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Assessment of Carbon Sequestration Potentials and environmental dynamics in the coastal area of Lagos

Adedoja T.B.
Adegboyega S.A.
Fakpor A.M.
Federal University of Technology (FUTA), Akure, Ondo State, Nigeria

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Abstract

Coastal environments comprise of multiple arrays of ecosystems, including forests, mangroves, wetlands, and oceans, which play a vital role in long-term carbon storage and mitigation of climate change. These ecosystems possess a unique ability to store carbon for prolonged periods, acting as natural carbon sinks and contributing to the reduction of atmospheric greenhouse gas up concentrations, which is one of the exceptional services they offer. However, despite their significance, the potentials of coastal land covers and their associated land use in mitigating global warming through carbon absorption is often overlooked in current researches. This study employed the InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) model together with Intergovernmental Panel on Climate Change (IPCC) Carbon pool data to assess the carbon stock and dynamics of various land use and land cover types in the coastal environment of Lagos for a period of 20 years. The results revealed a substantial reduction in net stored carbon from 1.33 x 10^8 metric tons Carbon in 2003 to 1.21 x 10^8 metric tons of Carbon in 2013, which accounts for a 6.66% decline in stored carbon during that period. Furthermore, the total carbon stock decreased by approximately 3.5 x10^8 Metric tons, or 2.94%, equating to a loss of over 300 million tons of carbon between 2013 and 2023. Through the identification and measurement of the carbon sequestration capacity of these varied coastal land covers, researchers can gain insight regarding their function in reducing global warming. The preservation and enhancement of these natural carbon sinks can be achieved by conservation efforts, sustainable management practices, and policy decisions informed by this information, thereby aiding in the global fight against climate change.

Keywords: Ecosystems, Coastal region, Carbon sinks, Cabon sequestration, Global warming

Introduction

The act of removing carbon dioxide (CO_2) from the atmosphere and storing it is known as carbon sequestration which is basically one of the ecosystem services, and it is essential for reducing climate change and global warming. The amount of greenhouse gases, especially CO_2 (Carbon dioxide) in the atmosphere has a significant impact on the Earth's climate.

The greenhouse effect has been greatly enhanced by rising atmospheric CO_2 levels, mostly as a result of human activities including burning fossil fuels, deforestation, and changes in land use (Yoro and Daramola, 2020). This has raised global temperatures by trapping more heat than required. It has been noted that coastal ecosystems are responsible for 55% of all carbon captured worldwide (Yang et al., 2024) thereby acting as significant carbon sinks, absorbing and storing carbon (Das et al., 2022; Iqbal and Shang, 2020) through photosynthesis and other natural processes. The global carbon cycle depends critically on this stored carbon, sometimes referred to as the carbon stock. The stored carbon is released back into the atmosphere when these ecosystems are disrupted or destroyed, which raises atmospheric CO_2 levels.

Over the past century, the burning of fossil fuels and other human activities have released carbon into the atmosphere (Soeder and Soeder, 2021) which has resulted in a significant rise in atmospheric CO_2 concentrations. It has been noted that the megacity of Lagos is now engaged in development projects linked to prospective carbon emissions that have not yet been quantified (Bola-Popoola et al., 2019). The Lagos coastline region has been the subject of recent studies in the ongoing fight against climate change and global warming. In an attempt to offer scientific proof in favor of the implementation of state-specific restoration plans, many facets of Nigeria's environmental management and carbon emissions, especially in Lagos, have been the subject of recent studies. In order to support state-specific restoration efforts, researchers have evaluated energy use and carbon emissions in Lagos across several sectors (Bola-Popoola et al., 2019). Carbon storage in forests for the creation of REDD+ strategies using the InVEST model have also been estimated by (Ibeabuchi, 2023) However, the potential of land use and land cover (LULC) dynamics in Lagos's coastal areas as a technique for carbon sequestration-based global warming mitigation, remains largely unexplored given the growing knowledge of coastal ecosystems' critical function as carbon sinks that can absorb and store atmospheric carbon dioxide (CO_2), (Yang et al., 2024),

This therefore indicates a substantial knowledge gap about the existing ability of various LULC types in this region to function as efficient carbon sinks. Lagos, a coastal city, is quickly becoming an urbanized city with significant LULC changes brought about by urbanization, economic growth, and population increase. The region's capacity to naturally absorb carbon dioxide and lessen the consequences of climate change is significantly impacted by these dynamic shifts in the carbon cycle. However, the quantification and assessment of carbon stocks across various LULC classes in Lagos's coastal areas remain largely unexplored. The study estimated the carbon stock for each land use type, carbon sequestration and storage across a landscape based on land cover and provides spatially explicit estimates of carbon sequestration of the eco-region.

Materials and Methods

Data Acquisition

The multispectral datasets needed for this research were obtained from the USGS Landsat Archive (https://earthexplorer.usgs.gov). The study area covers three scenes of Landsat image catalogue with Path 191/Row 55, Path 191/Row 56 and Path 190/Row 56. Landsat 7 Image of the selected scenes for the year 2003, and Landsat 8 Image of the same location for the year 2013 and 2023 was downloaded from the online archive. Furthermore, the InVest 3.13.0 workbench version for windows operating system was downloaded from the official website of Natural Capital Project Group of Stanford University
(https://naturalcapitalproject.stanford.edu/software/invest).

The model requires land use/land cover (LULC) maps representing current and future conditions as primary inputs. Additional necessary inputs include carbon pool data associated with each LULC class. Carbon pool estimates for vegetation classes in this study were derived from guidelines provided by the Intergovernmental Panel on Climate Change (IPPC, 2006)for tropical moist deciduous forests, aligned with the climatic zone encompassing the study area as shown in **Figure 1.** In this study, InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs), a tool developed by the Natural Capital Project at Stanford University, was utilized to model and map the delivery, distribution, and economic value of ecosystem services including carbon sequestration (Hamel et al., 2020) was used to estimate the carbon stock for each land use type in the study area. The tool estimates carbon sequestration and storage across a landscape based on land cover and can help inform decisions about natural resource management. InVEST provides spatially explicit estimates of carbon sequestration that account for various sequestration approaches across different land cover types (Tallis and Polasky, 2009). **Figure 2** shows the flow chart of the methods explored.

Figure 1: Study area map

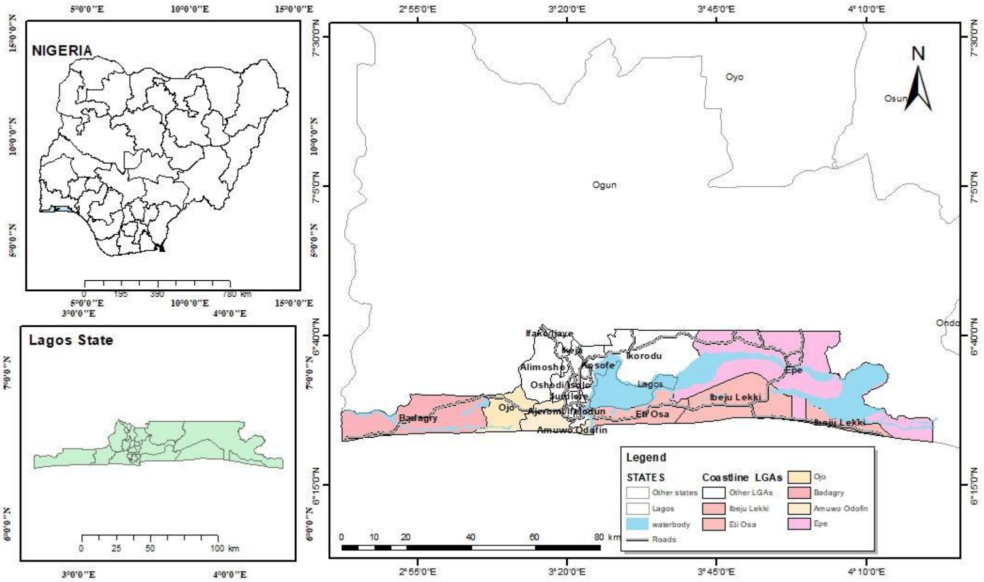
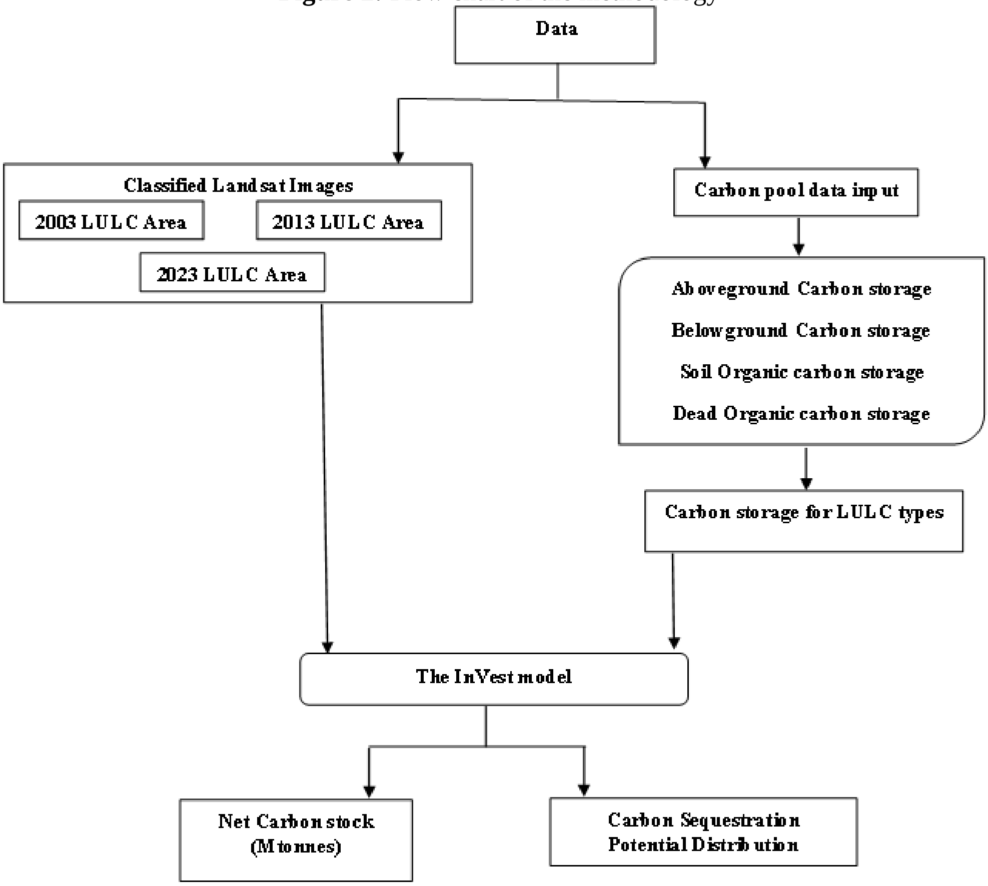


Figure 2: Flow chart of the methodology



Land use Land cover for the years 2003, 2013 and 2023

Image Processing / Classification

The analysis carried out on the data include: Band combination, Image Mosaicing, Image Subseting, 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 (Kokaly et al., 2017) 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. In the same software environment, a false-color composite image was created from these raw datasets by combining the selected stated bands. The three Landsat scenes were mosaicked together in the same software environment. While subsetting 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.

Accuracy Assessment

Field observation of the study area 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 QADI was run to derive the overall classification accuracy for the years understudy. To facilitate the process, a plugin for QADI was downloaded and added to the toolbox of the ArcMap 10.7 to produce a graph which presented the accuracy in confidence level (Appendix 1) of the classified imageries for the years understudy. Typically, the error matrix is saved for use with the QADI calculator plugin (Feizizadeh et al., 2022).

Data analysis using InVEST Model

The InVEST model consists of a series of sub-modules and algorithms which can simulate changes in ecosystem service functions in different land use/cover scenarios (Nelson and Daily, 2010). The amount of carbon stored in a particular area will be calculated in this study using the Carbon Storage and Sequestration module (He et al., 2016). Specifically, the calculation formulas are as follows:

$$C = C_{above} + C_{below} + C_{soil} + C_{dead} \text{.........3.1}$$

$$C_{total} = \sum_{k=1}^{n} A_k \, x \, C_k \; (k = 1,2,3, \ldots n) \text{........3.2}$$

where C is the total carbon storage per unit area of each land cover type, C_{above} is carbon density in aboveground mass, C_{below} is carbon density in belowground mass, C_{soil} is carbon density in soil, C_{dead} is carbon density in dead mass, A_k is the area of each land cover type, and C_{total} is the total carbon density of a cell. The carbon sequestration potential of the time periods was compared arithmetically to understand the transition with respect to carbon storage capabilities of the study area. **Table 1** summarizes the resulting carbon stock estimates derived from IPCC guidelines for each LULC class.

Table 1: Total Carbon pool for all the Landuse and Landcover Classes expressed in Tonnes/Hectares/Year

Lucode	LULC_name	C_above	C_below	C_soil	C_dead
1	Builtup	2	0.48	30	1
2	Baresurface	0	0	40	0
3	Cultivated land	50	12	20	0
4	Shrubland	180	43.2	4	2
5	Mangrove forest	150	36	0	0
6	Fresh water swamp	260	62.4	2	10
7	Wetland	100	24	2	0
8	Waterbody	0	0	0	0

IPCC: 2006

The InVEST model integrates this carbon pool inputs with the current and future LULC maps to estimate changes in carbon storage and sequestration across the study landscape over time. Use of IPCC guidelines provide standardized globally accepted estimates for carbon modeling

Results and Discussion

Land use Land cover analysis for the year 2003

The result of the land use landcover classification for year 2003 shows that Fresh water swamp, Shrubland and water body, were the dominant land use classes accounting for 28.22%, 26.62% and 24.62% respectively. Additionally, Mangrove Forest, Baresurface and Cultivated land had the least areal coverage with less than 1%. The result of the study also shows that Built-up areas and Wetland recorded about 11.54% and 7.87% respectively. **See Figure 3 and Table 2** respectively.

The result validation using the QADI reveals a high level of classification accuracy.

Land use Land cover analysis for the year 2013

LULC result for the year 2013 shows the same trends with the result of the years 2003 with Fresh water swamp, Shrubland and Water body accounting for 26.44%, 25.58% and 23.54% of the entire study area respectively. A similar trend was also observed for Mangrove Forest, Bare surface and Cultivated land account for less than 1% of the entire land use. Validation using QADI reveals a high level of classification accuracy. **Figure 4 and Table 3** shows the LULC map and statistics the year 2003.

Figure 3: Land use land cover map of the study area in 2003

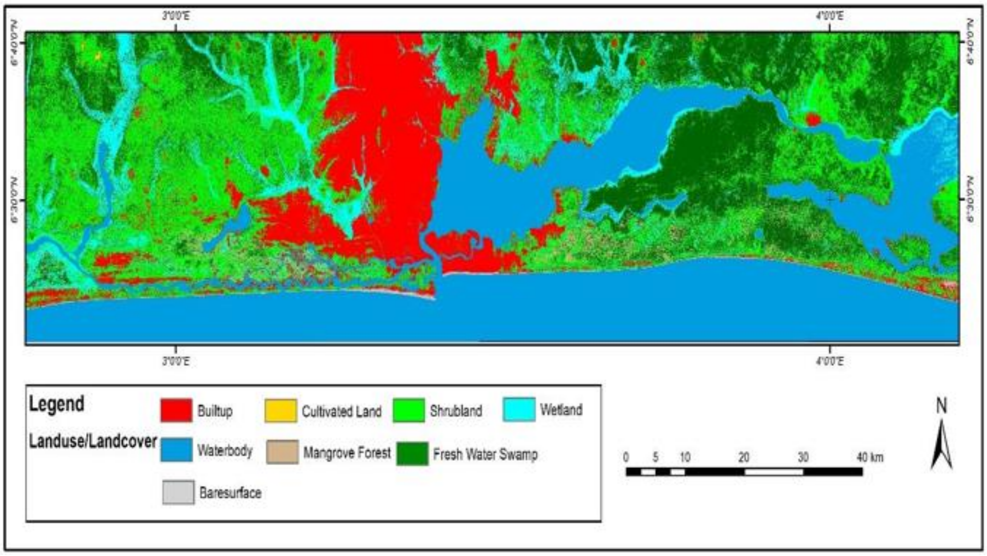


Table 2: Land use and Land cover Statistics for the year 2003

Class	Pixel count	Area (sq km)	Percent Cover (%)
Fresh water swamp	2439343	2195.41	28.22
Shrubland	2300971	2070.87	26.62
Waterbody	2128182	1915.36	24.62
Builtup	997059	897.35	11.54
Wetland	680454	612.41	7.87
Mangrove forest	63752	57.38	0.74
Baresurface	32383	29.14	0.37

Figure 4: Land use land cover map of the study area in 2013

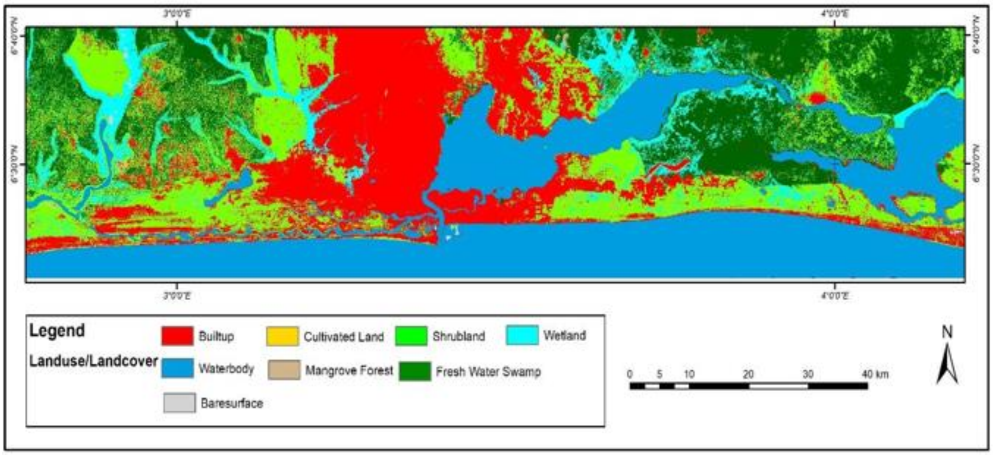


Table 3: Land use and Land cover Statistics for the year 2013

Class	Pixel Count	Area (sq km)	Percent Cover (%)
Shrubland	2285743	2057.17	26.44
Fresh water swamp	2211502	1990.35	25.58
Waterbody	2034774	1831.30	23.54
Builtup	1616596	1454.94	18.70
Wetland	425979	383.38	4.93
Mangrove forest	33374	30.04	0.39
Baresurface	31949	28.75	0.37
Cultivated land	4035	3.63	0.05

Author's Field Survey, 2024

Land use Land cover 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 Fresh water swamp, Waterbody and Built-up recording 23.72%, 23.47% and 21.12% respectively. While Wetland 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. See **Figure 5 and Table 4**.

Figure 5: Land use land cover map of study area in 2023

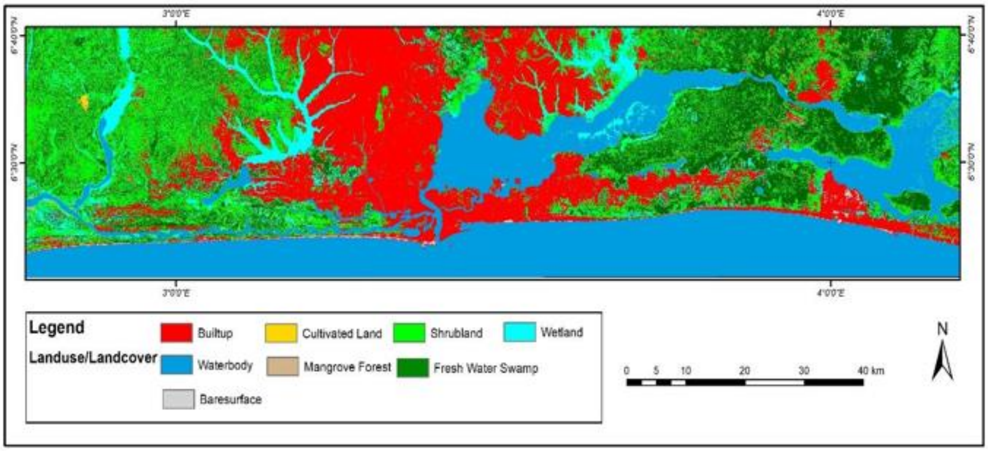


Table 4: Land use and Land cover Statistics for the year 2023

Class	Pixel count	Area (sq km)	Percent Cover (%)
Shrubland	2133878	1920.49	24.71
Fresh water swamp	2048590	1843.73	23.72
Waterbody	2026989	1824.29	23.47
Builtup	1823506	1641.16	21.12
Wetland	544482	490.03	6.31
Baresurface	29216	26.29	0.34
Mangrove forest	20399	18.36	0.24
Cultivated land	8226	7.40	0.10

Author's Field Survey, 2024

Land use Land cover dynamics between year 2003 and year 2013

Land use and land cover change are major drivers of environmental degradation globally, significantly impacting biodiversity, climate, biogeochemical cycles, and ecosystem services (Foley et al., 2012; Vitousek et al., 1997) It is estimated that over 75% of the Earth's land surface has been altered by human activities like agriculture, deforestation and urbanization leading to habitat loss, soil degradation, disrupted hydrology, and increased carbon emissions (Ramankutty et al., 2008; Sanderson et al., 2002) Given these substantial impacts, understanding the rates, causes, and consequences of land use and land cover change through methods like remote sensing and modeling is critical for developing strategies towards more sustainable land management (Liping et al., 2018).

In the study area, there were observed transition of Land use and Landcover classes which has been attributed to driving some of the environmental degradation as mentioned above. The analysis of Landuse and Landcover change is as expressed in table 5. The builtup and cultivated areas experienced a gain between 2003 and 2013 with a value of 557.59 sqkm (62.14%) and 2.21 sqkm (155.63%) respectively. While the remaining landuse and landcover classes experienced losses as follows; wetland: -229.03 (37.4%), baresurface: -0.39 sqkm (1.34%).

Table 5: Land use and Land cover dynamics between Year 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
Builtup	897.35	1454.94	557.59	62.14
Baresurface	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
Fresh water swamp	2195.41	1873.97	-321.44	-14.64
Mangroove forest	57.38	26.28	-31.10	-54.20

The table of Land use and Land cover change for (2013-2023) is as expressed in Table 6 The builtup and cultivated Land similarly experienced a gain between 2013 and 2023 with a value of 186.22 sqkm (12.80% gain) and 3.77 sqkm (103.86% gain) respectively. While the remaining landuse and landcover classes experiences losses as follows; wetland: -37.42 (7.09%), baresurface: -2.46 sqkm (8.56% loss), Waterbody: -7.01 sqkm (0.38% loss), Mangrove Forest: -7.92sqkm (30.14% loss), Shrubland: -112.74 sqkm (5.54% loss) and Fresh Water Swamp: -30.24sqkm (1.61% loss)

Table 6: Land use Land cover dynamics between year 2013 and year 2023

Class	2013 Area (sqkm)	2023 Area (sqkm)	Change	Percent Change (%)
Builtup	1454.94	1641.16	186.22	12.80
Baresurface	28.75	26.29	-2.46	-8.56
Wetland	527.45	490.03	-37.42	-7.09
Waterbody	1831.3	1824.29	-7.01	-0.38
Mangrove forest	26.28	18.36	-7.92	-30.14
Shrubland	2033.23	1920.49	-112.74	-5.54
Fresh water swamp	1873.97	1843.73	-30.24	-1.61
Cultivated Land	3.63	7.40	3.77	103.86

Carbon sequestration dynamics of the ecosystem in the study area

The InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) model was used to assess the carbon sequestration potential of the various land use and landcover types found in the study area Additionally, the model was used to estimate carbon sequestration rates by considering various factors such as vegetation type, biomass, land cover change, wave exposure, sea level change, population and land management practices (Bola-Popoola et al., 2019) To determine the potential for carbon sequestration, the model uses data inputs such as maps land cover, information about the climate and details about the soil. It estimated carbon stocks and sequestration rates based on ecosystem properties and management scenarios by using spatially explicit models and algorithms.

Carbon stock dynamics of the Land cover between 2003-2013

The result of the inVEST model executed on the landuse and landcover dataset over the study area is presented in **table 7**. The table presents dynamics and the associated changes in carbon stocks between 2003 and 2013 for different land cover types. There was a substantial reduction of the net stored carbon from 1.33 x 10^8 Mtonnes of Carbon to 1.21 x 10^8 Mtonnes of Carbon between 2003 and 2013 respectively. This indicates a net release of carbon into the atmosphere, potentially contributing to climate change. The overall 8.57% decline in stored carbon between the years' understudy highlights concerning trends of deforestation and loss of natural carbon sinks across the landscape (Le Quéré et al., 2018)and essentially due to the conversion on a type of LULC to another. The most significant contribution to the carbon stock decrease was from the fresh water swamp land cover type, which lost 10.7 x 10^8 Mtonnes of carbon (14.64% reduction). This suggests substantial deforestation and forest degradation occurred during this period, likely due to activities like logging, agricultural expansion, or urbanization. The built-up area experienced a substantial increase of 62.14%, indicating rapid urbanization. This land use change typically involves the conversion of vegetated areas (e.g., forests, wetlands) to impervious surfaces, contributing to the loss of carbon sinks. Both wetland and mangrove forest cover types experienced significant decreases in carbon stocks, with losses of 13.87% and 54.20%, respectively.

These ecosystems are known for their high carbon sequestration potential, and their degradation or conversion can release substantial amounts of stored carbon. the conversion of natural ecosystems to cultivated land can lead to soil carbon losses and reduced carbon sequestration potential. The bare surface and water body land cover types experienced relatively minor changes in carbon stocks, likely due to their limited capacity for carbon storage and sequestration. This is in agreement with (Aitali et al., 2022)which claim that bare surfaces and water bodies have limited capacity for carbon storage and sequestration due to their low productivity and minimal carbon accumulation. Overall, the results indicate that LULC changes, particularly deforestation, urbanization, and the degradation of wetlands and mangroves, played a significant role in the net release of carbon into the atmosphere during the study period.

Table 7: Net Carbon Stock for the study area between 2003 and 2013

Land use/Land cover	2003 (Mtonnes of C)	2013 (Mtonnes of C)	Difference	Percentage Change
Builtup	3004327.80	4871139.12	1866811.32	62.14
Baresurface	116560.00	115000.00	-1560	-1.34
Wetland	7716366.00	6645870.00	-1070496	-13.87
Waterbody	20.63	7.15	-13.48	-65.34
Mangrove forest	1067268.00	488808.00	-578460	-54.20
Shrubland	47464340.40	46601631.60	-862708.80	-1.82
Fresh water swamp	73414510.40	62665556.80	-10748953.6	-14.64
Cultivated land	11644.00	29766.00	18122	155.63
Total Carbon	132795036.83	121417778.67	-11377258.56	-8.57

Carbon stock dynamics of the Land cover between 2013-2023

The total carbon stock decreased by 3.5 x 10^8 Mtonnes approximately 2.94%, equating to over 300 million tones loss between 2013 and 2023. This indicates a continued net release of carbon into the atmosphere, although at a slower rate compared to the previous period (2003-2013). The forest land cover type experienced a decrease of 1.61% suggesting that deforestation and forest degradation activities persisted during this period, albeit at a slower pace compared to the previous decade. The built-up area continued to increase, with a 12.8% rise in carbon stocks. This trend likely reflects ongoing urbanization and the conversion of vegetated areas to impervious surfaces, contributing to the loss of carbon sinks. (Ding et al., 2022) Both wetland and mangrove forest cover types experienced further decreases in carbon stocks, with losses of 7.09% and 30.14%, respectively. This ongoing degradation and conversion of these high-carbon ecosystems remain a significant concern for carbon emissions. The cultivation land cover type increased by 103.86%, indicating a substantial expansion of agricultural activities during this period in which their potentials is also limited relative to natural vegetation. (Lorenz and Lal, 2018). While the overall contribution to carbon stock change may be relatively small, the conversion of natural ecosystems to croplands can lead to soil carbon losses and reduced carbon sequestration potential.

Furthermore, Agroecosystems lack the biodiversity and structural complexity of fresh water swamps, wetlands and mangroves that enables high rates of carbon accumulation and retention. Croplands are important for food production however; they are poor substitute in terms of producers of ecosystem services and climate regulation at large. The bare surface and water body land cover types experienced relatively small changes in carbon stocks, consistent with their limited capacity for carbon storage and sequestration, as discussed in the previous period. The Shrubland land cover type experienced a notable decrease of 5.54% in carbon stocks, suggesting potential degradation or conversion of these ecosystems, which can contribute to carbon emissions. The results indicate that land use/land cover changes, particularly deforestation, urbanization, and the degradation of wetlands, mangrove forest, and shrublands, continued to drive carbon emissions albeit at a slower rate compared to the previous decade. Also, The expansion of agricultural activities also contributed to the loss of carbon sinks.

Table 8: Net Carbon Stock for the study area between 2013 and 2023

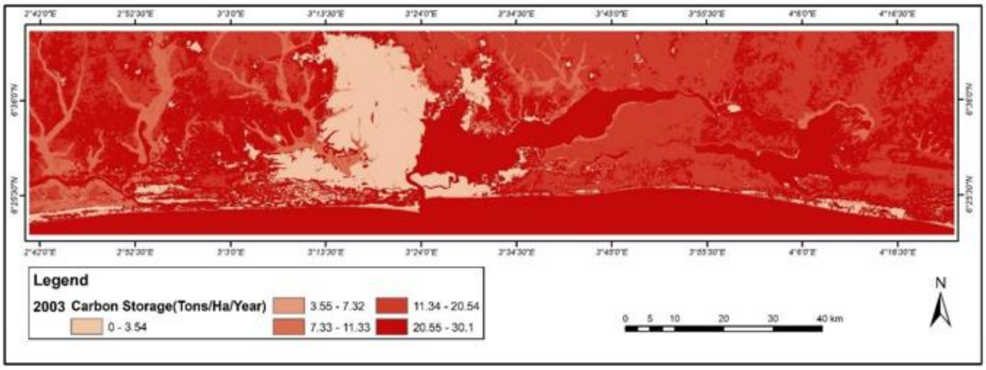
Landuse/Landcover	2013 (Mtonnes of C)	2023 (Mtonnes of C)	Difference	Percentage Change
Builtup	4871139.12	5494603.68	623464.56	12.80
Baresurface	115000.00	105160.00	-9840	-8.56
Wetland	6645870.00	6174378.00	-471492	-7.09
Waterbody	7.15	6.03	-1.12	-15.66
Mangrove forest	488808.00	341496.00	-147312	-30.14
Shrubland	46601631.60	44017630.80	-2584000.8	-5.54
Fresh water swamp	62665556.80	61654331.20	-1011225.60	-1.61
Cultivated land	29766.00	60680.00	30914	103.86
Total Carbon	121417778.67	117848285.71	-3569492.96	-2.94

The spatial distribution of the carbon sequestration Potentials in year 2003, 2013 and 2023

The spatial distribution of carbon sequestration potential across the Lagos coastal area for the years 2003, 2013, and 2023 is presented in Figures 6, 7, and 8, respectively. A visual analysis of these maps reveals a decreasing trend of carbon sequestration potential over time within the study area. In the 2003 map, large swaths of the region are depicted in darker shades, representing areas with high carbon sequestration capacity. However, the carbon sequestration potential progressively reduces in the year 2013 and

2023 in the region. Hence, low carbon sequestration potential, become more prevalent.

Figure 6: Distribution of Carbon Sequestration Potential in Year 2003



This observed pattern suggests a gradual degradation or conversion of land cover types that historically served as significant carbon sinks, such as Fresh water swamps, wetlands, and mangrove forest. The expansion of lighter shades of colours across the maps implies that an increasing proportion of the study area has lost its ability to effectively sequester and store atmospheric carbon, potentially exacerbating the impacts of global warming. (Oguntade et al., 2023)highlighted the impact of land-use changes, particularly the conversion of natural ecosystems to urban and agricultural areas, on reducing carbon sequestration potential in Lagos State

Figure 7: Distribution of Carbon Sequestration Potential in Year 2013

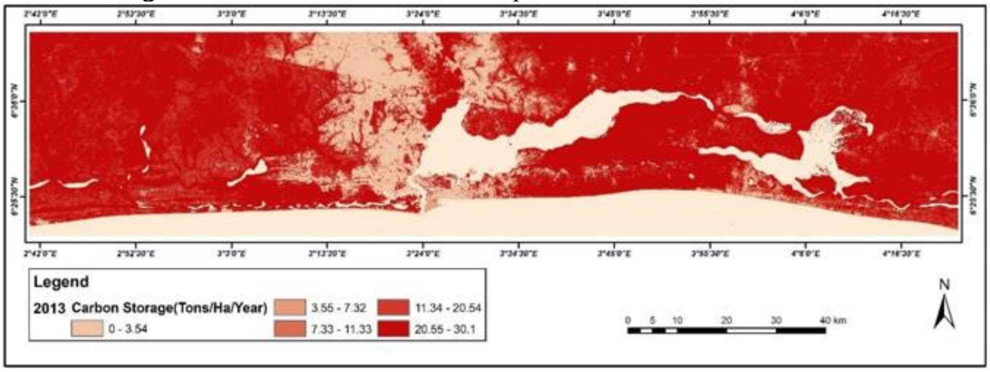
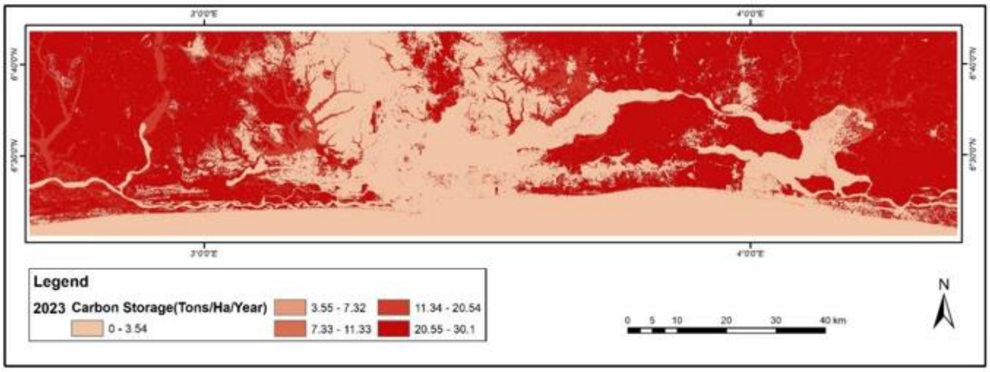


Figure 8 below shows an alarming reduction of the study area to absorb carbon. The diminishing carbon sequestration potential over the 20-year period can be attributed to various factors, including urbanization, deforestation, unsustainable land-use practices, and the degradation of natural ecosystems. These changes in land cover and land use have likely reduced the overall capacity of the Lagos coastal area to mitigate climate change through carbon sequestration and storage.

Figure 8: Distribution of Carbon Sequestration Potential in Year 2023



Conclusion and Recommendation

Through the identification and measurement of the carbon sequestration capacity of these varied coastal land covers, scientists can get important understandings regarding their function in reducing global warming. The preservation and enhancement of these natural carbon sinks can be achieved by conservation efforts, sustainable management practices, and policy decisions informed by this information, aiding in the worldwide fight against climate change. This Research will offer insightful information about the geographical distribution of carbon stores in Lagos's coastal areas and their current state within the varied LULC mosaic. Moreover, it will make it possible to determine which LULC categories that have the best chance of sequestering carbon, which will enable focused conservation and restoration initiatives. Finally, it will help design regional approaches to mitigating climate change that incorporate steps to improve land-based carbon sinks. Policymakers and communities may create practical plans to lower atmospheric CO_2 levels, improve carbon sequestration, and lessen the negative consequences of climate change on the environment by knowing the importance of carbon stocks and how they relate to global warming. To mitigate these impacts of the result, it is crucial to reduce CO_2 emissions and enhance carbon sequestration efforts. This can be achieved through various strategies, such as preserving and restoring natural ecosystems, adopting sustainable land-use practices, promoting reforestation and afforestation efforts, and developing technologies for carbon capture and storage (CCS). Hence, it is critical that coastal land covers and the ecosystems they support be given top priority in future research projects in order to fully realize their potential as an effective weapon in the fight against global warming through carbon absorption and storage.

Conflict of Interest: The authors reported no conflict of interest.

Data Availability: All data are included in the content of the paper.

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