AJLP & GS
African Journal on Land Policy and Geospatial Sciences

e-ISSN : 2657-2664, Vol. 7, Issue 1, February 2024

https://revues.imist.ma/index.php/AJLP-GS/index

https://doi.org/10.48346/IMIST.PRSM/ajlp-gs.v7i1.42439 *Category of the manuscript : Articles*

***Received in**: 25 August 2023* **Revised in:** 12 January 2024 ***Accepted in**:* 12 January 2024

Delineation of Land Reclamation Areas in Eti-Osa and Lagos Island Local Government Areas of Lagos State.

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ABSTRACT

Context and background

Land reclamation in Eti-Osa and Lagos Island, Lagos State, has led to infrastructure development but also created hazards like water overflow due to inadequately maintained drainage systems and uncontrolled urban growth.

Goal and Objectives

This study aimed to determine the area covered by land reclamation in Eti-Osa and Lagos Island, Lagos State, between 1992 and 2022, to mitigate hazards associated with reclaimed land for sustainable urban development.

Methodology

The spatiotemporal land use and land cover (LULC) were determined using historic Landsat images from different years (1992, 2002, 2013, and 2022). The reclaimed areas were extracted from the classified LULC, with the initial LULC map serving as the baseline data. The reclaimed areas were then detected by overlaying the LULC maps from 2002, 2013, and 2022, determining the area converted from water bodies and wetlands to bare land and built-up areas.

Results

The results showed that land use and land cover types in the study area included bare land, built-up areas, forests, shrubs, water bodies, and wetlands. The increase in built-up areas and bare land from 1992 to 2022 indicates urban development, while land reclamation on water bodies and wetlands has contributed to urban development. The study recommends the development of green infrastructure and sustainable urban drainage to absorb and store storm runoff, avoiding flood hazards and providing an absorption and storage area for storm runoff.

Keywords:

Land reclamation, land use and land cover (LULC), delineate, hazards

1. INTRODUCTION

According to Liu et al. (2020), reclamation is the process of turning a lake, river, or sea bank into land. According to Li and Norford (2016), clearing land for urban development is the reclamation's long-term objective. Reclaiming submerged land from water bodies or other wet areas is what it entails (Chigbu et al., 2020). The process of urban growth in the coastal zones of many maritime nations has been significantly impacted by cities' worldwide tendency to encroach further into the water, resulting in gigantic islands and enormous structures in coastal areas (Gaw and Richards, 2021).

Almost all of China's coastal provinces are working on initiatives to expand their coastlines. These projects may involve dumping soil from the mainland, dredging it out from the ocean floor, or blocking river estuaries to prevent silt from accumulating. Building out into the surrounding waters with the aid of sand, soil and rock mined and acquired from abroad has allowed the island state of Singapore to increase in size by 22% during the past 50 years. The Palm Jumeirah archipelago, a man-made metropolis, was built in Dubai using an estimated 110 million cubic metres of dredged sand. One of the world's most densely populated nations, the Netherlands, has long had to reclaim a sizable section of its coastal marshes and wetlands to accommodate its steadily growing population (Nogrady, 2016).

These locations' land use and land cover (LULC) are changing as global land reclamation activity increases. Monitoring the ongoing process of LULC patterns through time owing to land reclamation is vital to maintaining sustainable development, which necessitates knowledge of both the present and the past LULC. The analysis of these changes in the ecosystem and environment will also be aided by this knowledge (Singh, 2021). The majority of the reclaimed land in Lagos State's Eti-Osa and Lagos Island comes from wetlands, the Lagoon, and most recently, the Atlantic Ocean (Eko Atlantic). The majority of these places have been reclaimed, but they lack adequate drainage, causing water to return to its original level and other nearby lower-level locations. Due to its sand filling, various locations, including Lekki Phase One, Victoria Island, and others, experienced flooding in 2017 (Gbonegun, 2019).

As a result, water was able to enter residential areas. Nimi (2010) also expressed concern over predictions that Lagos, a low-lying city on Nigeria's Atlantic coast, may be rendered inhabitable by the end of this century due to rising sea levels brought on by climate change, as the issue is made worse by land reclamation, insufficient and poorly maintained drainage systems, unchecked urban growth, etc. The construction of a brand-new coastal city (Eko Atlantic), which is being built on land reclaimed from the Atlantic Ocean and protected from rising waters by an 8-kilometre-long wall made of concrete blocks, is contributing to the problem being faced in Eti-Osa and Lagos Island of Lagos State, including the washing away of the river bank of Lagos in Victoria Island. Therefore, the goal of this study is to delineate and determine the area covered by land reclaimed in the last 30 years, which will assist in taking inventory of the areas that have been reclaimed over the years for sustainable urban development.

2. STUDY AREA, METHODS AND DATA SOURCES

The study areas for this research include Eti-Osa and Lagos Island (Figure 1), which are both Local Government Areas (LGAs) in Lagos State. The two Local Government Areas both share boundaries

on the North with Lagos Lagoon. Eti-Osa LGA directly shares its boundary on the south with the Atlantic Ocean. Lagos Island Local Government Area in Lagos is a densely populated area in Lagos State (Figure 1). Eti-Osa Local Government Area is geographically located within Latitude 6°26' 34'' N and Longitude 3°24' 30'' E, and Latitude 6° 29' 04'' N and Longitude 3° 39' 09''E. It is a region of very high business activity in Lagos State and has a land size of roughly 190.89 square kilometres (Olayinka and Irivbogbe, 2017). Lagos Island has a land area of approximately 8.59 Square kilometres. It is located between Latitude 6° 26' 34'' N and Longitude 3°24' 30'' E on the left and Latitude 6° 27' 38'' N and Longitude 3° 22' 42'' E on the right. In the 2006 Nigerian census, the LGA had a population of 209,437.

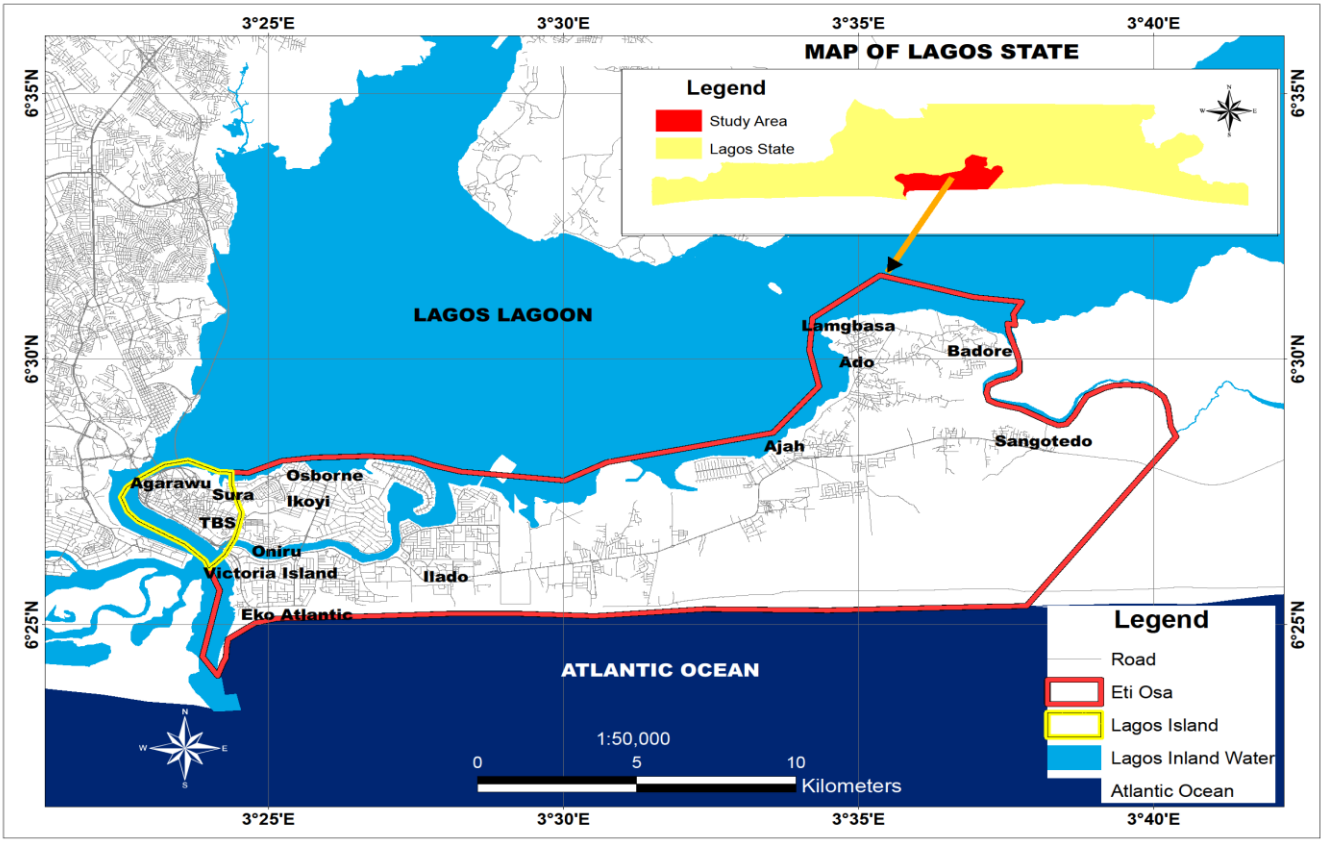

Figure 1: Map of the Study Area

Primary and secondary data were the two main data sources used to create the datasets for this study. The primary data used to undertake an accurate assessment of outcomes from remotely sensed data, such as the classification of land use and land cover, was data that was observed from the location using the Garmin eTrex 32x handheld GPS receiver. Secondary data was information gathered from many sources, including the Lagos State Administrative Map and Landsat photographs. ArcMap 10.2 was used for processing the acquired data. Table 1 lists these facts along with their sources.

Table 1: Data and their attributes

S/N	Data	Source	Year	Resolution/Scale
1	LANDSAT TM ETM+, and OLI/TIRS,	United States Geological Survey (USGS)	1992, 2002, 2013 and 2022	30 m
2	Digital Globe Imagery	Google Earth	2022	1.24 m
3	Lagos State Administrative map	Office of the Surveyor General of Lagos State	-	-
4	GPS coordinates	Field Survey	2022	-

Source (Author)

2.1. Land Use/Land Cover Delineation

The research area's land use and land cover (LULC) were identified using a supervised classification method. An image composite was created using false-colour band composites 5, 4, and 3, with soils ranging from dark to light brown, built-up areas as cyan blue, and vegetation as reddish hues. The panchromatic band (Band 8) was used for image enhancement, raising the resolution to 15 meters. Picture subsetting was performed to remove the study area's image from the Landsat scene. The goal of image classification is to analyze the physical characteristics of objects and settings. The maximum likelihood classifier was used to classify land cover categories in the area, including marshes, bare terrain, water bodies, woods, and shrubs. The accuracy assessment of the classified image was carried out by comparing it with ground coordinates obtained for all land cover types. GPS devices and data from a higher-resolution image were used to obtain and plot the coordinates of sample spots (10 points per land cover category) on the categorised image.

2.2. Detection and delineation of reclaimed land in the study area

The amount of reclaimed land in the study area was determined by overlay analysis. The land use and land cover categorization layer from the initial year (1992) served as the investigation's baseline data. The baseline data was used to identify the locations of the water bodies and wetland areas, and the bare land and built-up area layers from the years 2002, 2013, and 2022 were superimposed over the baseline data to identify the locations where water bodies and wetland had been converted into bare land and built-up areas. The clipped overlaid layers were then used to calculate the spatial extent of the reclaimed area over the research years.

3. RESULTS

The amount of reclaimed land in the study area was determined using overlay analysis. The land use and land cover classification layer from the initial year (1992) served as the investigation's baseline data. The locations of the bare land and built-up area layers from the years 2002, 2013, and 2022 were established by superimposing those layers over the baseline data. The locations of the water bodies and wetland regions were calculated using the baseline data. The clipped stacked layers were then used to calculate the spatial extent of the reclaimed area over the research years.

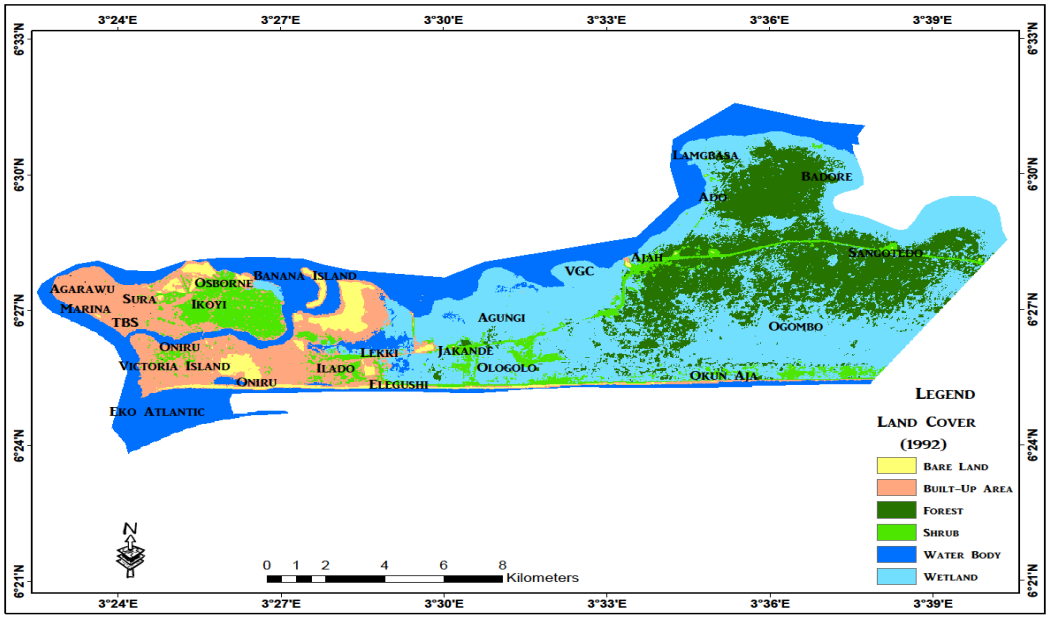

Figure 2: Map showing the land use and land cover map in the year 1992

The 1992 LULC map for the study area reveals various terrain types, including marshes, water bodies, wooded areas, and built-up areas. The eastern part is surrounded by wetlands, while the western part is dominated by marsh and woodland covers. The eastern half contains barren ground on Banana Island, while the eastern half is mostly covered with shrubs. Built-up areas are concentrated in the eastern half, with Marina, Agarawu, Sura, TBS, Oniru, and Victoria Island being the most concentrated. Wetland coverage decreased in 2002 but remained at its peak in areas around the study area's core. Land reclamation led to a concentration of bare land in the western half, while the eastern portion, initially covered with shrubs, experienced growth in built-up areas.

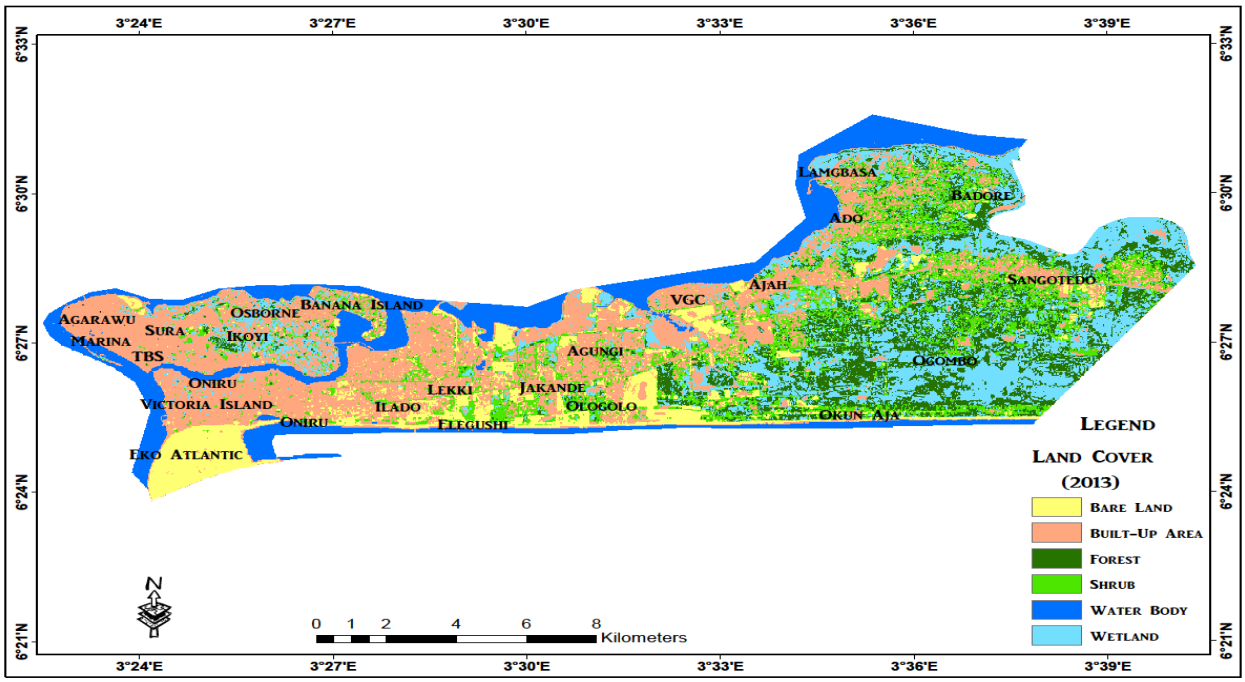

Figure 4: Map showing the land use and land cover map in the year 2013

Wetland decreased in 2013 as the study area's built-up Area rose dramatically. In regions that were formerly covered by wetlands, forests, and bushes, the built-up area increased. Places like VGC, Ajah, Ado, Lamgbasa, Badore, Sangotedo, and a few spots in Ogombo come to mind. Figure 4 demonstrated that there had been substantial land reclamation in the southern regions of the study area, including Ilado, Lekki, Elegushi, Ologolo, etc., with Eko Atlantic City—which had been reclaimed from the Atlantic Ocean—being the most significant. A sizable amount of land reclamation was also seen in the research area's north-western direction, towards Sura (Figure 4).

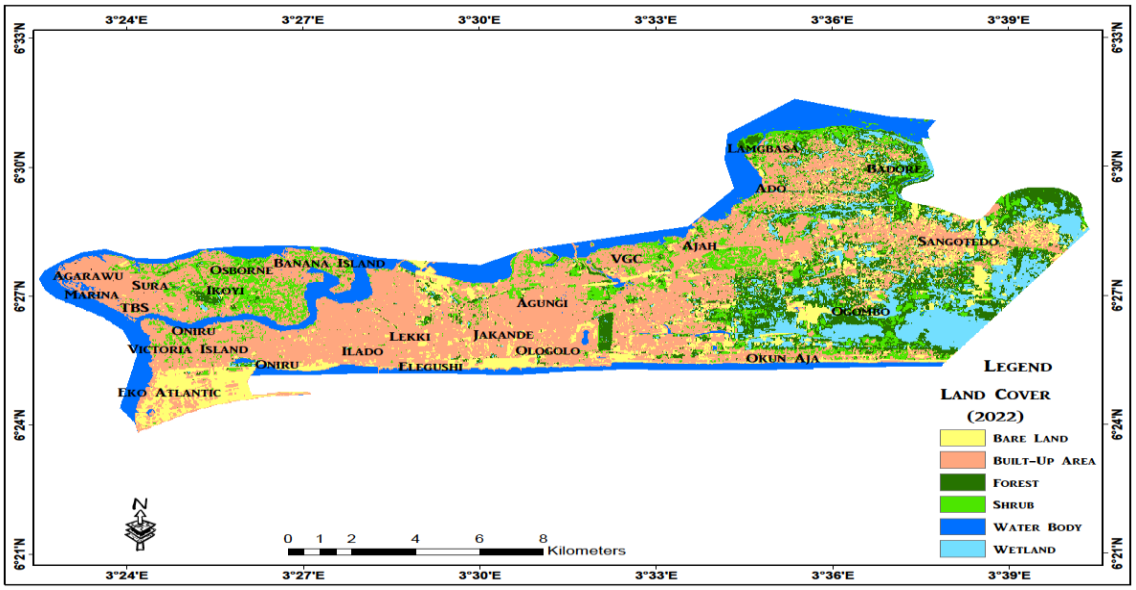

Figure 5: Map showing the land use and land cover map in 2022

A significant amount of natural land cover categories, including wetland, woodland, and water bodies, will have been converted into built-up areas by the year 2022, signalling extensive land reclamation in the study region. Built-up regions have largely encompassed places like Lekki, Agungi, Jakande, Victoria Island, and other places. Figure 5 demonstrates how Eko Atlantic City is progressively becoming a built-up area, which is proof that urban development was accomplished through land reclamation. For the years 1992, 2002, 2013, and 2022, the spatial extent or area of coverage (Square kilometres) of each land use and land cover category was estimated. This was done to ascertain the degree of physical changes brought on by human activity over time in the environment, as indicated in Table 2.

Table 2: Extent of land use and land cover from 1992 to 2022

S/N	Land Cover	1992 (Sq. km)	%	2002 (Sq. km)	%	2013 (Sq. km)	%	2022 (Sq. km)	%
1	Bare Land	6.1	3.0	14.8	7.3	20.2	9.9	24.6	12.0
2	Built-Up Area	25.6	12.5	36.8	18.0	62.0	30.3	89.1	43.6
3	Forest	41.3	20.2	38.1	18.6	26.0	12.7	25.8	12.6
4	Shrub	16.3	8.0	24.9	12.2	28.8	12	24.0	11.7
5	Water Body	41.5	20.3	34.5	16.9	28.8	12	23.9	11.7
6	Wetland	73.8	36.1	55.4	27.1	38.7	18.9	17.2	8.4
	TOTAL	**204.5**	**100.0**	**204.5**	**100.0**	**204.5**	**100.0**	**204.5**	**100.0**

The study area, covering 204.5 sq. km, is characterized by various land use and land cover types, including bare land, urban areas, forests, shrubs, water bodies, and wetland areas. Between 1992 and 2022, built-up areas and bare land increased, mainly due to the transformation of wetlands, forests, and water into bare land and land reclamation. Accuracy assessment of derived land use and land cover (LULC) classes was conducted for the years 1992, 2002, 2013, and 2023. Methods such as User Accuracy, Producer Accuracy, Overall Accuracy, and Kappa Coefficient were used to determine the accuracy of classified LULC classes. Overall Accuracy (%) was calculated by dividing the number of correctly classified pixels by the total number of reference pixels.

Table 3: Confusion matrix of derived LULC classes for the years 1992, 2002, 2013 and 2023

Category	Year	Bare land	Built-Up Area	Forest	Shrub	Water Body	Wetland
User Accuracy (%)		81.8%	90%	80%	77.8%	88.9%	90.9%
Producer Accuracy(%)		90%	90%	80%	70%	80%	100%
Overall Accuracy (%)				85%			
Kappa Coefficient (T)	1992			0.82			
User Accuracy (%)		83.3%	90.9%	100%	80%	100%	100%
Producer Accuracy(%)		100%	100%	80%	80%	90%	100%
Overall Accuracy (%)	2002			91.7%			
Kappa Coefficient (T)				0.90			
User Accuracy (%)		88.9%	87.5%	75%	90.9%	100%	90%
Producer Accuracy(%)		80%	70%	90%	100%	100%	90%
Overall Accuracy (%)	2013			88.3%			
Kappa Coefficient (T)				0.86			
User Accuracy (%)		100%	90%	83.3%	83.3%	100%	100%
Producer Accuracy(%)		90%	90%	100%	100%	80%	100%
Overall Accuracy (%)	2022			93.3%			
Kappa Coefficient (T)				0.92			

The categorised LULC for the study years and the ground truth agree, according to the Kappa coefficients for the study years (1992, 2002, 2013, and 2022), which were 0.82, 0.90, 0.86, and 0.92, respectively, and were all near to 1. Additionally, finding 85%, 91.7%, 88.3%, and 93.3% for the years 1992, 2002, 2013, and 2022 demonstrated that the ground truth and the categorised LULC for the research years concur. Therefore, it can be said that the classified LULC for the years 1992, 2002, 2013, and 2022 is correct and that the information gleaned from it yields trustworthy findings. Land reclamation has been occurring both in Lagos Island and Eti-Osa Local Government Areas, in which land reclamation occurs on areas initially covered by wetlands and water bodies. To determine the spatial extent of land reclaimed for the past 30 years (1992 to 2022) in the study area, the areas covered by water bodies and wetlands from the year 1992 were mapped out (Figure 6), which served as the baseline data for land reclamation in the study area.

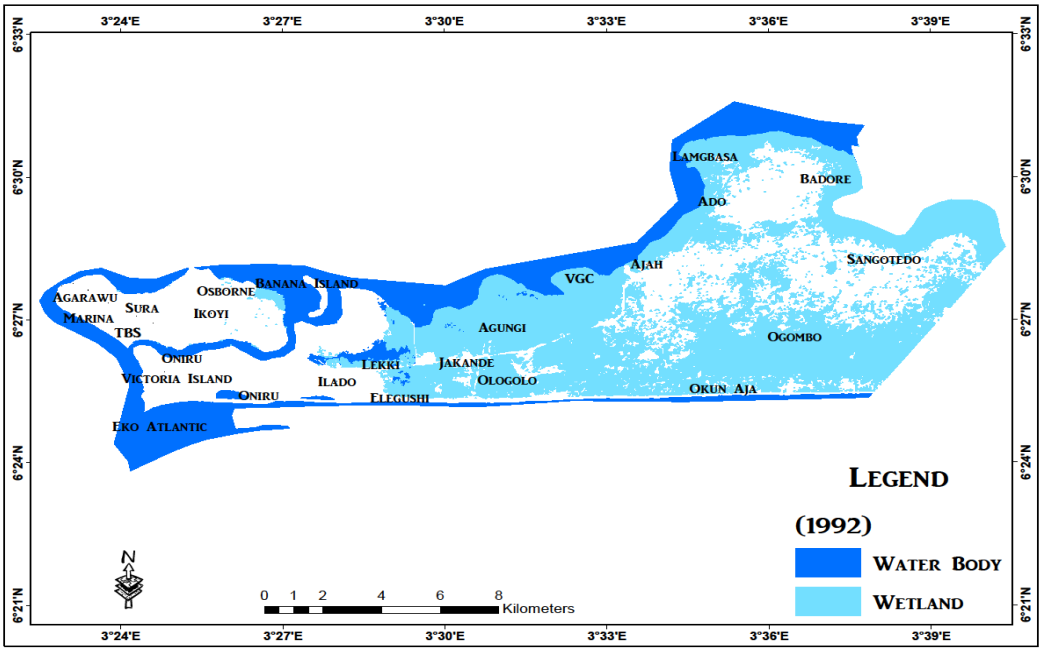

Figure 6: Map showing areas covered by wetlands and water bodies for the year 1992

Figure 4.11 shows areas covered by wetlands and water bodies in the study area in the year 1992. The map showed that large areas in the study area are covered by wetland land and water bodies. In the study area, as wetland covered 73.8 (36.1%) and the water body covered 41.5 Sq.km (20.3%), which showed that both wetland and water bodies covered 56.4% of the entire study area in the year 1992. Therefore, the spatial extent of reclaimed areas will be calculated from areas encroached by bare land and built-up areas on water bodies and wetlands between 1992 and 2002, 1992 and 2013 and 1992 and 2022, as shown in Figures 7 to 9.

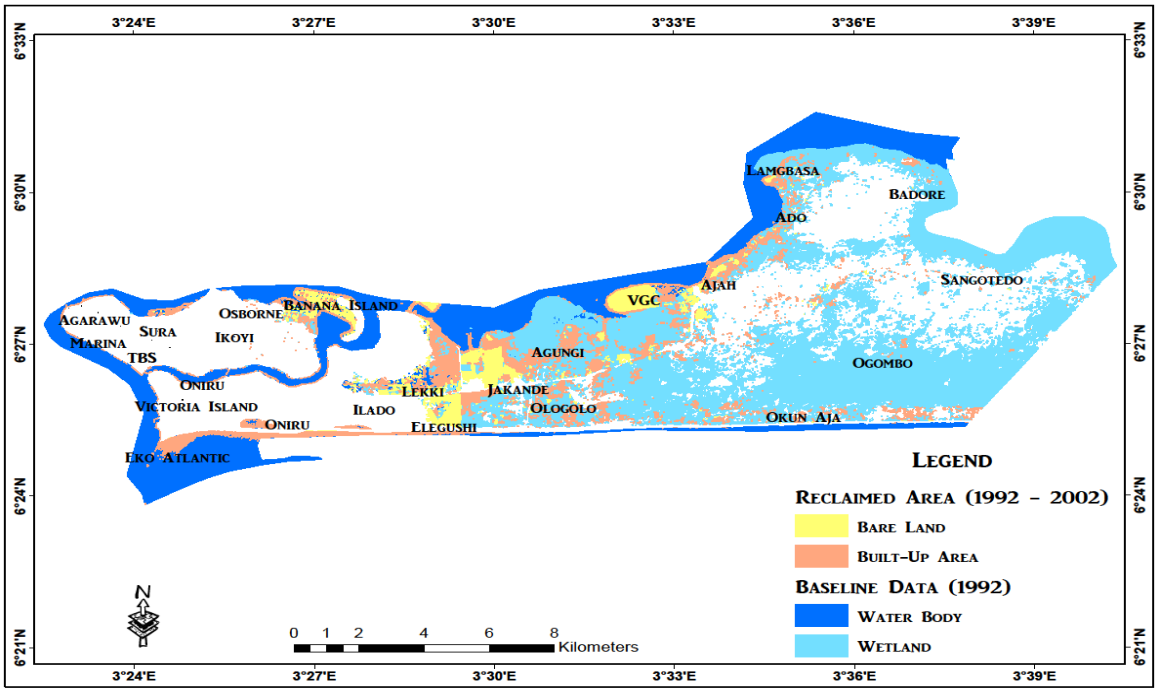

Figure 7: Map showing reclaimed areas between 1992 and 2002.

From Figure 7, it was deduced that between 1992 and 2002, land reclamation occurred as bare land, which is sand-filled areas and built-up areas encroached on wetlands and water bodies in areas such as Banana Island, Lekki, Elegushi, Victoria Garden City (VGC) and Ajah area. Figure 8 shows that reclaimed areas within the study area further expanded to different areas in the year 2013.

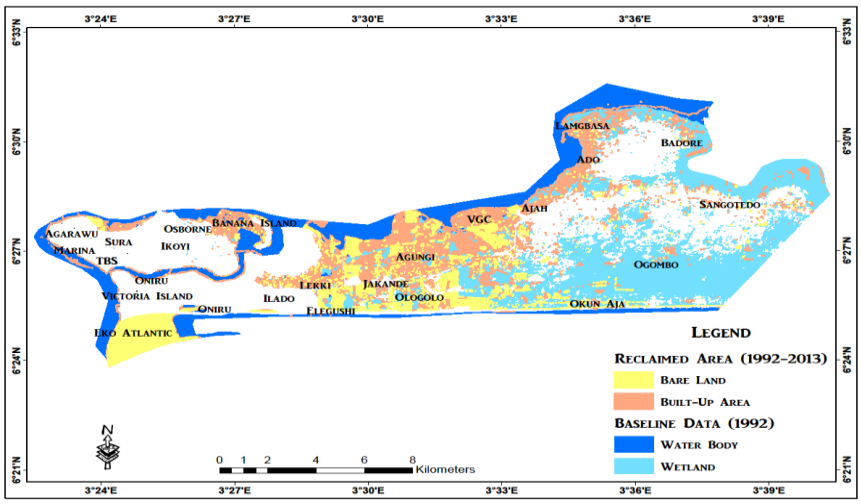

Figure 8: Map showing reclaimed areas between 1992 and 2013.

Figure 8 shows the further spread of land reclamation in the year 2013. From Figure 8, it was observed that land was reclaimed in the Eko Atlantic area, Ologolo area, and Oku-Aja area which was not reclaimed as of 2002. Areas such as Banana Island, Victoria Garden City (VGC), Ajah, and parts of Lekki which were reclaimed between the period of 1992 and 2002 were developed and transformed from bare land to built-up areas. It was also observed that enormous land reclamation and land conversion from bare land to built-up area was carried out at Agungi and Lamgbasa areas (Figure 8). Land reclamation between 1992 and 2022 was also assessed as shown in Figure 9. Figure 9 shows that reclaimed areas within the study area further expanded to different areas in the year 2022.

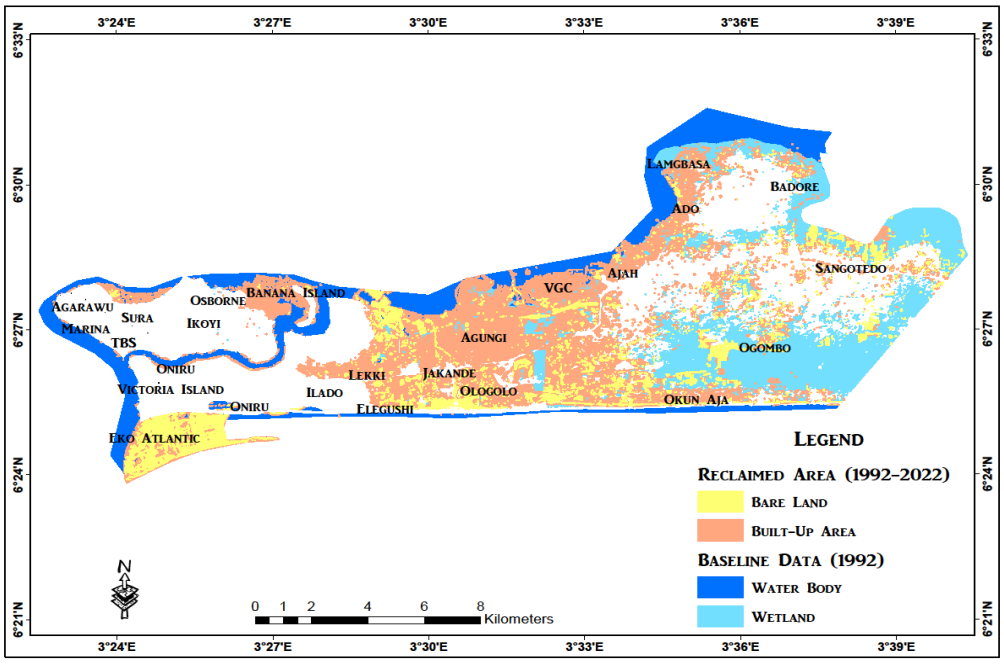

Figure 9: Map showing reclaimed areas between 1992 and 2022

Figure 9 shows that the reclaimed land in Eko-Atlantic is being transformed into a built-up area, and also in some areas such as the Okun Aja area. It was also observed in Figure 9 that built-up area has also increased in the reclaimed areas across the study area in areas such as Banana Island, Lekki, Agungi, Victoria Garden City (VGC) Ajah, Ado, Lamgbasa, Sangotedo, Ogombo, Okun Aja etc. To further analyse the reclaimed land in the study area over the years, the spatial extent of reclaimed land from the water body and wetland in the study area was calculated from the period between 1992 and 2002, 1992 and 2013, and 1992 and 2022 (Table 4).

Table 4: Spatial Extent of reclaimed areas between the study periods

Period	Bare Land (sq. km)	Built-Up Area (sq. km)	Total (Sq. km)
1992 - 2002	5.4	11.0	16.4
1992 - 2013	12.6	22.3	34.9
1992 - 2022	13.2	36.6	49.8

Table 4, it was shows that the area of bare land and built-up area reclaimed between the period 1992 to 2002 was 5.4 Sq.km and 11.0 Sq. km and the total reclaimed land was 16.4 Sq.km. Between the period of 1992 and 2013, the bare land reclaimed increased to 12.6 Sq.km and the built-up area also increased to 22.3 Sq.km, and the total reclaimed land was 34.9 Sq.km. Also, between the period of 1992 and 2022, the bare land reclaimed increased to 13.2 Sq.km the built-up area also increased to 36.6 Sq.km, and the total reclaimed land was 49.8 Sq.km, which indicates that land reclamation has been on the increase in the study area between the period of 1992 and 2022 (Figure 4.10).

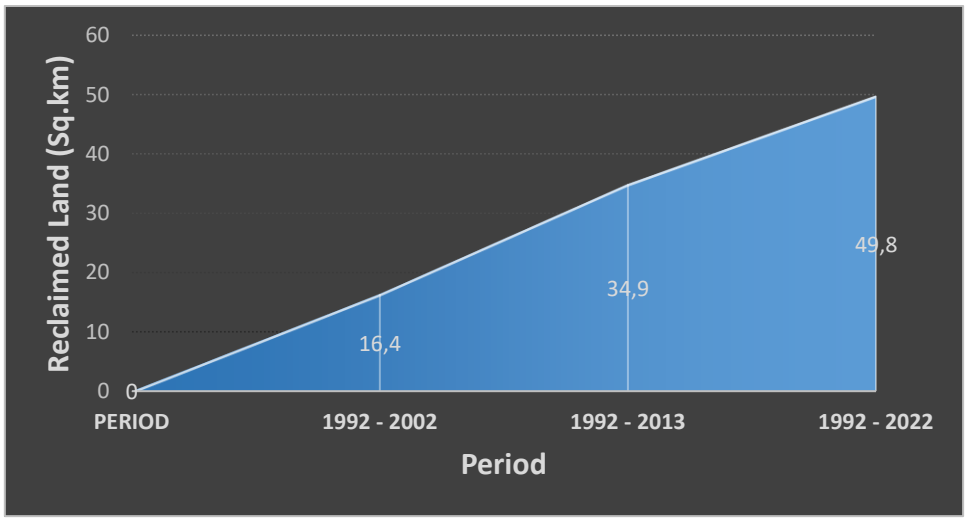

Figure 4.10: Chart showing the Spatial Extent of reclaimed areas from 1992 to 2022

4. DISCUSSION

The study examined the land use and land cover (LULC) in Lagos Island and Eti-Osa Local Government Areas of Lagos State from 1992 to 2022. The results showed a trend of increased built-up areas and bare land due to the conversion of major wetlands, forests, and bodies of water into bare land and the development of these bare land into built-up areas through massive land reclamation. Urban growth and development can increase environmental risks, such as flash flooding, pollution, and air pollution. Habitat loss and deforestation due to migration and population growth may result in a reduction in species populations, ranges, biodiversity, and interactions between organisms. Urban development also contributes to the environment through the spread of

diseases, rising regional temperatures, and increased water runoff. Land reclamation can restore the land to its former glory, but it can also negatively impact coastal habitats, degrade soil and water quality, and affect benthic animal and microbial populations, fisheries, and ecosystem functioning and services. Uncontrolled urbanization has a negative influence on human life due to land reclamation.

5. CONCLUSION

The study analyzed land reclamation activities in Eti-Osa and Lagos Island, Lagos State, to reduce natural hazards like water overflow and flood inundation. The research area land use and cover categories include bare lands, built-up areas, forests, shrubs, water bodies, and wetlands. The increase in built-up areas and bare land from 1992 to 2022 indicates urban growth. Land reclamation on water bodies and wetlands has also contributed to urban growth. The influence of land reclamation on population exposure to water overflow was found to be greater in areas with reclaimed lands, making them more susceptible to water overflow and prone to flooding. Flood inundation at various heights also revealed the level of inhabitants' sensitivity to flood dangers. To address this issue, land reclamation should be allocated to different purposes, such as open space, vegetated space, and maintaining wetlands, to provide an absorption and storage area for storm runoff.

6. AUTHOR'S CONTRIBUTIONS

Conceptualization, A.O.O, Methodology M.O.I, A.O.O, H.T; Software A.O.O; writing original draft A.O.O; formal analysis A.O.O; writing review and editing M.O.I, A.O.O, H.T; supervision M.O.I

7. ACKNOWLEDGEMENT

The authors thank the reviewers for their remarks and comments on the work.

8. CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest

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10. KEY TERMS AND DEFINITIONS

Land reclamation is the process of creating new land by altering and modifying the natural environment, typically by filling in bodies of water such as oceans, seas, lakes, or wetlands. This practice is often used to expand available land for various purposes, such as urban development, agriculture, infrastructure projects, and industrial facilities.

Land Use and Land Cover (LULC) are two related concepts that are used to describe and categorise the ways in which land is utilised and the types of surfaces that cover the Earth's surface. These concepts are crucial to understanding the interaction between human activities and the natural environment.

Delineate means to define, describe, or mark the boundaries or limits of something clearly and precisely. Furthermore, it is used to emphasise the need for clear, well-defined boundaries, whether they are physical, conceptual, or visual.

Hazards refer to potential sources of harm, danger, or risk that can pose threats to individuals, communities, the environment, or assets. Hazards can come in various forms, and they are typically characterised by their potential to cause negative impacts, whether immediate or over time.