
37		2	6.344565	4.579762
38		3	6.350621	4.573706
39		4	6.351172	4.566548
40		5	6.353374	4.559390
41		6	6.347318	4.568750
42		7	6.345666	4.565447
43		8	6.343464	4.558840
44		9	6.343464	4.576459
45		10	6.342363	4.569301
46		11	6.348419	4.579211
47	Okoroma	1	6.415590	4.625460
48		2	6.416691	4.631517
49	Oluasiri	1	6.450277	4.617752
50		2	6.447524	4.620505
51		3	6.459637	4.613348
52		4	6.464041	4.614449
53		5	6.463491	4.610595
54		6	6.453580	4.619955
55		7	6.455232	4.612797
56	Sabatoru	1	6.329699	4.595178
57		2	6.336857	4.596830
58		3	6.334654	4.586369

Source: Researchers field survey with GPS (2026).

Mining was clearly concentrated as shown in Figure 2. Ogbolomabiri recorded the most sites (11), followed by Bassambiri (9) and Liama (8). These three communities together held 28 of the 58 sites (48.3%), and with Iseoleogono and Oluasiri the top five communities held 72.5%. At the other extreme, Mini-Ikensi and Okoroma had two sites each, and Sabatoru three. The mean was 5.8 sites per community, but the standard spread of the distribution, from 2 to 11, shows that a uniform LGA-wide picture would be misleading. Several plausible explanations emerge from the field observations and the literature, although this study did not test them statistically. Ogbolomabiri is the traditional headquarters of the LGA and lies on the Nembe River and creek system, which may give it better transport links and nearer markets than more remote communities (Obinna *et al.,* 2022). Bassambiri and Liama may benefit from favourable channel and sediment conditions (Nwaka, 2020). The low counts at Mini-Ikensi and Okoroma may reflect less favourable deposits, weaker access for dredging equipment, smaller local demand or a combination of these.

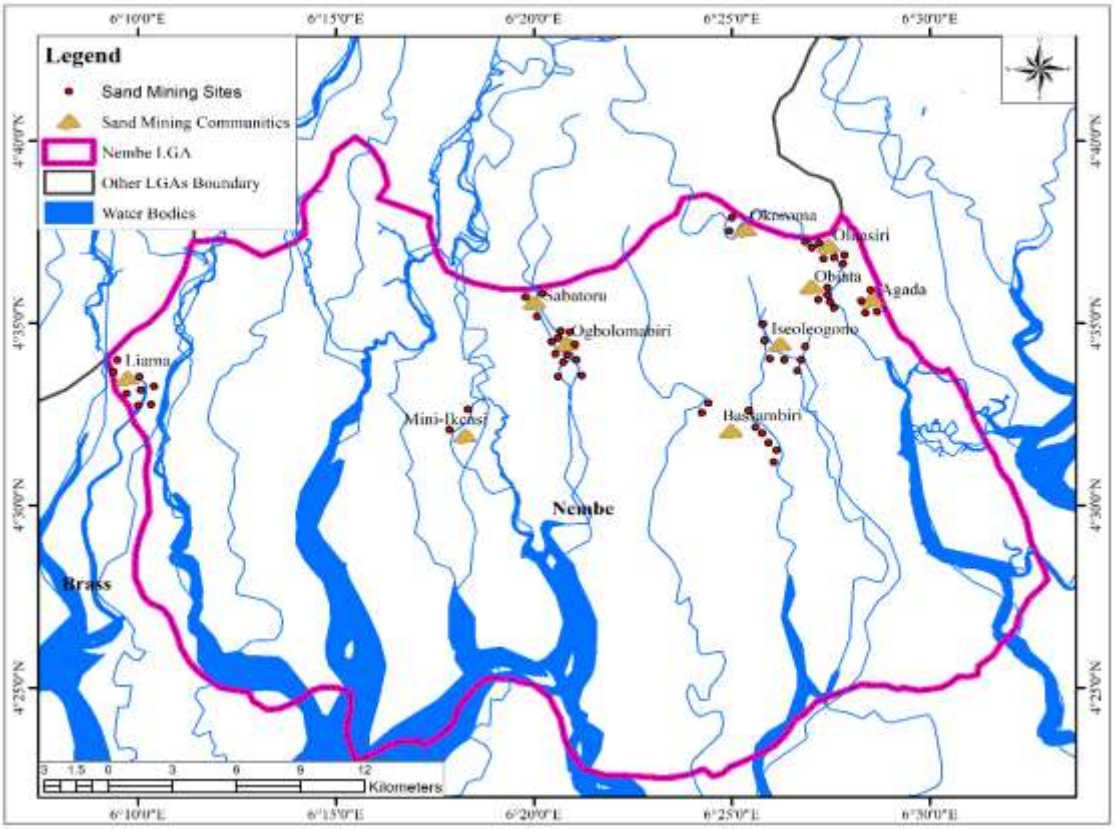

Figure 2: Spatial distribution of sampled sand mining sites in Nembe LGAs
Source: GIS Unit, Dept. of Geo. and Reg. Planning, Igbinedion University Okada (2026)

4.3 Methods of sand mining

Manual diving and scooping were the most common extraction method, reported by 174 of the 400 respondents (43.5%), followed by mechanised dredging (152; 38.0%) and a mixed approach combining manual and mechanised techniques (74; 18.5%) (Table 3). The gap between manual and mechanised mining is only 5.5 percentage points, so the sector is best described as mixed technology rather than dominated by either approach.

Table 3. Methods of sand mining in the study area

Method	Frequency	Percentage
Manual (diving and scooping)	174	43.5
Mechanised (dredging)	152	38.0
Mixed (manual and mechanised)	74	18.5
Total	**400**	**100.0**

Source: Field survey, 2026.

4.4 Sand products mined

Sharp sand taken from the rivers and riverbanks was the principal product, mined by 181 respondents (45.25%) (Table 4). Soft or plaster sand accounted for 20.5%, over-sharp sand for 19.5% and gravel or pebbles for 14.75%. Operators therefore extract several grades matched to different construction uses, but nearly half concentrate on one.

Table 4. Sand products mined

Product	Frequency	Percentage
Sharp sand (rivers and banks)	181	45.25
Soft sand / plaster sand (rivers)	82	20.50
Over-sharp sand (rivers)	78	19.50
Gravel / pebbles (rivers)	59	14.75
Total	**400**	**100.00**

Source: Field survey, 2026.

4.5 Units of measurement

Tons were the dominant unit for quantifying output, used by 294 respondents (73.5%) (Table 5). Pans (15.25%), basins (6.75%) and sandbags (4.5%) together accounted for 26.5%, which indicates a persistent small-scale, informal segment of the trade operating alongside bulk, truck-based transactions.

Table 5. Units used to measure sand mined

Unit	Frequency	Percentage
Tons	294	73.50
Pans	61	15.25
Basins	27	6.75
Sandbags	18	4.50
Total	**400**	**100.00**

Source: Field survey, 2026.

4.6 Daily output, unit price and income by product

Daily output and prices differed sharply by product (Table 6). Sharp sand had the highest reported output (40–50 tons a day) at ₦5,500 per ton. Soft or plaster sand yielded 30–50 tons a day at ₦6,500 per ton. Gravel and pebbles had the lowest output (15–20 tons a day) but sold at ₦26,000 per ton, nearly five times the price of sharp sand, and respondents reported the highest daily income for this product (above ₦75,000).

Table 6. Daily output, unit price and income by product

Product	Daily output (Tons)	Price per Ton (₦)	Reported daily income band (₦)	Implied gross value, output × price (₦)
Sharp sand	40–50	5,500	50,000 and above	220,000–275,000
Soft / plaster sand	30–50	6,500	Below 75,000	195,000–325,000
Gravel / pebbles	15–20	26,000	Above 75,000	390,000–520,000

Source: Researchers Field Survey, 2026.

The reported income bands are lower than the gross value implied by output and price. The difference probably reflects costs such as fuel, labour, equipment hires and transport, but the survey did not collect cost data, so the income bands are treated as indicative. Under either measure, gravel and pebbles ranked highest, which shows that profitability depends on the price of the product mined and not on volume alone.

5. DISCUSSION

5.1 An uneven geography of extraction

The central spatial finding is concentration. Almost half of the mapped sites (48.3%) lie in three communities, and the five largest hosts hold nearly three-quarters. This pattern agrees with the wider evidence that extraction clusters where deposits, navigable water and market access coincide (Nwaka, 2020; Oladele *et al*., 2021) and that remote communities with less favourable conditions host fewer sites (Obinna *et al*., 2022). It also

contrasts with the dispersed pattern reported for Etinan LGA, where no community held more than three sites (Marcus, 2016). Nembe's creek system, short haulage routes by water and proximity to construction demand in Yenagoa and beyond are consistent with the stronger clustering observed here, although these links remain inferences and not tested relationships.

The implication is distributional. Communities with many sites are likely to experience both the largest income and employment effects and the heaviest environmental burden, including bank erosion, channel deepening and habitat loss (Koehnken *et al*., 2020; Padmalal & Maya, 2014; Rentier & Cammeraat, 2022). A single LGA-wide regulatory regime would therefore be poorly matched to local conditions. Monitoring effort, livelihood support and enforcement should be weighed towards Ogbolomabiri, Bassambiri and Liama, while communities with few sites need baseline records that allow early detection of expansion.

5.2 A mixed-technology sector

The near-even split between manual (43.5%) and mechanised (38.0%) mining, with 18.5% combining both, fits the dual-technology pattern described for artisanal mining economies in developing regions (Adeola & Nkemdirim, 2021). Manual diving and scooping require little capital and so remains accessible to many local operators, a pattern that has also been linked to capital constraints elsewhere in South-South Nigeria (Oyinloye *et al*., 2020). Mechanised dredging, used wholly or partly by more than half of respondents (56.5%), signals that operators with access to capital and equipment are expanding. The mixed category suggests that some operators adapt their technique to water depth, deposit location, season or cost, as Kondolf (1997) and Padmalal and Maya (2014) note for in-stream operations generally.

The two techniques carry different risks. Manual methods absorb more labour per ton and expose divers to occupational hazard, whereas dredging extracts more sand per unit time and reshapes channels more rapidly (Koehnken *et al*., 2020). The mix of methods in Nembe therefore implies two overlapping regulatory challenges: workplace

safety and labour conditions for manual operators, and extraction limits and licensing for dredging. Because the survey recorded method by respondent and not by site, the study cannot yet say which communities are predominantly manual or mechanised; mapping method onto site would be a useful next step.

5.3 Products, prices and the volume–income trade-off

The dominance of sharp sand (45.25%) is consistent with demand-driven extraction for concrete, block moulding and general building (Eze & Okonkwo, 2022), and it matches the finding that building and construction are the main uses of sand from the area. The smaller shares of soft sand, over-sharp sand and gravel show a diversified product range serving different segments of the construction market. The price pattern adds a nuance that has received little attention in Nigerian studies: gravel and pebbles are mined least but are priced highest, so lower volume does not mean lower return. If operators respond to relative prices, specialisation could shift towards gravel, with consequences for where in the channel extraction takes place.

The predominance of tons as the unit of measurement (73.5%) points to a commercial, truck-based trade conducted in bulk. The 26.5% using pans, basins and sandbags marks a smaller informal segment linked to manual extraction and retail sales to individual buyers. This split matters for governance. Standard tonnage records would make it possible to estimate extraction volumes and, in time, to build sand budgets, whereas informal units are difficult to audit and undercount the volume actually removed from the channel.

5.4 Limitations

The study covers ten of the 32 sand-mining villages, selected purposively, so the results describe the sampled communities and not the whole LGA. Site counts are counts of sampled sites. The sample is overwhelmingly male (97.5%), and method, product and income data are self-reported. Income figures are bands, not audited earnings. Finally, the study describes the distribution of sites but does not model the factors that

drive it.

6. CONCLUSION AND RECOMMENDATIONS

Sand mining in Nembe LGA is spatially concentrated and technologically mixed. A total of 58 sampled sites were mapped across ten villages, with Ogbolomabiri, Bassambiri and Liama holding 48.3% of them. Manual diving and scooping (43.5%) are slightly more common than mechanised dredging (38.0%), sharp sand is the leading product (45.25%), most output is traded by the ton (73.5%), and gravel and pebbles earn the highest unit price despite low volumes. The sector is therefore neither purely artisanal nor fully mechanised, and its effects are likely to be felt most strongly in a few communities.

On this basis, the paper recommends that the Bayelsa State Ministry of Environment register all sand mining sites and prioritise routine monitoring of channels, banks and water quality in Ogbolomabiri, Bassambiri and Liama. Dredging operations should be licensed with explicit extraction limits, riverbank protection requirements and periodic impact assessments, while manual operations are supported with basic safety standards. Operators should adopt standard tonnage-based record keeping so that extraction volumes can be tracked and sand budgets estimated. Finally, future studies should extend the mapping to all 32 mining villages, record methods and products by site, collect cost data and measure channel change directly through bathymetric or remote-sensing surveys.

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