Japan Bilingual Publishing Co.

Urban Planning and Construction
https://ojs.bilpub.com/index.php/upc

ARTICLE

Extent and Techniques of Coastal Land Reclamation in the Niger Delta: A Spatio-Temporal Analysis

Temple Probyne Abali [1*] **, *Michael Uzodianya Didia*** [1] **, *Oye Ideki*** [2]

[1] *Department of Geography and Environmental Management, Rivers State University, Port Harcourt P.M.B. 5080, Nigeria*

[2] *Department of History, Geography, and Museum Studies, Morgan State University, Baltimore, MD 21251, USA*

ABSTRACT

This study examined the scale, pattern, and impacts of swamp reclamation in the Niger Delta between 1988 and 2018, with particular attention to its implications for urban development and environmental sustainability. Using Geographic Information System (GIS) and remote sensing techniques, Landsat satellite images were analyzed to quantify the extent of reclaimed areas and to assess associated land cover and land use dynamics. The findings revealed that large portions of the Niger Delta's wetlands have been reclaimed over the past three decades, with Rivers and Delta States recording the highest levels of reclamation, followed by Akwa Ibom and Bayelsa States. These spatial changes corresponded with significant reductions in swamp and primary forest areas, alongside increases in secondary vegetation, built-up surfaces, and other anthropogenically modified landscapes. The study demonstrates that while swamp reclamation contributes to urban growth, industrial expansion, and infrastructural development, it also results in severe ecological consequences such as habitat loss, biodiversity depletion, alteration of hydrological regimes, and declining ecosystem resilience. These environmental transformations threaten the ecological integrity of the Niger Delta,

*CORRESPONDING AUTHOR:
Temple Probyne Abali, Department of Geography and Environmental Management, Rivers State University, Port Harcourt P.M.B. 5080, Nigeria; Email: temple.abali@ust.edu.ng

ARTICLE INFO
Received: 4 August 2025 | Revised: 15 October 2025 | Accepted: 23 October 2025 | Published Online: 29 October 2025
DOI: https://doi.org/10.55121/upc.v3i2.657

CITATION
Abali, T.P., Didia, M.U., Ideki, O., 2025. Extent and Techniques of Coastal Land Reclamation in the Niger Delta: A Spatio-Temporal Analysis. Urban Planning and Construction. 3(2): 1–14. DOI: https://doi.org/10.55121/upc.v3i2.657

which serves as one of Nigeria's most productive and sensitive ecological zones. Consequently, the study underscores the need for an integrated and sustainable approach to land reclamation that incorporates strong regulatory frameworks, effective environmental impact assessments, and continuous geospatial monitoring. Such measures are essential to ensure that developmental goals are achieved without undermining the long-term environmental stability and socio-ecological well-being of the region.

Keywords: GIS; Niger Delta; Land; Swamp; Coast; Reclamation

1. Introduction

Nigeria is richly endowed with abundant wetland ecosystems, the majority of which are found in the Niger, Benue, and Chad basins [1], represent 2.6% of the country's area of about 923,768 km^2 [2]. The Niger Delta is one of the most important wetlands in Nigeria, the largest in West Africa and third largest in Africa and among the top 10 wetlands in the world [3]. Land scarcity for housing has resulted in a significant number of land reclamation activities taking place over the years and is still taking place today [4]. This resulted in loss of green areas as a result of land reclamation activities in Niger Delta. One thing common to all the above issues is that in a situation where land is not available or is available but not in the form required, then this would pose a great challenge to man in terms of where to put structures to enable him meet his basic needs. This is the Niger Delta region of Nigeria.

For instance, in Port Harcourt, the present location has a historical antecedence in that the city had to be sited, some 66 km from the Atlantic Ocean, on a relatively firm land at the bank of Bonny River. It has been argued that the spatial evolution of Port Harcourt is largely influenced by the poorly drained topography of the area [5–8]. The town is located on the coastal plains and has an average elevation of 13 km above mean sea level. The plains in question are crisscrossed by a maze swamps, creeks and waterways. The drainages of the Niger Delta are noticeably poor as a result of mainly low relief, high water table; high rainfall, as well as human interference in the natural drainage channels [9].

Niger Delta region has long struggled to accommodate growth given the difficulties of finding space within geographically constrained and densely populated areas [10]. However, due to innovative techniques introduced over the last few decades, lands can now be reclaimed. The presence of extensive swamps and marsh land in the Niger Delta implies that the topography is not firm [11–15]. Secondly, the existence of a maze of creeks simply points to the fact that the topography is also compartmentalized. The major issue to grapple with here then is: how can man set up his structures (such as housing, roads etc.) on this highly constrained topography? Is there a possibility of improving the drainage so as to make land more firm and therefore amenable to the setting up of some structures? Or is there a possibility of man using his technology and ingenuity to literally create more land to mitigate land shortfall? If possible, what are the socio-economic impacts?

Previous studies have documented the ecological richness of the Niger Delta and the challenges of settlement on its swampy terrain [5,6,8]. Others have described the drainage problems caused by low relief, high water tables, and extensive networks of creeks and waterways [16–18]. However, much of the existing research stops at describing these constraints or highlighting reclamation techniques in isolation. What remains less clear—and is therefore the gap this study addresses—is the extent, spatial distribution, and broader socio-environmental consequences of reclamation activities across the Niger Delta. Understanding these dimensions is critical, given the region's role as both a hub for national development and a hotspot of environmental vulnerability [19].

Port Harcourt, a key city in the region, illustrates these pressures vividly. Historically established on relatively firm land along the Bonny River, its spatial evolution has been constrained by poorly drained topography and rapid urban expansion [20]. With limited land available, residents and policymakers increasingly turn to reclamation as a solution, yet this raises pressing questions about sustainability, ecological trade-offs, and long-term resilience.

This study, therefore, investigates land reclamation practices in the Niger Delta by identifying the techniques employed, comparative evaluation of the extent and spa-

tial patterns of reclaimed land in the periods 1988 and 2018, and analyzing their environmental and socio-economic impacts. By so doing, it contributes to ongoing debates on sustainable urban development and provides evidence-based recommendations for managing reclamation in ways that balance growth, ecological preservation, and community well-being.

Basically, land reclamation in Port Harcourt is being actualized through a number of ways [21]:

1.1. Hydraulic Sand-filling

This is a method employed in land reclamation and construction, where material, often sand, is extracted from a riverbed or other body of water. Dredging equipment is deployed to scoop up this sand, along with other sediments like mud, and pump it through a pipeline to the designated fill area [22].

The process begins with the placement of bounding structures, typically made of concrete. These structures serve to contain the sand and define the boundaries of the reclaimed land. After the bounding structures are in place, the dredged material is discharged into the enclosed area. Pay-loaders are used to load the sand into trucks, which in turn move the sand into the construction area to raise the ground level [23–25].

The sand is then carefully distributed within the bounded area to achieve the desired elevation. Once filled, the sand is allowed to settle and compact naturally over time. This natural consolidation process is crucial for stability and load-bearing capacity. Sufficient time must be allowed to ensure ground stability before the subsequent construction activities begin. This waiting period ensures the integrity of the reclaimed land and prevents potential structural problems with the buildings built upon it. The exact duration of the stabilization period depends on soil type, depth of the fill, and other site-specific conditions.

1.2. The Use of Chikoko Mud Fill

One method used for land reclamation, particularly accessible to communities with limited resources, involves chikoko mud. In contrast to hydraulic sand-filling, which needs costly machinery and advanced methods, chikoko mud reclamation can be carried out with basic tools and local knowledge. The main resource, chikoko mud, is gathered in block form from mangrove swamps, often using age-old methods [5].

The special makeup of chikoko mud offers key benefits for reclamation. This mud is closely bound together by the intertwined roots of mangrove plants. This natural network of roots gives structure and stability to the mud, lowering the risk of erosion and collapse after placement. Also, chikoko mud is made up of small particles, making it less permeable. This low permeability is advantageous in reclamation projects because it stops water from flowing through the fill material too quickly. This helps to maintain the stability of the reclaimed land and avoids issues such as settlement and erosion [10].

This approach to land reclamation offers a way that is both practical and ecologically aware, especially in areas where mangrove ecosystems are present. By utilizing locally sourced materials and simple methods, chikoko mud reclamation can deliver a sustainable and cost-effective method for expanding land area while also recognizing the importance of protecting mangrove habitats.

1.3. The Use of Concrete Breakwater

This is another way to reclaim land, especially in riverine areas. This approach includes building concrete walls a certain distance into a river. Then, the area between the wall and the bank is filled, and the space is sealed with concrete to create a strong, stable platform.

To better elaborate, the reasons and processes for using concrete breaker for reclamation are expanded below [11]:

1.3.1. Reasons for Choice

(1) **Protection:** Concrete breakwaters act as barriers, shielding the reclaimed land from wave action and erosion, especially in dynamic river environments.

(2) **Stability:** The weight and structure of concrete make a solid base for construction.

(3) **Customization:** These structures can be made to fit specific site conditions and project needs.

1.3.2. Processes Involved

(1) **Site Assessment:** Before construction commences,

a detailed site investigation is conducted to evaluate the riverbed's soil composition, water currents, and possible environmental impacts. This assessment informs the design and placement of the breakwater.

(2) **Design and Planning:** Engineers plan the breakwater, determining its height, width, and the type of concrete to be used. The design considers the river's flow, potential flood levels, and the intended use of the reclaimed land.

(3) **Wall Construction:** The concrete walls are built using formwork and reinforced with steel to increase their strength. The formwork shapes the concrete as it hardens, ensuring the walls are structurally sound.

(4) **Filling and Sealing:** After the wall is in place, the area behind it is filled with suitable materials, such as sand, gravel, or rock. This fill is then compacted to offer a stable base. A concrete seal is applied over the fill to prevent erosion and maintain the integrity of the reclaimed land.

(5) **Environmental Concerns:** During the entire process, steps are taken to reduce environmental effects. This may include managing sediment runoff, protecting aquatic habitats, and complying with environmental regulations.

(6) **Monitoring and Maintenance:** Once the reclamation is complete, regular monitoring is important to check the stability of the breakwater and the reclaimed land. Maintenance may involve repairing any cracks or damage to the concrete structure and dealing with any erosion.

An example of this method can be observed at the Port Harcourt Harbour. The platform there was created using this type of reclamation, showing how effective concrete breakwaters can be in making new land in river areas.

1.4. Use of Solid Waste

The waste materials can gradually fill in low areas that are located next to wetlands and waterways. Once the ground has become more stable, buildings and structures can be built on these locations that were once prone to floods and swamps.

This approach to land creation has some benefits and drawbacks that should be carefully considered

1.4.1. Advantages

(1) **Waste Management:** Land filling can serve as a method for waste disposal, mainly in metropolitan areas where there is not enough space for waste management.

(2) **Land Creation:** It makes new land in places where it is wanted for construction, agriculture, or other needs.

(3) **Economic Benefits:** Transforming low-lying or swampy areas into usable land can increase property values and promote economic growth.

1.4.2. Disadvantages

(1) **Environmental Problems:** The dumping of solid waste has the possibility of polluting the soil and water. It can also affect the natural environment. Toxic chemicals from the waste will leach into the ground, which will end up polluting the nearby water bodies.

(2) **Health Risks:** Residents who live near places where waste is dumped will be exposed to various health threats.

(3) **Stability Issues:** Land created by waste may not be stable, which raises issues with the construction of buildings and infrastructure.

(4) **Aesthetics:** Garbage dumping can cause unpleasant views and odors, which lowers the quality of life in the neighborhood.

(5) **Greenhouse Gas Emissions:** Waste that is dumped in landfills has the possibility of producing methane gas, a strong greenhouse gas that contributes to climate change.

Because of these drawbacks, it is very important to be careful when using solid waste to reclaim land. To reduce any negative environmental and health consequences, proper waste management strategies are needed. These strategies should consist of reducing waste, reusing it, recycling it, and treating it before throwing it away. It is also crucial to carefully assess the stability and suitability of land reclaimed from solid waste before beginning any building work.

1.4.3. Dumping of Solid Wastes

The practice of land reclamation, though often exe-

cuted with subtlety, frequently entails the disposal of solid waste materials, particularly in close proximity to aquatic environments. With the passage of time, the accumulation of these wastes leads to the gradual filling of low-lying terrains that border marshlands and fluvial systems. As the accumulated matter undergoes consolidation, yielding a comparatively stable substrate, construction activities start, resulting in the emergence of structures upon what were formerly waterlogged or flood-prone areas [12].

Land reclamation by solid waste dumping near water offers inexpensive land for construction in coastal or riverside zones. It transforms useless wetlands into usable spaces. While it seems straightforward, this method involves waste management, foundation challenges, and environmental impacts.

The process starts with ongoing solid waste disposal in targeted areas, usually wetlands or shallow water bodies. The waste compacts over time, raising the land. This reclaimed land then becomes a base for constructing buildings or infrastructure [13].

Engineers must address foundation stability on such reclaimed land. Solid waste composition varies, causing uneven settling. Proper compaction and soil stabilization are needed for safe construction. Techniques like piling, soil replacement, or ground improvement are used, depending on waste composition and desired land usage [14].

Environmental issues are central to this reclamation form. Solid waste near water can pollute it, harming aquatic ecosystems. Leachate, produced during decomposition, may seep into the water, carrying pollutants. Waste also changes water flow. Careful waste selection, liners, and leachate treatment can control negative impacts, but land reclamation projects must balance economic gains with environmental stewardship for long-term sustainability [15].

Over the past ten years, land reclamation in the coastal Niger Delta has caused major worries about the damage done to both people and the environment. This study looks into how land is being reclaimed in the Niger Delta [16].

First, it pinpoints the different ways this is currently being done in the area. Then, it measures how much land has been reclaimed and where it is, while also figuring out how these actions affect the environment and the lives of the people who live there.

Based on what the study finds, it gives useful advice on how to make land reclamation more sustainable. This means finding a balance between the need for growth, protecting the environment, and taking care of the communities involved.

The focus is on understanding the methods used for land reclamation, figuring out their scale and impact, and suggesting better ways to do it that consider both development and the conservation of the environment [15]. The Niger Delta is known for its rich biodiversity and important ecosystems, but it also faces big environmental problems because of activities like oil extraction and land use changes. Land reclamation, which involves creating new land from water bodies, is one such activity that can have far-reaching effects.

To really understand what's happening, this study breaks down the different ways land is reclaimed in the Niger Delta. This includes looking at the tools, processes, and strategies used by different groups, from large corporations to local communities. By identifying these methods, we can better understand the immediate changes to the landscape and the possible long-term outcomes.

One of the main things the study does is map out where and how much land reclamation is happening. By using GIS technology and remote sensing data, the study shows the spatial distribution of these activities. This helps people see which areas are most affected and how reclamation projects are changing the natural landscape.

Also, the study carefully examines how these reclamation activities affect both the environment and the people living there [10]. Environmentally, it looks at things like changes in water quality, loss of habitats, and risks to local species. Socio-economically, it thinks about how reclamation projects affect people's livelihoods, access to resources, and community structures. The study uses surveys, interviews, and field observations to collect detailed data on these effects [23].

After collecting and analyzing all this information, the study comes up with practical ideas for making land reclamation more sustainable [15]. These ideas are aimed at reducing negative impacts and boosting positive outcomes. The study suggests ways to improve environmental regulations, promote community participation in decision-making, and use eco-friendly reclamation techniques.

In conclusion, this study provides a detailed look at land reclamation in the Niger Delta, offering valuable insights for policymakers, environmental managers, and community members. By pushing for more sustainable practices, the study hopes to help balance development needs with the critical need to protect the environment and support the well-being of local communities. This research is a step towards making sure that land reclamation contributes to the long-term sustainability of the Niger Delta region.

2. Materials and Methods

The study area is the Niger Delta Region of Nigeria, which is the Southern Nigeria (**Figure 1**).

The nature of data for this study is primary data, which were primarily Landsat imagery of the years 1988, 1998, 2008, and 2018 over the study area. The imagery for this study was acquired from the global land cover facility stream data over the study area for the year 1988, 1998, 2008, and 2018. The Landsat imagery was derived from the shuttle radar imageries owned by U.S. National Geo-spatial-Intelligence Agency (NGA) and global land cover facilities owned by the U.S. National Aeronautics and Space Administration (NASA). The land cover image of the study area was imported into the ArcGIS environment and was spatially geo-processed to ascertain the degree of land cover in relation to reclamation activities in the study area.

The data were processed and bands 1, 3, 5, and 7 were collapsed in the composite band in the ArcGIS environment which were processed and classified using the supervised classification to differentiate the area cover by vegetation, and reclaimed soil in the study area. Under supervised classification polygon for features were collated and named to represent the various features. The polygons were analysed using the maximum likelihood analysis to collect data of features classes with similar reflection in the study area.

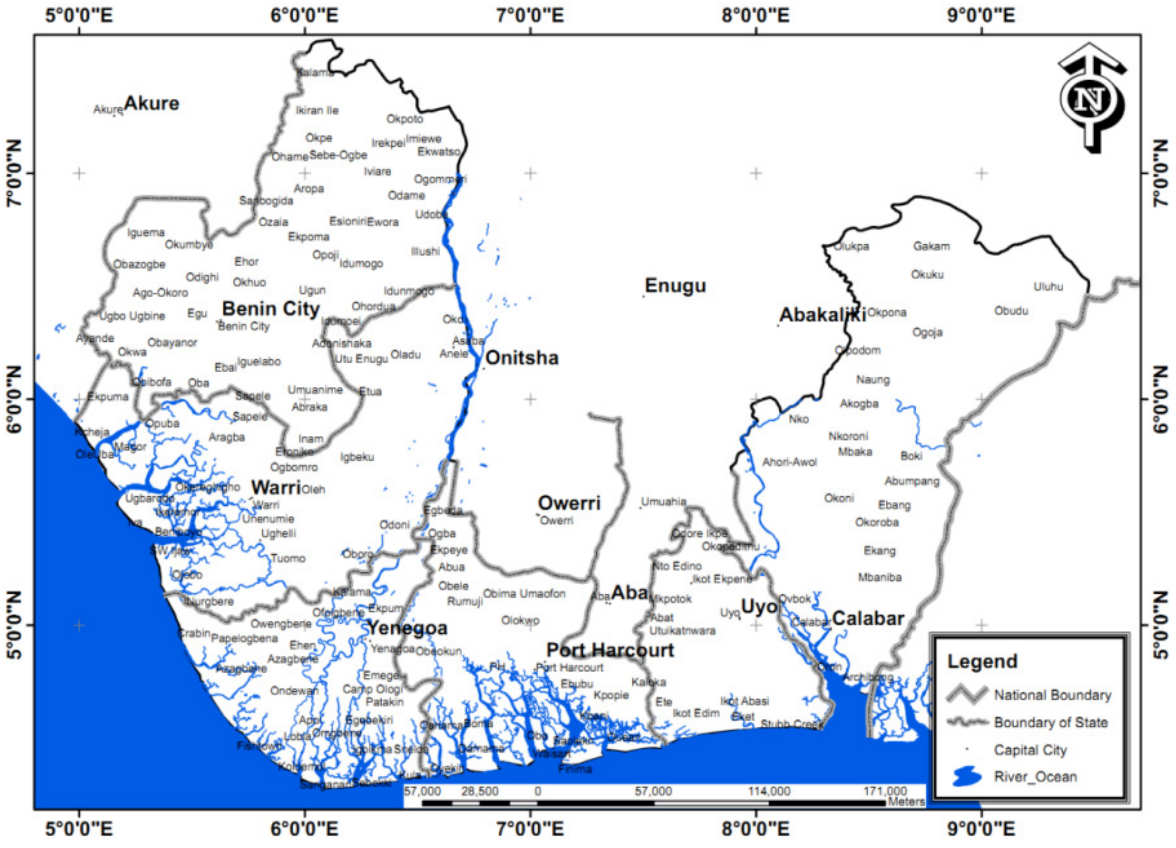

Figure 1. Study Area Showing Geographical Boundaries.

2.1. GIS and Remote Sensing Methodologies

In analyzing land reclamation in the Niger Delta, GIS and remote sensing provided a robust framework for mapping, monitoring, and assessing spatial and temporal changes. The methodology includes:

2.1.1. Satellite Imagery Acquisition

- Landsat Sensors Used:
  - TM (Thematic Mapper)—for data 1988, 1998, 2008 and 2018 (30 m resolution; 7 bands)
  - ETM+ (Enhanced Thematic Mapper Plus)—1988, 1998, 2008 and 2018; includes a 15 m panchromatic band.
  - OLI (Operational Land Imager)—onboard Landsat 8 & 9; improved radiometric resolution and cloud detection. These sensors offer long-term, consistent imagery for detecting land cover changes related to reclamation.

2.1.2. Image Preprocessing

- Radiometric and Atmospheric Correction using tools like ENVI or QGIS.
- Georeferencing and Subsetting to align data with base maps and extract the Niger Delta study area.

2.1.3. Classification Techniques

- Supervised Classification using training samples identified through field data or high-resolution imagery.
- Common Algorithms:
  - Maximum Likelihood Classification (MLC)—assumes normal distribution of classes; widely used and reliable.
  - Support Vector Machine (SVM)—effective for small training datasets with high accuracy.
  - Random Forest (RF)—a robust ensemble learning algorithm used for land cover classification with high performance.

2.1.4. Change Detection Analysis

- Multi-date imagery (1988, 1998, 2008, and 2018) used to quantify reclamation extent.
- Post-classification comparison helps assess gains in built-up or reclaimed land.

2.1.5. GIS Integration

- Classified maps are imported into GIS software (e.g., ArcGIS or QGIS) for:
  - Spatial overlay analysis
  - Area computation (e.g., extent of reclaimed land)
  - Map production and statistical summaries

3. Results and Findings

3.1. Extent of Land Reclamation in the Coastal Niger Delta

The reclamation sites across the Niger Delta reveal a hotspot of reclamation activities across the study areas, as revealed and shown in **Figure 2**. Rivers State shows a dominance of reclamation activities in the tone of 42 cases or reclamation sites, which is the highest recorded so far in the Niger Delta, with Bayelsa as second highest recording 16 cases followed by Delta with 4 reclamation sites and then Akwa-Ibom with only 3 sites.

3.2. Akwa Ibom State

From the analysis as shown in **Figure 3**, it revealed that as of 2018, the level of anthropogenic alteration represented by the red colour is spatially distributed in the study area with high level of secondary forest cover as shown by the dark green colour. Swamp forest lies in the southern part of the study area with pockets of primary forest across the study area.

3.3. Bayelsa State

From the analysis as shown in **Figure 4**, it is revealed that as at 1986, there was widespread of primary forest to the west and to the east is the primary forest. Spatially spread across the study area is the impact of man on the environment. The presence of water bodies across the study area is also well pronounced.

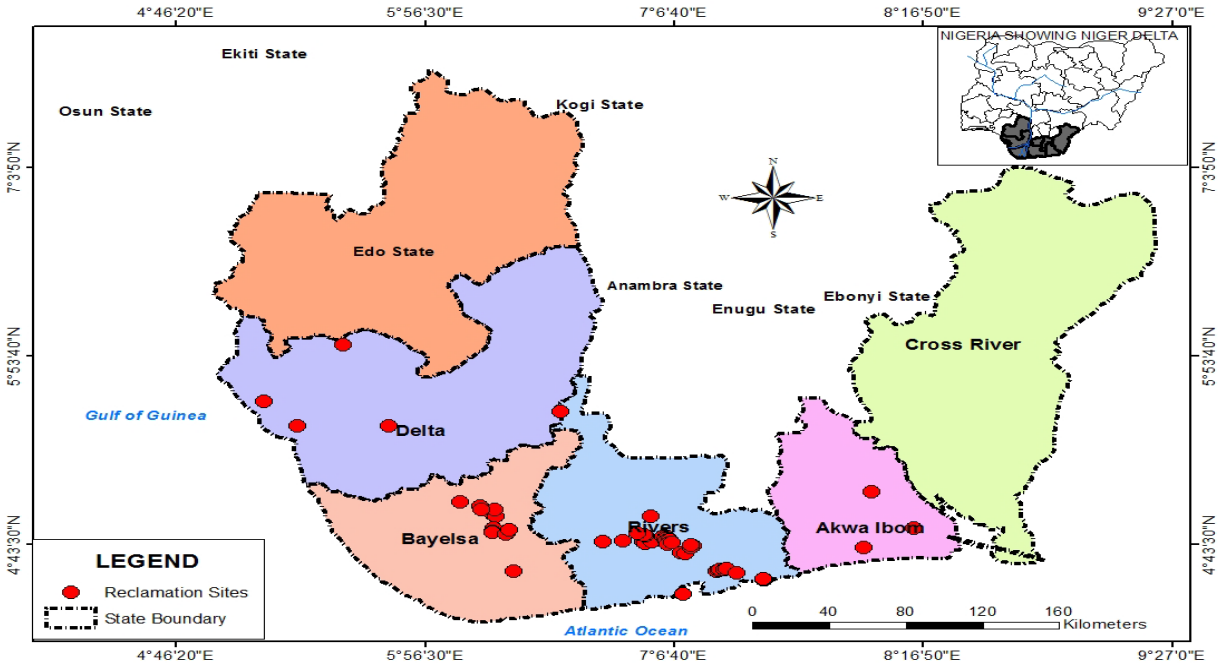

Figure 2. Reclamation Sites in the Niger Delta Region.

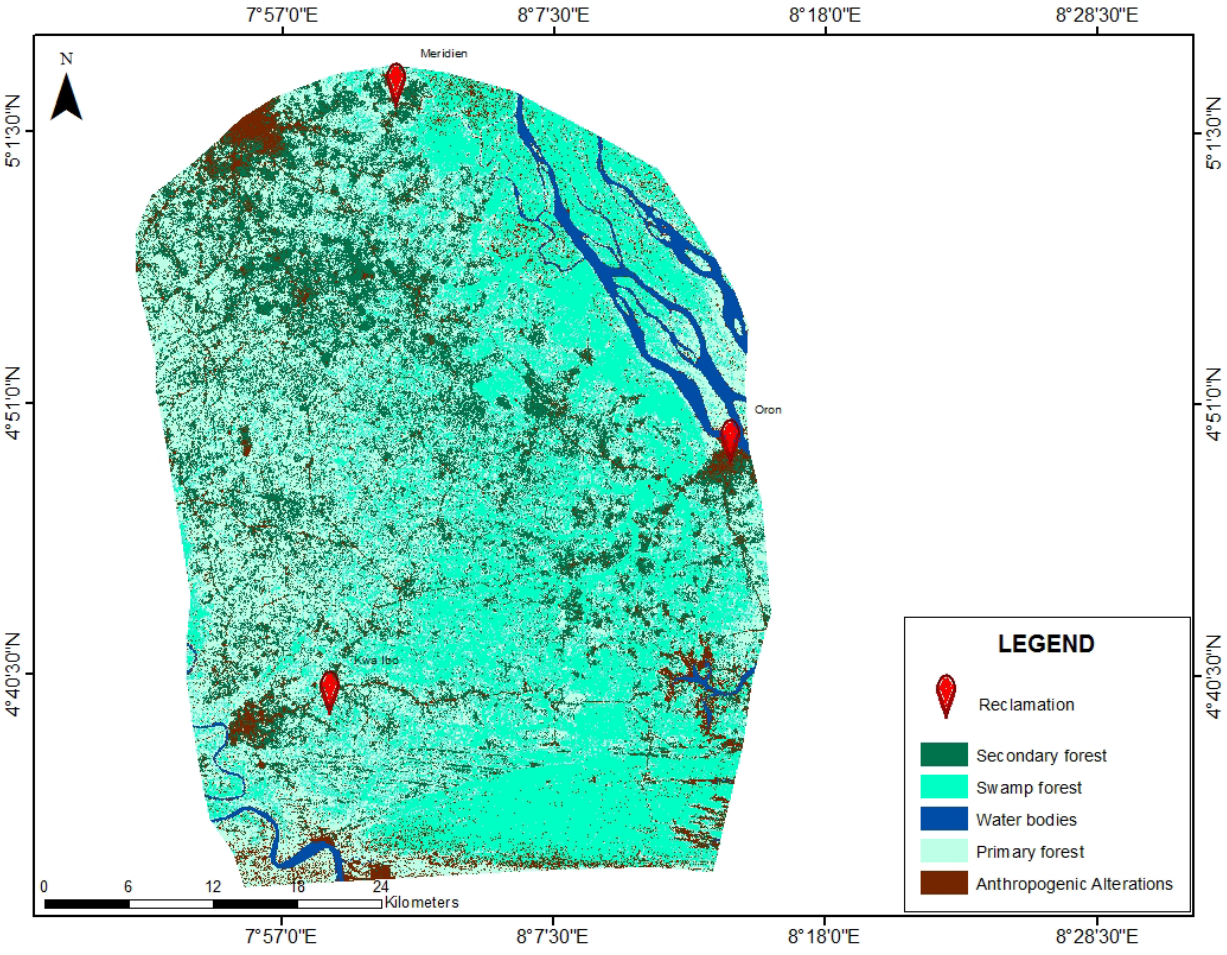

Figure 3. 2018 Image Classification Analysis for Akwa Ibom State.

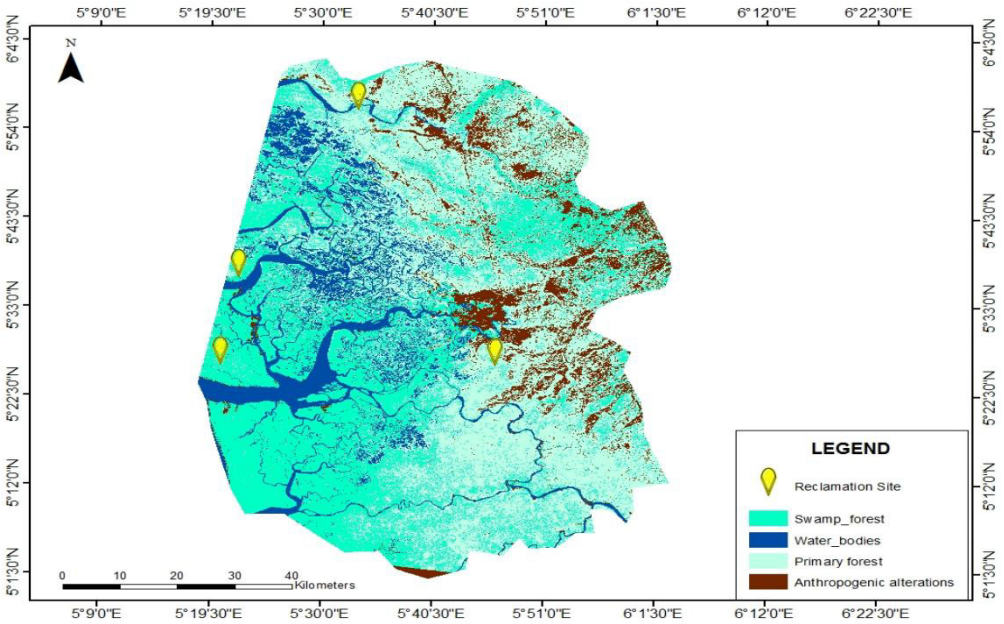

Figure 4. 1986 Image Classification Analysis for Bayelsa State.

3.4. Rivers State

Figure 5 shows the near infrared composite band associating each spectre band to the primary colour of red, green, and blue, creating a single Landsat data set from multiple bands. This allows us to visualize the wave length the human eye does not see (near Infrared Red). The near inferred composite is very important in vegetation monitoring, as this will aid the understanding of vegetal depleted areas across the study area. Reflecting from the near infrared red the image will provide or give a high avenue for the identification of vegetal structure that is less visible to mere visualization.

Table 1 below reveals the extent of land reclamation across the entire States under study. It revealed that Rivers State has the highest number of reclaimed sites, totaling 29,090,654 m2. Next in hierarchy is Delta State, totaling 25,248,022 m2 followed by Akwa-Ibom with the total number of 13,013,799 m2. The least in area of land reclamation sites among the States under study is Bayelsa with the total area of reclaimed land put at 5,816,309 m2.

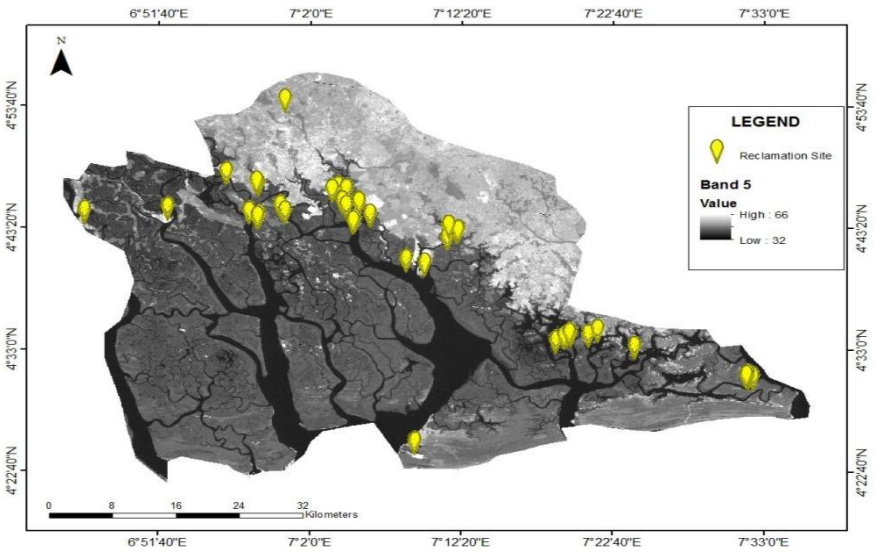

Figure 5. Landsat 1986 Band 5 showing reclamation sites for Rivers State.

Table 1. Extent of Land Reclamation in the Niger Delta.

States	Areas Reclaimed (m^2)
Akwa-Ibom	13,013,799
Rivers	29,090,654
Delta	25,248,002
Bayelsa	5,816,309
Total Reclaimed	73,168,764

Table 2 below shows the comparative extent of land surface cover across the study area owing to reclamation activities from 1986 to 2018. There is a noticeable increase in the area coverage of water bodies by 26,552,466 m2, secondary forest by 17,060,056 m2, and area of anthropogenic alterations by 26,778,380 m2, while reverse is the case for primary forest by 3,615,822 m2 and swamp forest by 66,775,080 m2, where there is noticeable decrease in its area coverage in 2018 compared to 1986.

Significantly, it is revealed that there is a reduction trend for the area covered by swamp forest, primary forest, and secondary forest with an increase in area of anthropogenic alterations, and water bodies across the study area (**Figure 6**).

The analysis, as shown in **Figure 6**, reveals that as of 1986, the level of anthropogenic alteration within the study area is not very visible. The swamp forest lies across most parts of the study area, while the secondary forest occupies the northern part of the study area.

Figure 6 presents the land cover distribution within the study area in 1986. As illustrated, the analysis reveals that anthropogenic alteration at this time was minimal. The landscape was largely dominated by swamp forest, which extended across most parts of the study area, while secondary forest was mainly concentrated in the northern section. This pattern reflects the relatively undisturbed natural environment that characterized the region prior to extensive human-induced modifications.

Table 2. Areas of Different Land Cover Types in Parts of the Study Area.

Land Cover Type	1986 Area in m^2	2018 Area in m^2	Difference Area in m^2	
			Decrease	Increase
Swamp Forest	88,439,786	21,664,706	66,775,080	----------
Water Bodies	69,832,200	96,384,666	----------	26,552,466
Primary Forest	4,268,353	652,531	3,615,822	
Anthropogenic Alterations	132,774,112	159,552,492	----------	26,778,380
Secondary Forest	50,880,312	67,940,368	----------	17,060,056
Total Land cover	346,194,763	346,194,763	70,390,902	70,390,902

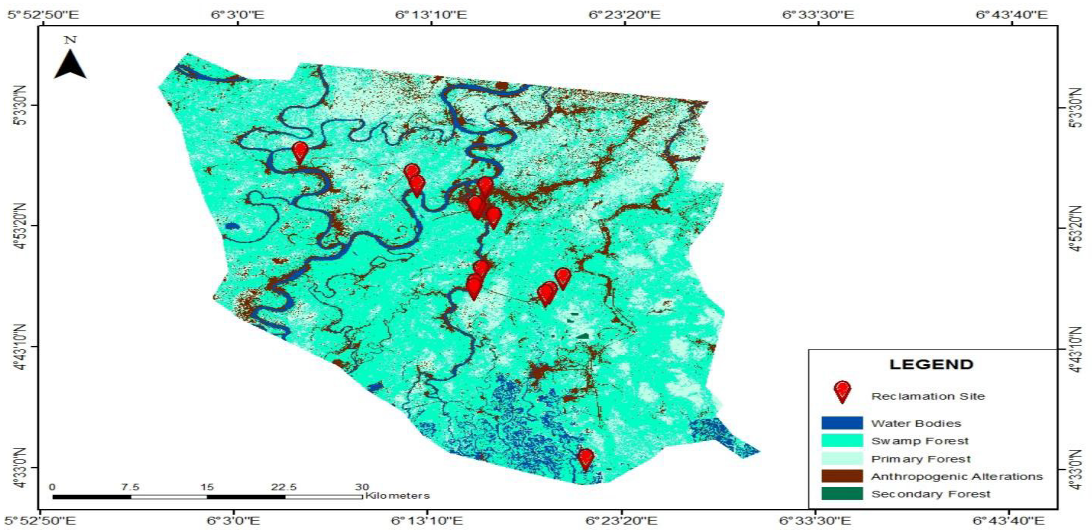

Figure 6. 1986 Image classification analysis.

Figure 7 shows the 2018 land cover classification of the study area, highlighting water bodies, site camp forest, secondary forest, and primary forest. Red pins indicate reclamation sites. The map provides a clear spatial overview useful for assessing vegetation distribution and land-use changes.

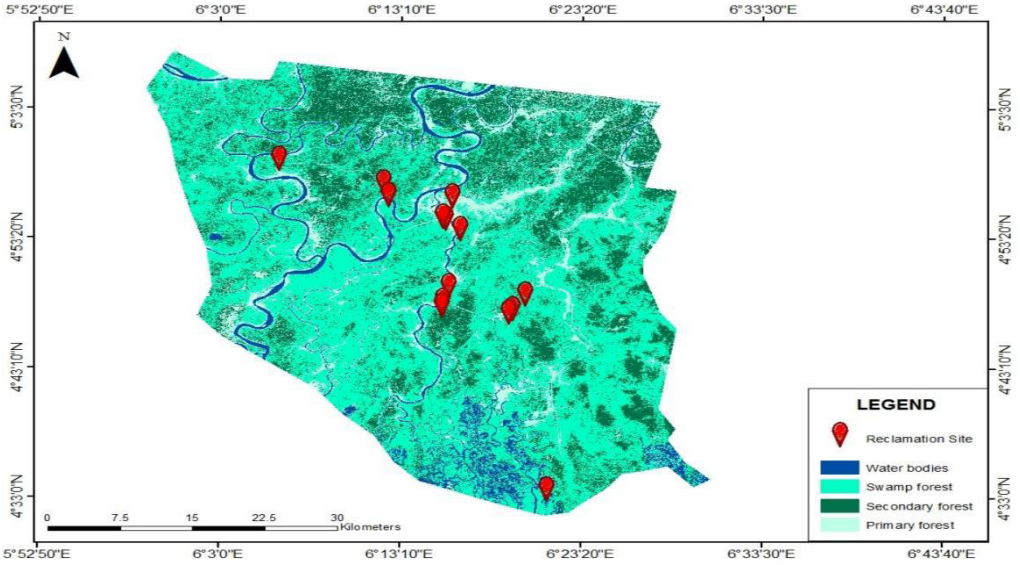

Figure 7. 2018 Image Classification Analysis.

4. Discussion

The findings of this study reveal that swamp reclamation in the Niger Delta has expanded considerably over the three decades examined, particularly within Rivers and Delta States, which collectively account for the largest reclaimed areas. This pattern reflects the high population densities, industrial activity, and rapid urbanization pressures in these states, which have historically attracted investments in oil exploration, port infrastructure, and real estate development [11]. The spatial distribution of reclamation highlights the intersection between economic drivers and environmental change, with land reclamation often presented as a pragmatic response to both land scarcity and urban growth challenges [1].

However, the extensive reclamation has not occurred without ecological costs. The marked decline in swamp areas and primary forests underscores the severity of habitat alteration. Wetlands in the Niger Delta are globally recognized as biodiversity hotspots, providing critical ecosystem services such as flood regulation, water purification, carbon sequestration, and nursery habitats for fish and other aquatic species [3]. Their loss, therefore, represents more than localized environmental degradation—it contributes to regional vulnerability to climate change impacts, including sea-level rise and increased flooding [12]. The observed increase in secondary vegetation and anthropogenically altered surfaces reflects a transition towards disturbed ecosystems with reduced ecological integrity and resilience [14].

From an urban development perspective, reclamation has facilitated the expansion of housing, industrial layouts, and transport corridors. Yet, the sustainability of this model is questionable. In many reclaimed areas, soil instability, poor drainage, and the destruction of natural flood buffers have amplified urban flood risks, as witnessed in Port Harcourt and Yenagoa [15]. Furthermore, the high cost of maintaining reclaimed lands—especially in low-lying and flood-prone environments—undermines the long-term economic rationale of large-scale reclamation, raising concerns about maladaptive development [8].

The study's findings resonate with global debates on the ecological trade-offs of land reclamation. Similar to reclamation practices in Asian megacities such as Jakarta and Manila, short-term urban gains are often achieved at the cost of long-term environmental sustainability [2]. In the Niger Delta context, this trade-off is particularly acute given the fragile nature of wetland ecosystems and the dependence of local communities on these landscapes for

fishing, farming, and cultural identity [12]. Biodiversity loss and ecosystem degradation, therefore, translate into both ecological and socio-economic dislocations, disproportionately affecting rural and peri-urban populations.

The results of this study also highlight governance gaps in Nigeria's land reclamation practices. Weak regulatory oversight, coupled with limited enforcement of environmental guidelines, has enabled ad hoc reclamation activities by both state and private actors [10]. The lack of systematic geospatial monitoring has further obscured the cumulative impacts of reclamation, making it difficult to design adaptive responses. This underscores the urgent need for institutional strengthening and the adoption of routine geospatial technologies to guide land use planning in the region.

In moving forward, a more integrated approach is necessary—one that recognizes reclamation as both a developmental necessity and an environmental threat. Strengthening environmental impact assessments, ensuring compliance with urban planning regulations, and prioritizing ecosystem-based approaches to development could help achieve a balance between urban expansion and environmental sustainability [5]. Incorporating green infrastructure, promoting wetland restoration in degraded sites, and aligning reclamation projects with Nigeria's commitments under the Paris Agreement and Sustainable Development Goals (SDGs) would foster a more sustainable trajectory for the Niger Delta.

In conclusion, while reclamation has expanded the spatial footprint of urban development in the Niger Delta, the associated ecological costs raise profound questions about sustainability. Without stronger regulatory frameworks and geospatially informed planning, reclamation risks deepen environmental vulnerabilities in a region already facing significant ecological and socio-economic pressures.

5. Conclusions

The study evaluated the extent of reclamation in the Niger Delta Region within the period of 1986 and 2018. From the analysis, it was shown that Rivers State dominates in the extent of reclaimed land, next to Delta State, Akwa Ibom, and Bayelsa States. Land sat image of Rivers State, Delta State, Akwa Ibom, and Bayelsa State, from 1986 to 2018, revealed the extent of anthropogenic alterations across the study area, with Rivers State taking the peak. This analysis revealed a clear, distinct bare soil surface representing reclamation activities from vegetal surface, wetland, and built-up areas. The result of the supervised classification analysis reveals the extent of land cover alteration in the study area, with a declining extent for swamp forest, primary forest, and an increasing extent for secondary and anthropogenically altered surfaces. This accounts for the reason for the high percentage of reclaimed land in Niger Delta. To examine the possible physical environmental issues associated with land reclamation such as flooding in Niger Delta.

The analysis reveals a very high impact on the natural cover of the environment by the reclamation activities, revealing the extent of vegetal cover after reclamation activities have taken place. Though the re-vegetation of the surface after reclamation activities has taken place is at a slow pace due to the nature of the soil retrieved from the river bed. From the analysis, it revealed that the composition of the forest after re-vegetation indicates that the pattern at which the re-vegetation is growing reveals a high level of randomness, which sometimes takes a scattered dimension, showing the spatial spread of the reclamation site across the study area. After all data was gathered and analyzed, it was concluded that Rivers State is dominated by reclamation sites/activities, followed by Bayelsa, then Delta State, and Akwa-Ibom State.

The Niger Delta is one of the most important wetlands in Nigeria, the largest in Africa, and the third largest in the world. Land scarcity for housing has resulted in a significant number of land reclamation activities taking place over the years and is still taking place today. This resulted in the loss of green areas as a result of land reclamation activities in the Niger Delta. Having to cope with pressing urbanization trends, the Niger Delta has a lot to gain from the more competitive costs of reclamation, which is a strategic spatial development plan feasible in overcrowded areas and be used to accommodate the demand for new housing, employment, transport, and other infrastructural facilities. This enables cities to allay congestion, enhance services, and remain attractive locations for both people and businesses.

These functions are of relevance for the entire community, since these enhancements have positive returns not only for investors and users, but for the quality of life and competitiveness of the entire region. Nevertheless, public

and private stakeholders have expressed concern about the impacts of reclamation projects. In addition, a lack of knowledge about how such effects can be evaluated in practice is an important deficiency, since it is often in the light of social or indirect impact that reclamation projects have comparative advantages over other plans that compete for public investments. Considering the full socio-economic value of reclamation projects, there should be a fundamental step for guiding investors and public bodies towards efficient choices on resource allocation.

In order to increase land supply, there is one approach, which is land reclamation for development. The land made available from land reclamation can be used for residential and commercial purposes or infrastructure development. These activities show that reclamation has become one of the main solutions for the land shortage issue. Nevertheless, reclamation would alter the condition of the ecosystem in several aspects, thus leading to the change in the quality of life of the local community.

Author Contributions

Conceptualization, T.P.A. and O.I.; methodology, O.I.; software, M.U.D.; validation, T.P.A., O.I. and M.U.D.; formal analysis, T.P.A.; investigation, O.I.; resources, M.U.D.; data curation, O.I.; writing—original draft preparation, T.P.A.; writing—review and editing, M.U.D.; visualization, O.I.; supervision, T.P.A.; project administration, O.I.; funding acquisition, M.U.D. All authors have read and agreed to the published version of the manuscript.

Funding

This work received no external funding.

Institutional Review Board Statement

No ethical approval required.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The data are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflict of interest.

References

[1] Ogbeibu, A.E., Oribhabor, B.J., 2023. The Niger Delta Mangrove Ecosystem and Its Conservation Challenges. In: Baylen Yllano, O. (Ed.). Mangrove Biology, Ecosystem, and Conservation. IntechOpen: London, UK. DOI: https://doi.org/10.5772/intechopen.112543

[2] Edo, I., Albrecht, E., 2021. Threats to Niger-Delta Wetlands: A Case Study of Apoi Creek Forest. Open Journal of Ecology. 11(2), 136–147. DOI: https://doi.org/10.4236/oje.2021.112012

[3] Elekwachi, W., Phil-Eze, P.O., Etuk, E.A., et al., 2021. Spatiotemporal Characteristics of Wetlands Ecosystem in the Niger Delta Region. Journal of Geoscience and Environment Protection. 9(12), 12–22. DOI: https://doi.org/10.4236/gep.2021.912015

[4] Enwin, A.D., 2024. Affordable Housing as Tool for Economic Development of the Niger Delta Region of Nigeria. International Journal of Research and Innovation in Social Science (IJRISS). 8(15), 66–79. DOI: https://doi.org/10.47772/IJRISS.2024.815EC006

[5] van Ginkel, M., Olsthoorn, T.N., 2020. Land Reclamation: The Potential for Subsurface Freshwater Storage. Terra et Aqua. 161, 6–17. Available from: https://www.iadc-dredging.com/article/land-reclamation-freshwater-storage/

[6] Sivakugan, N., Rankine, K., Rankine, R., 2015. Geotechnical Aspects of Hydraulic Filling of Australian Underground Mine Stopes. In: Indraratna, B., Chu, J., Rujikiatkamjorn, C. (Eds.). Ground Improvement Case Histories. Butterworth-Heinemann: Oxford, UK. pp. 83–109. DOI: https://doi.org/10.1016/B978-0-08-100698-6.00003-9

[7] Priyandes.A., Rafaee., M.M., 2009. Impact of the Reclamation Activities on the Environment Case Study: Reclamation in Northern Coast of Batam. Jurnal AlamBina. 15(1), 21–34.

[8] Overo, K.E., Gilbert, D.R., 2024. Impact of Chikoko Calcination Temperature on the Compressive Strength Properties of Blended Concrete. International Journal of Advances in Engineering and Man-

agement (IJAEM). 6(10), 585–591. DOI: https://doi.org/10.35629/5252-0610585591

[9] Gundlach, E.R., Giadom, F.D., Akpokodje, E.G., et al., 2021. Core Sediments and Oil Chemistry from Contaminated Mangroves in Eastern Niger Delta, Ogoniland, Nigeria. Marine Pollution Bulletin. 171, 112714. DOI: https://doi.org/10.1016/j.marpolbul.2021.112714

[10] Fang, H., Duan, M., 2014. Special Problems in Sea Petroleum Engineering for Beaches and Shallow Sea Areas. In Offshore Operation Facilities. Gulf Professional Publishing: Oxford, UK. pp. 687–780. DOI: https://doi.org/10.1016/B978-0-12-396977-4.00005-6

[11] Orlova, T., Melnichuk, A., Klimenko, K., et al., 2017. Reclamation of Landfills and Dumps of Municipal Solid Waste in an Energy Efficient Waste Management System: Methodology and Practice. IOP Conference Series: Earth and Environmental Science. 90(1), 012110. DOI: https://doi.org/10.1088/1755-1315/90/1/012110

[12] Danyaya, H., Abdallah, S., Sagagi, B., et al., 2022. Waste Management, Recycling, and Land Reclamation: A Review. In Proceedings of the International Mediterranean Congress, Mersin, Turkey, 16–18 November 2022; pp. 1–17. Available from: https://www.researchgate.net/publication/374415900_Waste_Management_Recycling_and_Land_Reclamation_A_Review

[13] Mohan, R.K., Herbich, J.B., Hossner, L.R., et al., 1997. Reclamation of Solid Waste Landfills by Capping with Dredged Material. Journal of Hazardous Materials. 53(1–3), 141–164. DOI: https://doi.org/10.1016/S0304-3894(96)01831-6

[14] Kumari, S., Ahirwal, J., Maiti, S.K., 2022. Reclamation of Industrial Waste Dump Using Grass-Legume Mixture: An Experimental Approach to Combat Land Degradation. Ecological Engineering. 174, 106443. DOI: https://doi.org/10.1016/j.ecoleng.2021.106443

[15] Numbere, A.O., 2020. The Impact of Landscape Reclamation on Mangrove Forest and Coastal Areas in the Niger Delta, Nigeria. In: Loures, L. (Ed.). Landscape Reclamation – Rising from What's Left. IntechOpen: London, UK. DOI: https://doi.org/10.5772/intechopen.82053

[16] Jimoh, H.I., Ajewole, O.D., Onotu, S.I., et al., 2011. Implications of Land Degradation, Reclamation and Utilisations in the Oil Producing Areas of Nigeria: Perspectives on Environmental Sustainability and Development. International Journal of Business and Social Science. 2(22), 248–254.

[17] Abali, T.P., 2008. Hydraulic Geometry as a Key Indicator of Channel Reclamation in the Niger Delta Region of Nigeria: A Case Study of Dockyard Channel in Port Harcourt. EVP Multidisciplinary Journal of Public Policy and Contemporary Issues. 1(1), 89–94.

[18] Abali, L.M.O., Aminigbo, T.P., 2022. Morphological Implication of Land Reclamation in Port Harcourt, Southern Nigeria. In Proceedings of the 4th International "Başkent" Congress on Physical, Social and Health Sciences, Istanbul, Turkey, 26–27 February 2022.

[19] Nnaemeka-Okeke, R.C., Okeke, F.O., 2024. Assessing the Influence of Seasonal Precipitation Patterns on Groundwater Quality in the Coal-Rich Environment of Enugu, Nigeria. Discover Applied Sciences. 6, 208. DOI: https://doi.org/10.1007/s42452-024-05837-x

[20] Elisha, O., Gbaranbiri, I., 2024. The Struggle of the Niger Delta Region of Nigeria: The Duality of Liquid Gold and Poverty. Journal of Economics and Trade. 9(2), 1–14. DOI: https://doi.org/10.56557/jet/2024/v9i19000

[21] Ogoro, M., Oyegun, C., Lawal, O., 2016. Vulnerability of Coastal Communities in the Niger Delta Region to Sea Level Rise. Quest Journals: Journal of Research in Humanities and Social Sciences. 2(8), 1–8.

[22] Didia, M.U., 2020. Investigation of the Impact of Land Reclamation Activities in the Niger Delta [PhD Thesis]. Rivers State University: Port Harcourt, Nigeria.

[23] Didia, M.U., Abali, T.P., 2024. Socioeconomic Impact of Land Swamp Reclamation: Implications on Environmental Security in the Niger Delta Region of Nigeria. In: Dung, E.J., Bombom, L.S., Avwunudiogba, A., et al. (Eds.). Environmental Security in Africa: Conflicts, Politics and Development. Bloomsbury Publishing: London, UK. pp. 255–267.

[24] Sladen, J.A., Lee, K.M., Shen, C.K., et al., 2000. Effects of Placement Method on Geotechnical Behavior of Hydraulic Fill Sands. Journal of Geotechnical and Geoenvironmental Engineering. 126(10), 942–944. DOI: https://doi.org/10.1061/(ASCE)1090-0241(2000)126:10(942)

[25] Sultanov, T., Fayziev, K., Toshmatov, E., et al., 2020. Stability of Dam Slopes of Phosphogypsum Sludge Collectors. IOP Conference Series: Materials Science and Engineering. 869, 072031. DOI: https://doi.org/10.1088/1757-899X/869/7/072031