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RESEARCH ARTICLE:

Quantifying Ecosystem Services and Environmental Dynamics in Lagos State's Coastal Zones

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Abstract

Coastal regions are experiencing rapid urbanization, leading to substantial land use and land cover (LULC) transformations that profoundly impact the environment, livelihoods, and ecosystem services, and this has become a concern for environmentalists. However, research linking dynamics to ecosystem service valuation in this critically important ecoregion is rarely studied. This study attempts to bridge this gap by quantifying the ecosystem services in Lagos, Nigeria's rapidly urbanizing coastal region. A multi-temporal Landsat imagery of 2003, 2013, and 2023 was employed to map LULC categories in the region. Furthermore, the Value transfer method was employed to estimate the ecosystem services in each LULC type. The estimated ecosystem service values revealed significant transitions, with an overall decline of $985.01 million from 2003-2013; built-up areas experienced the most significant increase, rising with $47.06 million, while mangrove forests saw the most significant decline, dropping to $ 602.86 million. Between 2013 and 2023, built-up continue to exhibit the most significant increase in value, with $15.72 million. Conversely, mangroves experienced a sharp decline, decreasing with $153.52 million. The valuation of LULC-associated ecosystem services in Lagos's coastal zone highlights the urgent need to integrate environmental accounting into coastal management.

Keywords: *coastal region; sustainability; ecosystem service; ecosystem service valuation; LULC*

Introduction

The cost of allowing land to deteriorate is becoming increasingly apparent for local owners and society, both in the short and especially in the long run (Turner *et al*., 2016: 191). This makes the study of land use and land cover (LULC) hold primary importance in modern environmental research and management, providing a critical understanding of landscape transformations, the impact of human activities on ecosystems, and the assessment of natural resources (Long *et al*., 2021: 903). Changes in LULC from natural ecosystems have affected biotic diversity and reduced their ability to continuously provide society with products and services necessary for the survival of the current and future generations (Arowolo *et al*., 2018: 2). These insights are crucial for informed decision-making in urban planning, agriculture, freshwater swamp management, wetland conservation, and disaster management. An ecosystem, the spatial expression of an area over the Earth's surface, is an integrated part of the environment, with each ecosystem providing unique services (Chatterjee *et al*., 2022). These range from providing services that directly affect people (like food, water, and fuel) to regulating (like water purification and climate regulation) and providing cultural services (such as recreation and aesthetic values) that largely indirectly affect people (like soil formation and erosion control). Ecosystem services are non-excludable; once given by nature or the environment, they benefit everyone in the impacted area. Without paying for it (Lant *et al*., 2008: 973). Their services are necessary for human existence, well-being, and livelihoods (Costanza *et al*., 1997: 2). However, humans still need to appreciate and recognize those services' invaluable nature fully.

Africa is home to a high number of developing countries, and more than half of its rural population is entirely reliant on ecosystem services (Jamouli and Allali, 2020: 1). Nevertheless, many ecosystems in the region are severely

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degraded, resulting in biodiversity loss and disruption of ecosystem functioning and services. This degradation is due to the variety of anthropogenic stressors faced in Africa, such as rapid population increase, rising demand for food, water, and energy, climate change, and overexploitation of natural resources (Jamouli and Allali, 2020: 2). Globally, the resilience and economics of coastal communities rely heavily on ecosystem services; coastal regions house one-third of the world's population and are twice as densely populated as inland places, although making up only 4% of the planet's total land area and 11% of its ocean area (Mehvar *et al*., 2018: 2). There is a growing concern over how to lessen the adverse effects of urbanization and economic growth on natural ecosystems and the services they provide on a global scale (Wang *et al*., 2019: 826). The fact that many of the services provided by these ecosystems are public goods that are not sought after by the market presents a significant issue in that their economic worth is not widely recognized. De Groot *et al*. (2012: 3) noted that the ability of ecosystems to consistently provide the flow of ecosystem services for both the current and future generations is threatened by ecosystem degradation and biodiversity loss, which impair ecosystem resilience and functioning.

These risks are anticipated to worsen due to climate change and human resource demand. It is no longer possible to approach biodiversity, and the ecosystem services it supports as limitless and free 'goods', it is necessary to appropriately account for their actual value to society and the costs associated with their loss and degradation. (DeGroot *et al*., 2014) Valuating ecosystem services economically make their immense contributions to society and the economy more visible by quantifying ecosystem services in units such as dollars (Costanza *et al*., 1997: 4). Historically, research on ecosystem services in Nigeria's coastal regions has been constrained by its broad emphasis, compartmentalized approach, and possibly biased methodology. Past studies have either provided nationwide overviews (Arowolo *et al*., 2019) or concentrated on single local governments (Adegboyega *et al*., 2019) or specific ecosystems (Israel, 2021), resulting in a lack of comprehensive, localized understanding. While some research has examined spatial and temporal changes in ecological assets due to rapid urban expansion in western Lagos State (Obiefuna *et al*., 2021) and the impact of wetland loss on surface water flow management (Israel, 2021), a holistic spatiotemporal analysis of land use and land cover (LULC) changes in this rich coastal ecoregion has been lacking. These past trends have left significant gaps in the understanding of coastal ecosystem services in Nigeria. To address these limitations, this study aims to provide a more comprehensive assessment by analysing all land cover types across six coastal local governments, employing value transfer techniques for valuation. This approach seeks to offer a more nuanced, literature-based evaluation of ecosystem services in Nigeria's critical coastal regions, potentially contributing to more effective coastal management strategies and filling the void in understanding the complex patterns and primary drivers of LULC changes in this ecologically significant area. Accurate mapping and assessment of LULC dynamics are paramount for quantifying ecosystem services and informing sustainable management strategies within any region (Mengist *et al*., 2022: 1).

Bridging these technical and significant research gaps through robust spatiotemporal assessments and ecosystem services valuations is crucial for informing sustainable environmental management strategies and conservation efforts tailored to the unique characteristics and challenges of the Lagos coastal environment. To accomplish this aim, satellite imagery, broadly embraced as a valuable method for fast information collection to assess the dynamic changes of natural objects, natural resources, and the Earth's surface generally (Aminigbo, 2021: 4), is employed. In addition, the study integrated one of the most valuable tools- the Geographical Information System (GIS) to uncover complex interdependencies between urbanization, environmental factors, and socio-economic drivers (Ibrahim, 2022: 4). The study periods (2 decades) allow for a balanced comparison of ecosystem changes over equal time facilitating the identification of long-term pattern and trends the 2003-2023 study periods includes the most recent available quality Landsat data ensuring an analysis that captures current ecosystem dynamics—facilitating the identification of long-term trends and patterns. Also, it is envisaged that the output of this research will contribute valuable insights essential for sustainable land management and coastal resilience planning in the Lagos Coastal region. Furthermore, it will serve as a foundation that can be deployed for valuation in other coastal regions across the continent.

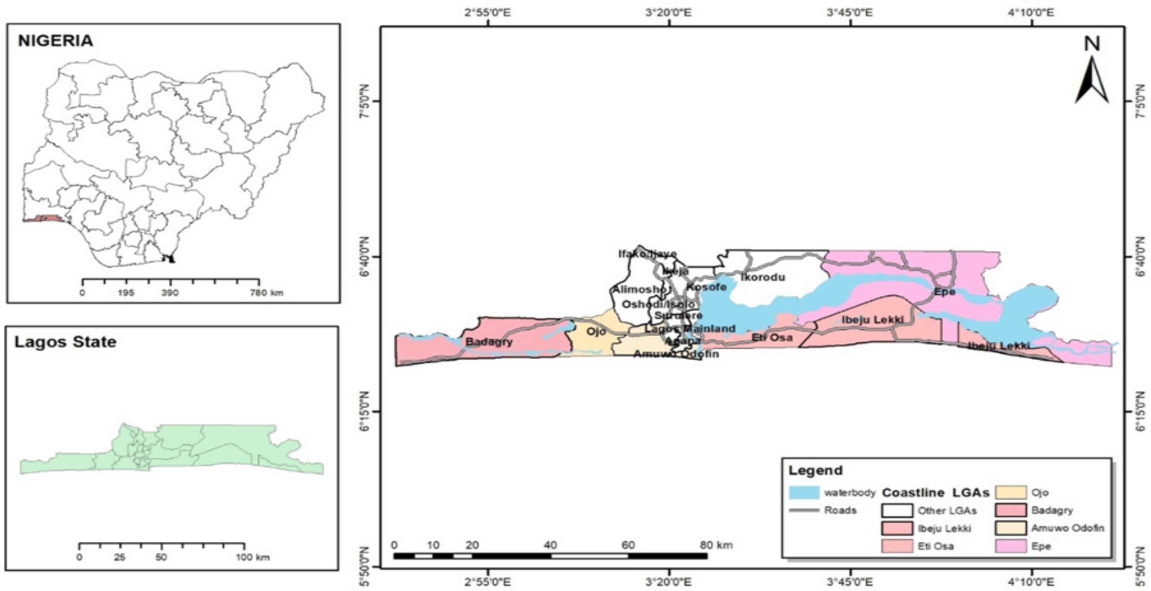

Figure 1: Map of the study area

Methods, Materials and Study Area

Lagos, the current economic hub of Nigeria, is a coastal city characterized by its low-lying topography and abundant ecological assets, including lagoons and wetlands. The Lagos Lagoons, the largest of which spans 646 square kilometres, are surrounded by wetlands (Ajibola *et al*., 2012). Geographically, Lagos State is situated on the confined coastal floodplain along the Bight of Benin in the southwestern region of Nigeria. Its coordinates range approximately from latitude 6.5244° N to 3.3792° N and longitude 2.6869° E to 4.5838° E. The state shares its borders with the Republic of Benin to the west, Ogun State to the north and east, and the Atlantic Ocean to the south. Administratively, Lagos State is divided into five major divisions: Ikeja, Badagry, Ikorodu, Lagos Island, and Epe. These divisions were further subdivided into 20 Local Government Areas (LGAs) during the establishment of Nigeria's States and LGAs in 1999. This research considers six local governments in the coastal areas, namely Ibeju Lekki, Eti Osa, Badary, Amuwo odofin, Ojo, and Epe.

The multispectral datasets required for this research were obtained from the USGS Landsat Archive (*https://earthexplorer.usgs.gov*). The study area covers three scenes of the Landsat image catalog: Path 191/Row 55, Path 191/Row 56, and Path 190/Row 56. Landsat 7 Images of the selected scenes for 2003 and 8 Images of the exact location for 2013 and 2023 were downloaded from the online archive. The analysis carried out on the data includes band combination, image mosaicking, image subsetting, image classification, and accuracy assessment. The combination of bands in Landsat ETM+ and OLI imageries is efficient for the extraction of various LULC features, notably from the coastal area, according to (Fortier et al., 2019) report on image processing. In this analysis, for the year 2003, the study made use of band 1 (0.45-0.51), band 2 (0.5-0.60), band 3 (0.63-0.69), band 4 (0.76-0.89), and band 5 (1.54-1.75) of the Landsat ETM+ and for the years 2013 and 2023, band 2 (0.45-0.51), band 3 (0.5-0.60), band 4 (0.63-0.67), band 5 (0.85-0.87), and band 6 (1.56-1.65) OLI images are combined into a multispectral image for land feature extraction.

In Erdas Image geoprocessing software, the training sets were derived from polygons drawn on consistent groups of pixels to derive the spectral signature for the different LULC types, as stated above. Spectral signatures for the respective LULC types derived from the satellite imagery were recorded by using the pixels enclosed by these polygons. A false-colour composite image was created from these raw datasets in the same software environment by combining the selected stated bands. The three Landsat scenes were mosaicked together in the same software environment. While sub-setting into the study area, the maximum likelihood algorithm was used to classify the image into the following classes: built-up, bare surface, wetland, waterbody, cultivated land, mangrove, freshwater swamp, and shrubland. Field observation of the study area (Figure 1) was used to support the image classification procedure to enhance the accuracy of the classified image. For each land use and LULC dataset, the accuracy assessment was carried out by randomly locating 10 points per each land use and LULC class. Furthermore, the error matrix was then calculated, and the quantity and allocation disagreement (QADI) was run to derive the overall classification accuracy for the years under study. Typically, the error matrix is saved for use with the QADI calculator plugin (Feizizadeh *et al*., 2022: 4). The methodology flow chart is shown in (Figure 2).

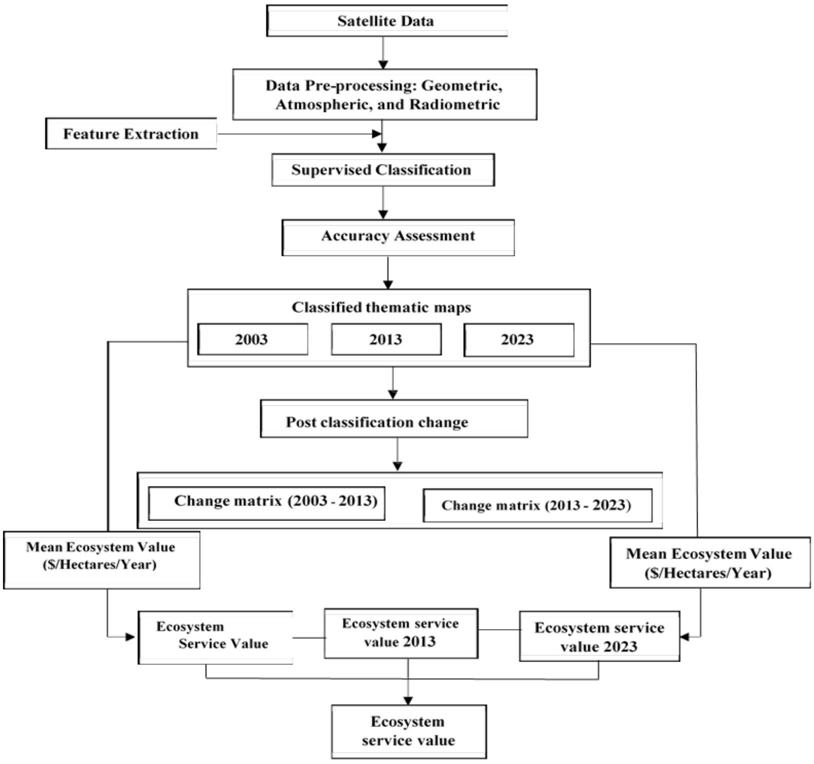

Figure 2: Flow chart of the methods

The post-classification comparison technique, encompassing the change detection matrix, was used to estimate the changes in land use and land cover features using the Land Change Modeler (LCM) in Terrset Geospatial software. LCM was used to analyse land cover change, empirically model the relationship between land cover and its explanatory variables, and project future changes (Salem *et al*., 2020: 4). The module readily provides the change detection on location, amount, and spatial trends with graphs, maps, and tabular data including the transition information between the three-years understudy.

Furthermore, this study used the value transfer method (VTM) (De Groot *et al*., 2012). Using this approach, the value of an ecosystem function is ascertained by using an existing valuation estimate for a comparable ecosystem in another location entirely. While there are many developing approaches for categorizing, measuring, and valuing ecosystem services, it is still unclear which approach is best or is limited to the preferences of the researcher (Legesse *et al*., 2022 :3). Several scholars more recently like (Arowolo *et al*., 2018; Grammatikopoulou *et al*., 2023) have effectively used the VTM with excellent and satisfactory outcomes. When highly complex primary monetization strategies are unfeasible due to financial, time, or other constraints, value transfer (VT) processes and other indirect valuation techniques can serve as a workable workaround (Brander, 2013). Furthermore, the ease of use of accessible valuation databases and the ability to draw on existing data make the value transfer method attractive (Obst *et al*., 2016: 1). The ecosystem value for each land use was calculated using Equation (1.1.)

$$ESV = \Sigma\ (A\text{k}\ x\ VC\text{k}) \qquad (1.1)$$

ESV represents the estimated ecosystem value in dollars per hectare per year ($/ha/yr). *Ak* signifies the area, while *VCk* represents each land use category's value coefficient ($/ha/yr). Table 1 shows the Mean Ecosystem Service Value for each land use and cover type.

Table 1: Mean ecosystem service value

Landuse / Landcover		Mean Ecosystem Value ($/Hectares/Year)
1	Builtup	844
2	Baresurface	0
3	Wetland	25682
4	Mangrove forest	193845
5	Water body	4267
6	Shrubland	1588
7	Freshwater swamp	5264
8	Cultivated land	141

Source: (De Groot *et al.*, 2012: 6)

The ESV is expressed in $/ha/yr. The change in ecosystem service values was estimated by calculating the difference between the estimated values for each land-cover category in 2003, 2013, and 2023.

Results and Discussion

This section examines the qualitative assessment of ecosystem service values in the study area, presenting key findings from multiple analytical approaches to provide a comprehensive assessment of the coastal ecosystem under study.

Land-use landcover analysis for the year 2013

The land use/landcover analysis was first presented, followed by the trend analysis of land-use changes for the study period. The result of the land landcover classification for the year 2003 shows that water swamps, shrubland, and water bodies were the dominant land classes, accounting for 28.22%, 26.62%, and 24.62%, respectively. In addition, Mangrove Forest, Bare-surface, and cultivated land had the least area coverage, with less than 1 %. Further analysis shows that the built-up areas and wetlands resulted in 11.54% and 7.87%, respectively. The comprehensive analyses of the results are shown in Figure 3 and Table 2. The realization of the QADI index value (0.05341) implies the accuracy and reliability of the result.

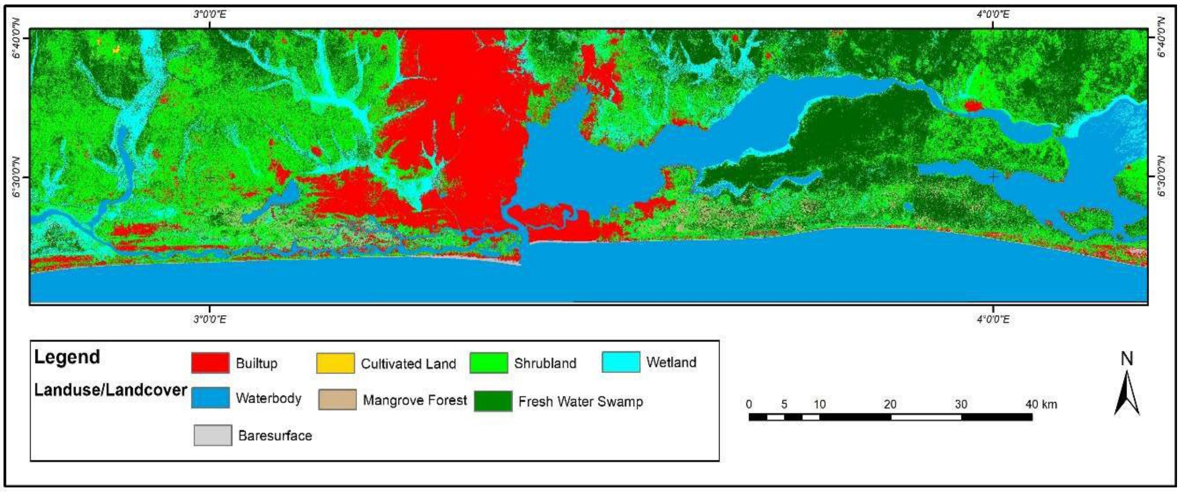

Figure 3: Results of analysis of land-use and landcover for the year 2003

Table 2: Land-use and landcover statistics for the year 2003

Class	Pixel count	Area (sqkm)	Percent Cover (%)
Built-up	997059	897.35	11.54
Bare-surface	32383	29.14	0.37
Wetland	680454	612.41	7.87
Waterbody	2128182	1915.36	24.62
Mangrove forest	63752	57.38	0.74
Shrubland	2300971	2070.87	26.62

Freshwater swamp	2439343	2195.41	28.22
Cultivated land	1580	1.42	0.02

Author's field survey, 2024

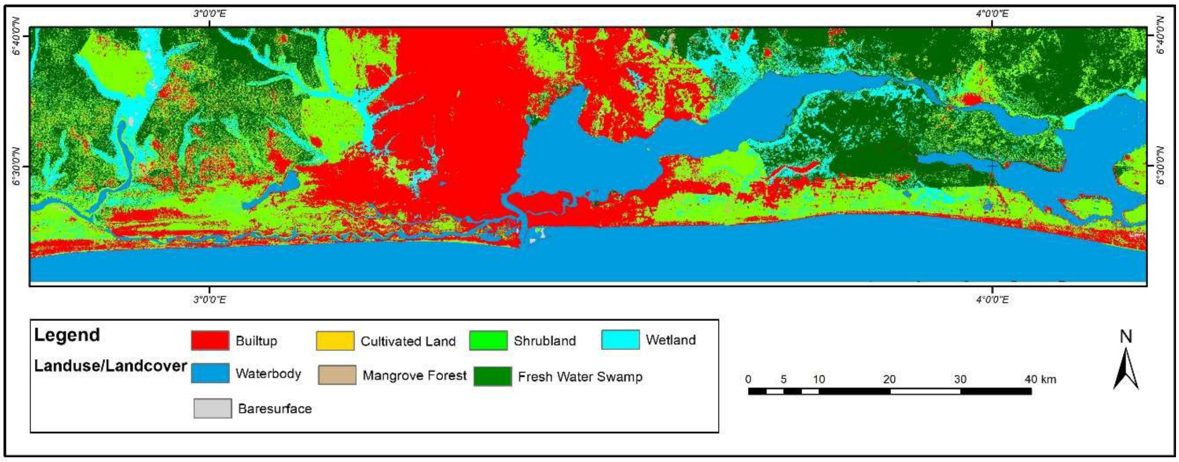

Figure 4: Results of analysis of land-use and landcover for the year 2013

Table 3: Land-use and landcover statistics for the year 2013

Class	Pixel count	Area (sqkm)	Percent Cover (%)
Built-up	1616596	1454.94	18.7
Bare surface	31949	28.75	0.37
Wetland	425979	383.38	4.93
Waterbody	2034774	1831.3	23.54
Mangrove forest	33374	30.04	0.39
Shrubland	2285743	2057.17	26.44
Freshwater Swamp	2211502	1990.35	25.58
Cultivated land	4035	3.63	0.05

Author's field survey, 2024

Land-use landcover analysis for the year 2023

The result of this analysis shows that shrubland accounted for the largest size, 24.71% of the entire study area. This was followed by Freshwater swamp, waterbody, and built-up, recording 23.72%, 23.47%, and 21.12%, respectively (Figure 5 and Table 4). While wetlands recorded about 6.31% of the entire land use of the study area, Bare-surface, Mangrove Forest, and Cultivated land recorded the least with less than 1 % each.

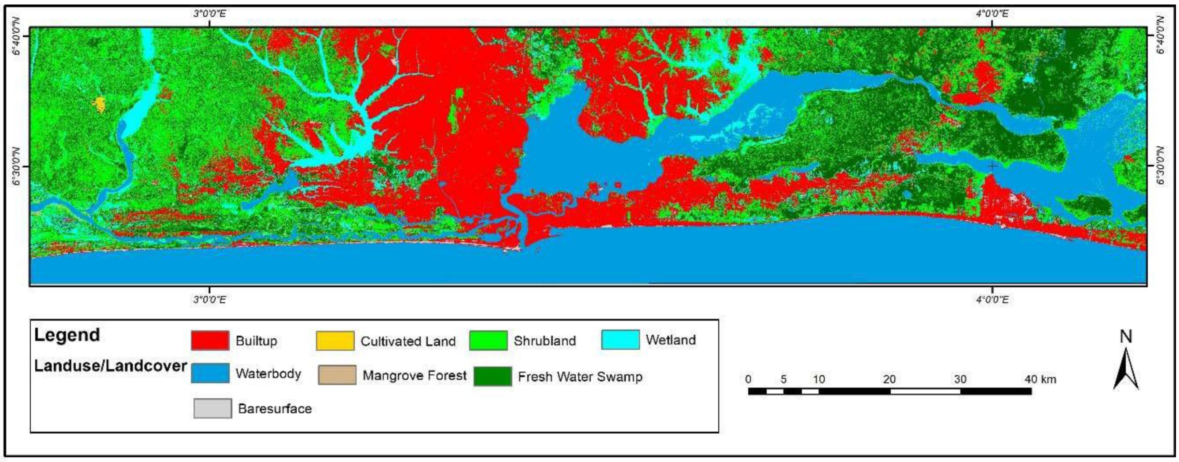

Figure 5: Results of analysis of Land-use and landcover for the year 2023

Table 4: Land use and landcover statistics for the year 2023

Class	Pixel count	Area (sqkm)	Percent Cover (%)
Built-up	1823506	1641.16	21.12
Bare-surface	29216	26.29	0.34
Wetland	544482	490.03	6.31
Waterbody	2026989	1824.29	23.47
Mangrove forest	20399	18.36	0.24
Shrubland	2133878	1920.49	24.71
Freshwater swamp	2048590	1843.73	23.72
Cultivated land	8226	7.4	0.1

Author's field survey, 2024

Comparative Analysis between 2003 and 2013

In the study area, transitions of land use and land cover classes were observed, which were attributed to driving some environmental degradation, as stated earlier. In the analysis of Land use and land cover change (Table 5), the built-up and cultivated areas experienced a gain between 2003 and 2013 with a value of 557.59sqkm (62.14%) and 2.21 sqkm (155.63%). While the remaining land use and landcover classes experienced losses in terms of; wetland: -229.03 (37.4% loss), bare surface: -0.39 sqkm (1.34% loss). This indicated that built-up and cultivated land dominated the other land use, which could be attributed to an increase in urban population resulting in an increase in food production. The result also shows that the changes mainly affected wetlands, freshwater swamps, and mangrove freshwater swamps, recording 13.87%, 14.64%, and 54.20%, respectively. This implies that human activities are fast affecting these land uses.

Table 5: Land-use and landcover change between years 2003 and 2013

Class	2003 Area (sq km)	2013 Area (sq km)	Change	Percent Change (%)
Cultivated land	1.42	3.63	2.21	**155.74**
built-up	897.35	1454.94	557.59	**62.14**
Bare-surface	29.14	28.75	-0.39	**-1.34**
Shrubland	2070.87	2033.23	-37.64	**-1.82**
Waterbody	1915.36	1831.30	-84.06	**-4.39**
Wetland	612.41	527.45	-84.96	**-13.87**
Freshwater swamp	2195.41	1873.97	-321.44	**-14.64**
Mangrove forest	**57.38**	**26.28**	**-31.10**	**-54.20**

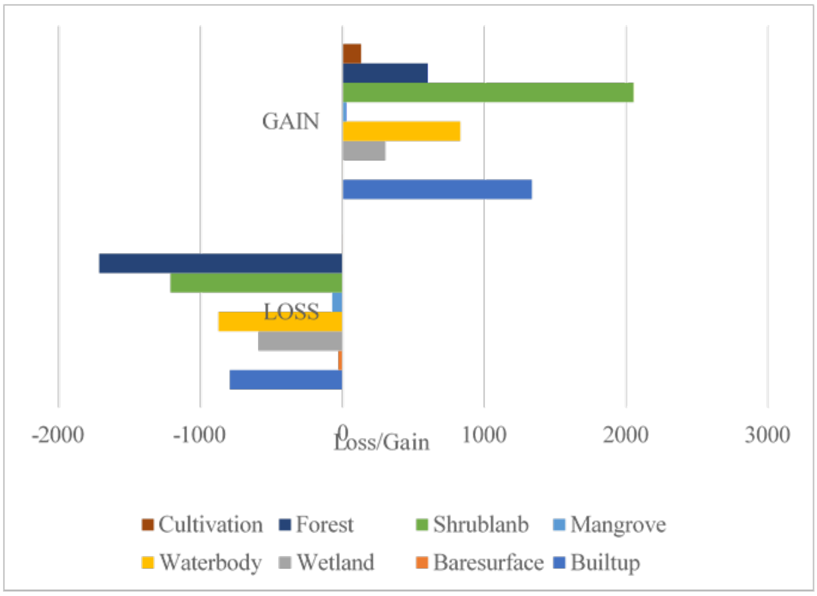

Figure 6: Graphical representation of loss and gain between 2003-2013

Comparative Analysis between 2013 and 2023

The comparative analysis of the landcover result between the years 2013 and year 2023 shows a similar trend to the result between the years 2003 and 2013, with Cultivated land (103.86%) and Built-up (12.80%) areas recording gains (Table 6). The study further shows that water and Freshwater swamps recorded a reduction of --0.38 % and -1.61%, respectively. This implies that neither water bodies nor freshwater swamps have significantly changed. However, the study's results show that Mangrove Forest (-30.14%) was the land use most affected by the decline (Table 6).

Table 6: Land use and landcover change between the years 2013 and 2023

Class	2013 Area (sq km)	2023 Area (sq Km)	Change (sq km)	Percent Change (%)
Cultivated land	3.63	7.40	3.77	**103.86**
built-up	1454.94	1641.16	186.22	**12.80**
Waterbody	1831.30	1824.29	-7.01	**-0.38**
Freshwater swamp	1873.97	1843.73	-30.24	**-1.61**
Shrubland	2033.23	1920.49	-112.74	**-5.54**
Wetland	527.45	490.03	-37.42	**-7.09**
Bare surface	28.75	26.29	-2.46	**-8.56**
Mangrove forest	**26.28**	**18.36**	**-7.92**	**-30.14**

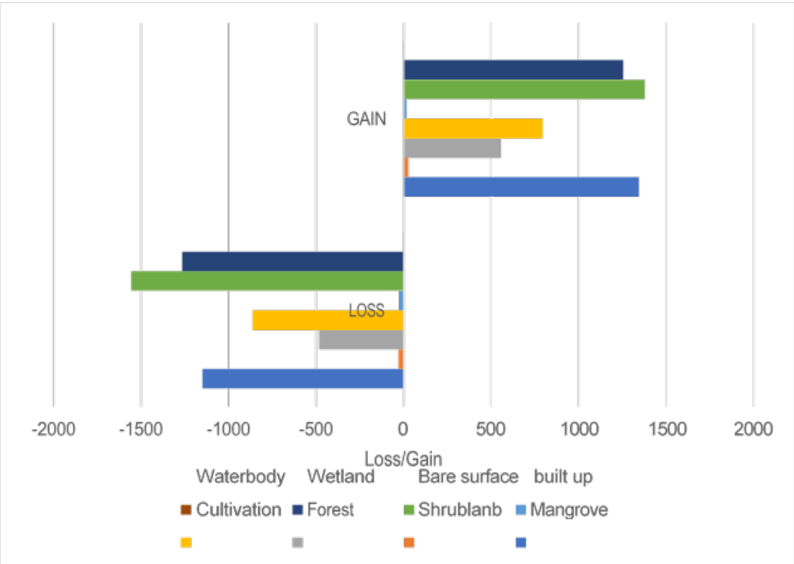

Figure 7: Land-use and Landcover Transitions from the year 2013 to the year 2023

Estimated Ecosystem Service Values Per Ecosystem for Land Use/Landcover Types and Changes in the Years 2003-2013 and 2013-2023

The estimated ecosystem service values for different land use and land cover types in the years 2003 and 2013 are presented in Table 7. Built-up areas saw the most significant increase in ecosystem service value from the years 2003 to 2013, going from $75.74 million to $128.80 million, an increase of $47.06 million. Mangrove areas experienced the most significant decrease, dropping from $1112.28 million in ecosystem service value in 2003 to $509.42 million in 2013, a decrease of $602.86 million. Overall, the total ecosystem service value across all land use and land cover types decreased by $985.01 million from $5062.62 million in 2003 to $4077.62 million in 2013. This can be attributed to several interrelated factors. Land use changes such as urbanization, agricultural expansion, and deforestation have led to the loss and fragmentation of natural habitats. This transformation is often accompanied by environmental degradation, including pollution, climate change impacts, and soil erosion. Overexploitation of resources, such as overfishing, excessive logging, and overgrazing has further diminished the capacity of ecosystems to provide valuable services. Additionally, the spread of invasive species and the occurrence of natural disasters have contributed to ecosystem disruption and reduced functionality. The most significant losses came from decreases in mangrove, forest, and wetland areas, while gains were seen in built-up and cultivated areas, which generally have lower ecosystem values. The increment experienced in built-up and cultivated areas likely reflects rising recognition of the socio-economic and environmental benefits of sustainable urban planning.

Table 7: Estimated ecosystem service values per ecosystem for land-use/landcover types and changes between 2003 and 2013

Land-use and Landcover Types	**Area (Ha)**		**Ecosystem Service Value US$ x 10^6/Year**		**2013 - 2003 (US$ x 10^6)**
	2003	2013	2003	2013	
Built-up	89735	145494	75.74	122.80	47.06
Bare-surface	2914	2875	0	0	0
Wetland	61241	52745	1572.79	1354.60	-218.19
Waterbody	191536	183130	817.28	781.42	-35.87
Mangrove forest	5738	2628	1112.28	509.42	-602.86
Shrubland	207087	203323	328.85	322.88	-5.60
Freshwater swamp	219541	187397	1155.66	986.46	-169.21
Cultivated Land	142	363	0.02	0.05	0.03
Total			**5062.62**	**4077.62**	**-985.01**

Furthermore, estimated ecosystem service values for land use and land cover types in the years 2013 and 2023 are presented in Table 8. Built-up areas and cultivation experienced increased ecosystem service value within this interval. Built-up saw the most significant increase in ecosystem service value, going from $122.80 million in 2013 to $138.51 million in 2023, which is equivalent to an increase of $15.72 million. Mangrove areas experienced the most significant decline in this study interval, a decrease of $153.53 million in ecosystem service value, from $509.42 million in 2013 to $355.90 million in 2023. In general, the ecosystem service value across all land use and land cover types experienced a total decrease of $270.67 million from $4077.62 million in 2013 to $3806.95 million in 2023. The most significant losses came from decreases in mangrove, forest, and wetland areas, while gains were seen in built-up and cultivated areas.

Table 8: Estimated ecosystem service values per ecosystem for land-use/landcover types and changes between 2013 and 2023

Land-use and Landcover Types	**Area (Ha)**		**Ecosystem Service Value US$ x 10^6/Year**		**2023 - 2013 (US$ x 10^6)**
	2013	2023	2013	2023	
Built-up	145494	164116	122.80	138.51	15.72
Bare surface	2875	2629	0	0	0
Wetland	52745	49003	1354.60	1258.50	-96.10
Waterbody	183130	182429	781.42	778.42	-2.99
Mangrove forest	2628	1836	509.42	355.90	-153.53
Shrubland	203323	192049	322.88	304.97	-17.90
Freshwater swamp	187397	184373	986.46	970.54	-15.92
Cultivated land	363	740	0.05	0.10	0.05
Total			**4077.62**	**3806.95**	**-270.67**

The significant declines in the estimated value of wetland, freshwater swamp, and shrubland ecosystem services in Lagos are alarming signs that these habitats are diminishing within and around the city. The work report (Onilude and Vaz, 2021) has shown that urban expansion and deforestation continue to drive the loss of forests, wetlands, and other natural areas in Lagos. However, De Groot *et al*. (2002: 51) highlighted that these ecosystems provide invaluable services, including water filtration, flood control, air cooling, and biodiversity habits which makes the current degradation further threaten Lagos' sustainability and resilience. Likewise, forests play an essential role in flood regulation. Their soil and vegetation absorb and slow runoff, protecting downstream communities. Without this service, floods from intense rainfall can be more severe (Tolkkinen *et al*., 2020). Wetland loss also reduces Lagos' natural filtration capabilities, allowing pollution from sewage, chemicals, and sediment to enter waterways untreated. This contributes to public health hazards and environmental degradation, impairing quality of life, as emphasized by (Koul *et al*., 2022). The declining trends in ecosystem value significantly impact planning for resilient coastal environments and sustainable land management. These developments mainly result in heightened susceptibility to natural catastrophes because they diminish the natural buffers that protect coastal communities from storms, floods, and erosion. With less carbon sequestered and fewer natural adaptive responses to sea level rise, climate change mitigation and adaptation capacity weakening exacerbates this vulnerability. Economically, the downturn impacts sectors that depend on ecosystems, like tourism and fishing, while also driving up the price of man-made coastal defenses. In addition, these modifications jeopardize biodiversity, upset food chains, and might result in the extinction of species in coastal regions, which would influence traditional livelihoods and food security.

Additionally, the decline of freshwater swamps, wetlands, and shrublands diminishes Lagos' natural air-cooling services during hot seasons. Through transpiration and shade, vegetation keeps urban areas cooler than their surroundings. As these green spaces disappear due to development, Lagos may likely experience hotter temperatures, as noted by Abolade *et al*. (2019: 73), amplifying the urban heat island effect. Higher temperatures can increase heat-related illnesses and deaths, reduce outdoor comfort, and increase energy costs for cooling. The loss of natural habitats also degrades critical biodiversity as many plant and animal species are forest- or wetland-dependent. Their decline threatens to erode native biodiversity (Mafiana *et al*., 2022: 45) in Nigeria. This may have unforeseen consequences for ecosystems, as species play essential roles in processes like pollination, pest control, and soil fertility maintenance Although, the ecosystem service value of Built-up area increases in value, this is at a detriment to other land-use and landcover type with higher ecosystem values such as wetland, freshwater Built-up area increases in value, this is at a detriment to other land-use and landcover type with higher ecosystem values such as wetland, freshwater swamp, and mangrove forest. The alterations in the environment call for a reevaluation of land use planning and coastal development regulations. This could result in the controlled withdrawal of coastal populations and heightened competition for less susceptible locations.

Conclusions and Recommendation

The valuation of LULC-associated ecosystem services in Lagos's coastal zone highlights the urgent need to integrate environmental accounting into coastal management. The quantitative insights offer a basis for policymakers to balance urbanization with conservation goals, mitigate environmental degradation, and safeguard coastal communities' well-being. Integrating ecosystem service valuation and conservation into Lagos's urban planning and decision-making processes is vital for attaining sustainable development goals and safeguarding the well-being of present and future generations. To better safeguard and conserve coastal ecosystems and the services they provide. Identifying and accounting for the economic value of ecosystem services can lead to a lack of foresight of the coastal dwellers, particularly in Lagos, in progress policies that jeopardize the very natural capitals upon which human well-being and economic wealth depend. Furthermore, the effects of the deterioration of coastal ecosystems may go well beyond the nearby communities. For instance, the disappearance of mangrove forests, which serve as organic barriers against coastal erosion and storm surges, can make coastal communities under study more susceptible to the effects of climate change and natural catastrophes, endangering infrastructure and human life. Policymakers may ensure that the advantages of coastal ecosystems are retained for future generations by balancing economic development with environmental conservation through the integration of ecosystem service valuation into coastal management measures. This strategy supports social cohesion, long-term economic resilience, and environmental sustainability. In conclusion, this study's findings highlight how crucial it is to acknowledge and value the ecological services that coastal settings in Lagos and elsewhere provide. If this is not done, policies may be implemented with limited vision and endanger the very natural resources that promote economic growth and human well-being.

To achieve sustainable development goals and protect the welfare of current and future generations, ecosystem service assessment must be incorporated into coastal management and urban planning. It is recommended to review and update the environmental laws and regulations in place, establish a standardized methodology for routinely assessing and mapping the spatial and temporal patterns of ecosystem services in Lagos State's coastal zones, and tighten development controls and zoning laws to stop unsustainable urban expansion and incursion into ecologically sensitive coastal areas. Promoting public awareness and education programs is vital to encourage community understanding of the value of coastal ecosystems and the significance of protecting them for current and future generations. Furthermore, it is essential to encourage the involvement and cooperation of stakeholders in coastal zone management initiatives from the public and private sectors, academic institutions, and local populations. This will guarantee that various viewpoints and concerns are considered and that all parties involved co-create and support the solutions. Lagos State and other coastal regions can strive toward accomplishing sustainable development goals, protecting the welfare of their citizens, and maintaining the priceless ecosystem services offered by coastal ecosystems by putting these recommendations into practice.

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