Spatio-Temporal Changes in Land Use Across South East Senatorial District of Rivers State

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Abstract
Forests provide abundant resources for sustaining life forms and aid in carbon sequestration. Recently, due to urbanisation, forested areas are likely to be affected. To determine the nature of the forest, this study conducted a geospatial assessment of forest decline in the Southeast senatorial district of Rivers State, Nigeria. The study utilized satellite images (Landsat 7, 8, and Sentinel-2) downloaded from the USGS (United States Geological Survey). The downloaded imagery is used to carry out LULC (land use and land cover) analysis utilizing maximum likelihood supervised image classification techniques in ArcGIS 10.7 software, spanning the period from 1990 to 2020. The use of QGIS 3.40.1 software is employed to model and predict changes in land use by 2040. Additionally, the study employed the Fragstat software to determine the forested area and assess the level of forest decline in the study area. To further establish the authenticity of the results, the NDVI (Normalized Difference Vegetation Index) technique was used. The LULC result reveals that the built-up area increased from 9.42% in 1990 to 65.39% in 2020, while vegetation cover decreased from 63.40% to 21.21% between 1990 and 2020. Bare land, on the other hand, decreased from 18.40% to 5.64% from 1990 to 2020. The prediction analysis reveals that vegetation cover will decrease from 21.21% to 7.12% between 2020 and 2040, resulting in a 14.09% reduction. Meanwhile, built-up areas will increase from 65.39% to 77.78%, leading to a 12.39% increase. These changes are clear indications of forest decline. The result of the Fragstat analysis on the spatial extent of forested areas also reveals that the forested area, which was 11.30% in 1990, has decreased to 2.97% by 2020. The ANOVA (Analysis of variance) results indicate that there is a statistically significant variation with a p-value of 0.942152 0.05 in the land uses. The study concludes that farming and lumbering are the primary causes of forest decline. Instead, the study recommends implementing adequate policies to prevent further decline in the remaining forested areas. To this end, the study strongly recommends the practice of afforestation.

Keywords: *Spatio-temporal, Land use change, Senatorial District, Geospatial assessment, Forest decline, urbanization.*

Introduction

The pace, magnitude and spatial reach of human alterations of the Earth's surface are unprecedented. Changes in land cover (the biophysical attributes of the Earth's surface) and land

use (the human purpose or intent applied to these attributes) are among the most significant (Turner, 1990; Lambin et al., 1999). Land-use and land-cover changes are so pervasive that, when aggregated globally, they have a significant impact on key aspects of the Earth System's functioning. They directly impact biotic diversity worldwide (Salau et al., 2000), contribute to local and regional climate change as well as to global climate warming (Houghton et al., 1999), are the primary source of soil degradation (Tolba et al., 1992), and, by altering ecosystem services, affect the ability of biological systems to support human needs (Vitousek et al., 1997). Urbanization remains one of the most significant causes of environmental challenges of our time. It affects all countries in the developing world and has significant impacts on the depletion of biological species and extinctions.
Recently, the gradual encroachment of urbanization into rural centres has affected forest levels The forest level being cut down for this purpose contributes to heating the earth's surface, thereby increasing the land surface temperature experienced within the study area—for instance, more sustainable use of natural resources, energy efficiency, and valuation of ecosystem services. Excessive forest decline can have a drastic impact on the economy. This action has been identified with social implications in the cultural values of the people of Rivers Southeast. Notwithstanding, the current global debate and moves towards forest conservation will be beneficial in assessing the status of the local government area's economic development in terms of equity development. However, a region does not achieve economic advancement in development single-handedly without adequate mobilization of its natural and human resource base. Ibe (2018) asserted that there is increasing pressure on land resources, basically because of the rapid population growth, as well as the economic problem that arises when every individual tries to secure the most significant benefit from the resources at the expense of others. He identified a deterioration of land resources, which is a result of uncoordinated land-use policies and other forms of land-use, such as agriculture, grazing, urbanization, industrialization, and water management, leading to bare surfaces, desertification, and general environmental degradation and pollution. It is reported that the tropical rainforest belt has lost approximately 95% of its total forest cover and now must import 75% of the timber it requires for its purposes. Hence, Nigeria is currently losing approximately 351,000 square kilometres of its landmass to grassland vegetation and desert encroachment, advancing southward at a rate of 0.6 kilometres per year (Salau, 1993). The available landmass is now threatened by indiscriminate land use alteration and policy change. It is on the strength of this that this study aims to conduct a geospatial assessment of the spatial and temporal changes in land use across the Rivers South-East Senatorial District, Nigeria.

Theory of land-use transitions

Land-use extent and intensity changes interact to produce nonlinear trajectories of land systems. Rapid, non-linear changes in land resource uses are driven by positive feedback, where initial interventions or disturbances precipitate a cascade of further changes (Peters et al., 2004; Ramankutty & Coomes, 2016). These dynamics produce land-use transitions, which are structural transformations of land systems from one dynamic equilibrium to another (Lambin & Meyfroidt, 2010; Müller et al., 2014), akin to regime shifts in complex systems theory (Scheffer et al., 2001; Biggs et al., 2012; Filatova et al., 2016; Kull et al., 2017). The development of theories of land-use transition constitutes a key achievement of recent land system science, which we synthesize.

Land-use transition theories, paralleling urban theories, explain cycles of urban growth, decline and renewal (Clark et al., 2002). Stylized theories of land-use transition, more akin to grand theories, posit that land use in a region follows a series of transitions that accompany socioeconomic development and changes in societal metabolism. Sequences run from wildlands with low human population densities dependent on hunting, foraging, resource extraction, and extensive use of fire to frontier clearing for subsistence agriculture and increasingly intensive and commercial agricultural systems, ultimately leading to intensive industrial agriculture supporting large urban populations and the abandonment of low-suitability agricultural lands (Fischer-Kowalski & Haberl, 2007). These theories aim to explain long-term land-use trajectories, which are presented as a directional modernization process akin to Rostow's stages of growth (Rostow, 1960). It also evokes the Environmental Kuznets Curve, which posits that environmental degradation increases in the early stages of economic development and then reverses with higher income, a trajectory moderated by policies (Barbier et al., 2010). These transitions can be theorized as resource substitution and problem shifting, where the adoption of intensive fossil fuel-based land use displaces impacts from land systems towards climate (Erb et al., 2008). Similarly, socio-cultural niche construction theory explains long-term changes in the human societal scale and the transformation of the biosphere through land use as the product of socio-cultural evolution in subsistence regimes based on ecosystem engineering, social specialisation, and non-kin exchange. Some of these stylised theories have been criticised for being overly deterministic, simplifying the complexities of land-use trajectories, and overlooking trade, geopolitics, and other interregional relations (Perz, 2007). However, they provide a bird's-eye perspective and umbrella frameworks under which more specific, middle-range theories can be formulated.

The Study Area

Rivers South-Eastern Local Government Area is one of Rivers State's twenty-three local government areas. The area covers a total land area of 1,598.2 km². Geographically, these local government areas are situated between latitudes 4° and 14° North of the Equator and longitudes 3° and 15° East of the Greenwich Meridian. This latitudinal location implies that the area is situated in the tropical rainforest region, characterized by its unique climatic and topographic features. The study area comprises seven local government areas: Gokana, Khana, Eleme, Tai, Andoni, Opobo/Nkoro and Oyigbo. These local government areas have a swampy plain and gentle land surface with an elevation of between 5 metres and 50 metres above sea level (Oyegun & Arokoyu, 2003). Traditionally, the land was initially shared among the communities, which were later subdivided into chiefdoms or compounds. According to Oyegun and Arokoyu (2003), this arrangement provides an instant development of a neatly bound rural settlement, and every piece of land within the confines of each community is shared between the compounds on a once-and-for-all basis.

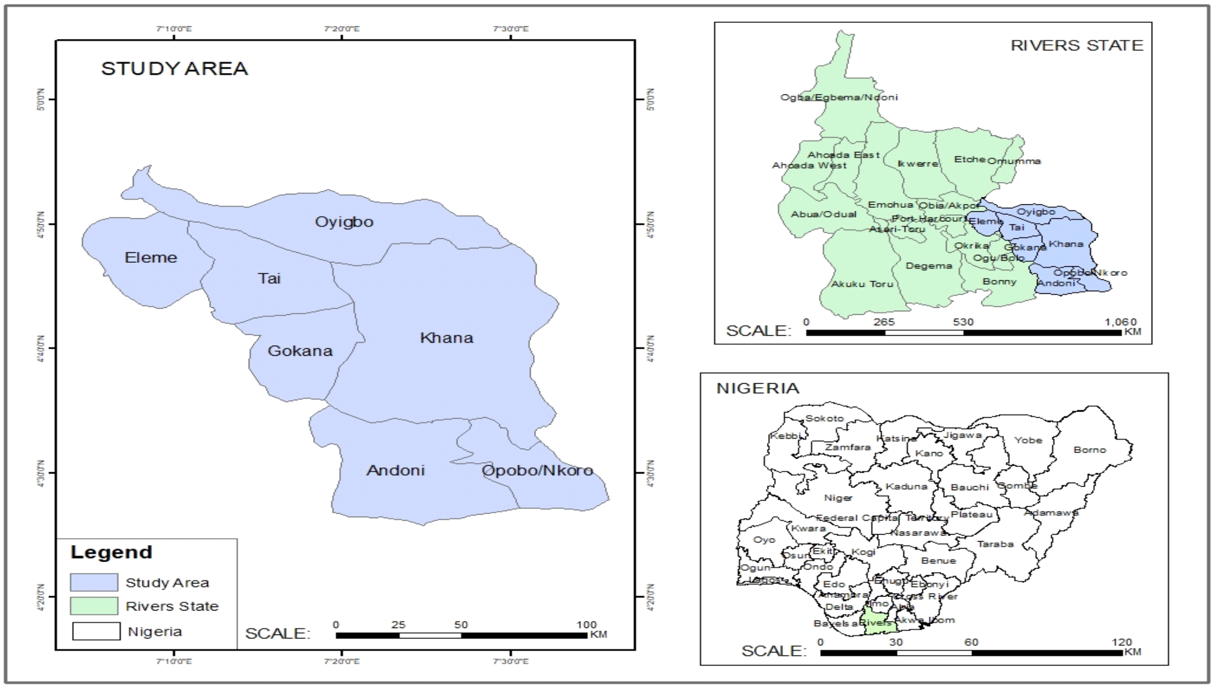

Figure 1: Rivers State Showing Local Government Areas
Source: Researcher's GIS/Remote sensing analysis (2025**)**

Method

This study adopts a longitudinal observational research design, in which data are gathered repeatedly for the same subjects over a period. Longitudinal research projects can span years or even decades. The primary goals and objectives of longitudinal research are as follows: to quantify trends in human behaviour, to describe the progression of life events, to identify patterns of behavioural change, to test theories, and to justify interventions aimed at preventing human and societal ills. The primary use of longitudinal research has been to study the development and natural history of events in the life course. This type of design is often regarded as superior to a cross-sectional design because it enables the identification of processes and causes of change within individuals and among individuals (Eludoyin et al., 2011).

Time-series analysis (TSA) is a statistical methodology suitable for longitudinal research designs that involve single subjects or research units measured repeatedly at regular intervals over time. Time series analysis is one of the empirical methods used for explaining social science phenomena. Time series analysis accounts for the fact that data points taken over a period may have an internal structure, such as autocorrelation, seasonal variation, or trend, that should be documented or accounted for. A time series is a collection of observations made sequentially in time. Time series analysis enables us to understand the underlying forces driving a specific trend in the time series data points, aiding in forecasting, prediction, and trend monitoring (Eludoyin et al., 2011). This study also employs time-series analysis in conducting the investigation, as the data span from 1990 to 2020.

The data used for this study were satellite remotely sensed data, spanning from 1990 to 2020. The study primarily utilized both primary and secondary data. The secondary data included various satellite data downloaded over the period under review, as well as journals, magazines, bulletins, internet resources, and other relevant publications.

The study's population comprises various local government areas. The various local government areas (Andoni, Eleme, Gokana, Khana, Opobo/Nkoro, Oyigbo, Tai) in Rivers South-East Senatorial district were captured. Additionally, the population of this study is primarily centred on the forest reserve and the various land uses present in the identified communities within the senatorial district.

Prior to the actual study, a reconnaissance survey was conducted to determine the predominant land use in the study area. The coordinate points of each surveyed local government area were collected. In carrying out the study, purposive sampling was used to cover all seven local government areas in Rivers South-East. These geospatial data revealed to the researcher the variation in land use.

Table 1: Coordinate Locations of Sample LGA

	Local Government Area	Latitude	Longitude	Area Size
1	Andoni	4°30'42.193"N	7°22'46.999"E	232.96 Sq.km
		9°20' 32.153"N	3°21 '35.219"E	
2	Eleme	4°47'22.473"N	7°8'2.752"E	138.08 Sq.km
		6°37'26.423"N	5°8' 6.855"E	
3	Gokana	4°40'26.356"N	7°17'30.911"E	129.96 Sq.km
		4°43'26.476"N	7°16' 24.451"E	
4	Khana	4°42'18.388"N	7°25'51.05"E	559.72 Sq.km
		4°36'18.258"N	6°22'32.04"E	
5	Opobo/Nkoro	4°30'2.182"N	7°31'35.146"E	130.9 Sq.km
		8°20' 4.152"N	5° 21' 55.176"E	
6	Oyigbo	4°50'10.52"N	7°18'54.934"E	248.06 Sq.km
		3°40'20.57"N	6°16'52.584"E	
7	Tai	4°46'2.45"N	7°14'46.865"E	158.52Sq.km
		3°42' 4.35"N	4°22 '45.835"E	

Source: Researcher's Compilation (2025)

The data for this study were obtained from satellite imagery provided by the USGS (United States Geological Survey). The data were divided into four epochs: 1990, 2000, 2010, and 2020. The research utilized multi-spectral satellite photos from the Landsat 8 Thematic Mapper (TM), Landsat 7 Thematic Mapper, Enhanced Thematic Mapper (ETM+), Thermal Infrared Sensor (TIRS), and Landsat 8 Operational Land Imager (OLI). These images with a high level of detail were obtained from the USGS. Landsat images were utilized due to their capacity to provide valuable and uninterrupted records of the Earth's surface, enabling the classification, analysis, and monitoring of changes in both human-made and natural environments (Lambin et al., 2003; El Bastawesy et al., 2017). The images were improved by merging all the image bands using the ArcGIS 10.7 software application. A false-colour composite image, consisting of bands 7, 4, and 2, was chosen for each year for further analysis. The band sequence 7, 4, 2 RGB is suitable for land cover classification and could accurately distinguish various plant types. Enaruvbe and Atafo

(2015) have verified that using a combination of channels 2 (blue), 4 (green), and 5 (red) is successful in differentiating various types of vegetation cover. Data about each land cover shall be gathered through a comprehensive field study prior to the categorization of satellite images (Enaruvbe & Atafo, 2015). The field survey will be conducted throughout the entire research region using a global positioning system (GPS). The GPS is a very effective Geographic Information System (GIS) tool used for direct data gathering in the field. It is an integral element of the ground-truthing process (Balogun et al., 2011).

Table 2: Data Acquisition Timeline and Description

Image	*1990*	*2000*	*2010*	*2020*	*Projected 2040*
Acquisition date/description	Landsat MSS image acquired	Landsat 7 ETM image acquired	Landsat 8 and 9 images acquired	Sentinel-2, image acquired	Landsat 8 level 2
Resolution	$79m^2$	$79m^2$	$30m^2$	$5m^2$	$30m^2$
Cloud Cover	<10%	<10%	<10%	<10%	<10%
Path	162	162	151	151	205
Row	56	56	56	56	56

Source: Researcher’s GIS computational Analysis (2025)

This study employs GIS and remote sensing techniques in its data analysis. The downloaded satellite images from the USGS were imported into ArcGIS 10.5, where the pre-processing procedure was carried out. This involves various band combinations. Bands 3, 4, 5, and 6 were combined for the analysis, which corresponds to the area within the electromagnetic spectrum that encompasses the visible and near-infrared bands for LULC analysis. Supervised imagery classification techniques, utilizing maximum likelihood classification methods, were employed in training the samples and analysis. Supervised classification employs basic algorithms to categorize pixels in remote sensing images as ground cover types or classes. This is an algorithm in the ArcGIS environment used to perform spatial statistical analysis. The signature files were trained using various training samples and subsequently created. This includes built-up areas, Vegetation cover, water bodies and bare land. A Geographic remote sensing technique is a computer program used to map and analyze geographical features, patterns, and occurrences. Standard database procedures, such as querying and statistical analysis, can now be performed on maps using GIS technology. In conducting this research, the incorporation of GIS/RS is essential to provide general mapping and delineate the extent of the study area, as well as to highlight the various uses of land resources within it. The various results from the analysis are presented in tables, maps, and charts, and the discussions of the associated results are presented in tandem with the various objectives.
The ArcGIS 10.7.1 software and QGIS 3.40.1 software were used. Results obtained from the land use and land cover are subjected to descriptive statistics, including mean and standard deviation. The one-way statistical test, known as analysis of variance (ANOVA), is employed with a p-value of less than 0.05 to determine if there is statistically significant variation in land use and land cover over the years.

Result and Discussion

The data used for this study were satellite remotely sensed data, spanning from 1990 to 2020, a 30-year period. The study primarily utilized both primary and secondary data. The secondary data included various satellite data downloaded over the period under review, as well as journals, magazines, bulletins, internet resources, and other relevant publications.

The study's population comprises various local government areas. The local government areas (Andoni, Eleme, Gokana, Khana, Opobo/Nkoro, Oyigbo, Tai) in the Rivers South-East Senatorial District were captured.

Spatial-temporal changes in the land use (1990- 2000)

Table 3: LULC Analysis (1990-2000)

	Land Uses	***Area coverage (1990)***	***% (cover)***	***Area Coverage (2000)***	***% (cover)***	***% (Change Difference)***
	Built-Up	166848	9.42	445648	25.16	**+15.74**
	Vegetation	1122728	63.40	644398	36.38	**- 27.02**
	Water Body	155405	8.77	133720	7.55	**- 1.22**
	Bare Land	325850	18.40	547065	30.89	**+ 12.48**
Total		**1770831**	**100 %**	**1770831**	**100 %**	**56.47 %**

Source: Researcher's Analysis (2025)

From the results of the analysis carried out using GIS/Remote sensing techniques, it is revealed that the built-up area, which originally occupied an area size of 166848 sq. km in 1990, represented a 9.42% increase to 445648 Sq. Km with a 25.16% cover increase by 2000. This, however, translated to a +15.74% difference from 1990 to 2000. While vegetation cover, which was 1122728 Sq. km with an associated percentage of 63.40%, was observed to reduce to 36.38% in 2000, with an area cover of 644398 Sq. km. This indicates that vegetation cover was reduced by 27.02%.

Further analysis revealed that the water body, initially occupying an area of 155,405 sq. km and accounting for 8.77% of the total area in 1990, was reduced to 7.55% in 2000, with an associated area coverage of 133,720 sq. km. In contrast, bare land, one of the land uses in the study area, increased from 18.40% in 1990 to 30.89% in 2000, representing a 12.49% increase in bare land. This significant increase is attributed to the level of development and man-made activities that occurred from 1990 to 2000.

Spatial-temporal changes in the land use (2000-2010)

Table 4: LULC Analysis (2000-2010)

	Land Uses	***Area coverage (2000)***	***% (cover)***	***Area coverage (2010)***	***% (cover)***	***% (Change Difference)***
	Built-Up	445648	25.16	724628	40.92	**+15.76**
	Vegetation	644398	36.38	378933	21.39	**-14.99**
	Water Body	133720	7.55	158923	8.97	**+1.42**
	Bare Land	547065	30.89	508347	28.70	**-2.19**
Total		**1770831**	**100 %**	**1770831**	**724628**	**34.36 %**

Source: Researcher's Analysis (2025)

In 2000, the analysis revealed that the built-up area occupied an area of 445648 Sq. km with an area coverage of 25.16%, increased to 724628 Sq. Km with 40.92% area coverage. This increment resulted in a 15.76% change difference. The vegetation cover that occupied 644398 Sq. km in 2000, with 36.38% area coverage, decreased to 378933 Sq. km with an area coverage of 21.39%, bringing the change difference to 14.99%. this, however, shows another reduction in 2010. Furthermore, the water body that occupied 133720 Sq. km, that is, an area coverage of 7.55%, increased to 8.97 % in 2010, revealing a 1.42 % change difference. The increase in the water body is attributed to flooding or the general increase in the water body because vast water bodies surround the study area. This can result in intermittent increases and decreases in the water bodies in the study area. At the same time, bare land reduced from 30.89 % area coverage in 2000 to 28.70 % area coverage in 2010. This is also a clear indication that there was a 2.19% difference between 2000 and 2010.

Spatial-temporal changes in the land use (2010-2020)

Table 5: LULC Analysis (2010-2020)

	Land Uses	*Area coverage (2010)*	*% (cover)*	*Area coverage (2020)*	*% (cover)*	*% (Change Difference)*
	Built-Up	724628	40.92	1158009	65.39	**+ 24.47**
	Vegetation	378933	21.39	375747	21.21	**- 0.18**
	Water Body	158923	8.97	137060	7.73	**-1.24**
	Bare Land	508347	28.70	100015	5. 64	**- 22.06**
Total		**1770831**	**100 %**	**1770831**	**1770831**	**47.95 %**

Source: Researcher’s Analysis (2025)

However, in 2010, an analysis revealed that the built-up area occupies an area of 724,628 sq. km and represents a percentage of 40.92%. Interestingly, in 2020, built-up areas increased slightly from 40.92% to 65.39%, occupying an area of 115,8009 sq. km. This increase translated to a 24.47 % change difference. On the other hand, vegetation cover occupied an area of 378933 Sq.km with a %age of 21.39 %, further reduced to 21.21 % and occupying an area of 375747 Sq.km, which resulted in a 0.18 % reduction. This reduction is attributed to the anthropogenic activities that occurred during this period. Moreover, the water body within the study area decreased slightly from 8.97% in 2010, occupying an area of 158923 Sq. Km, to 7.73% in 2020, occupying an area of 137060 sq. km. This resulted in a decrease of 1.24 %. Bare land, on the other hand, accounted for 28.70% of the total land area in 2010, covering an area of 508,347 sq. km, and decreased to 5.61% of the total land area, covering an area of 100,015 sq. km, by 2020. This reduction in bare land area resulted in a 22.06% loss of bare land in the study area. This drastic reduction is primarily attributed to deforestation, as evident from the results, which show a decrease in vegetation and an increase in bare land. It is reasonable to posit that the cutting down of trees (lumber) in the study area is increasing. This tree is what the locals used to produce furniture, etc. Additionally, due to the high rate of farming activities within the study area, especially in Khana, Gokana, Eleme, and Tai LGAs, the vegetation areas are being severely affected, resulting in a decrease in bare land areas. However, the recent artisanal refining activities and the constant oil spills that have plagued the area have also contributed to the decline in vegetation cover and increased bare land.

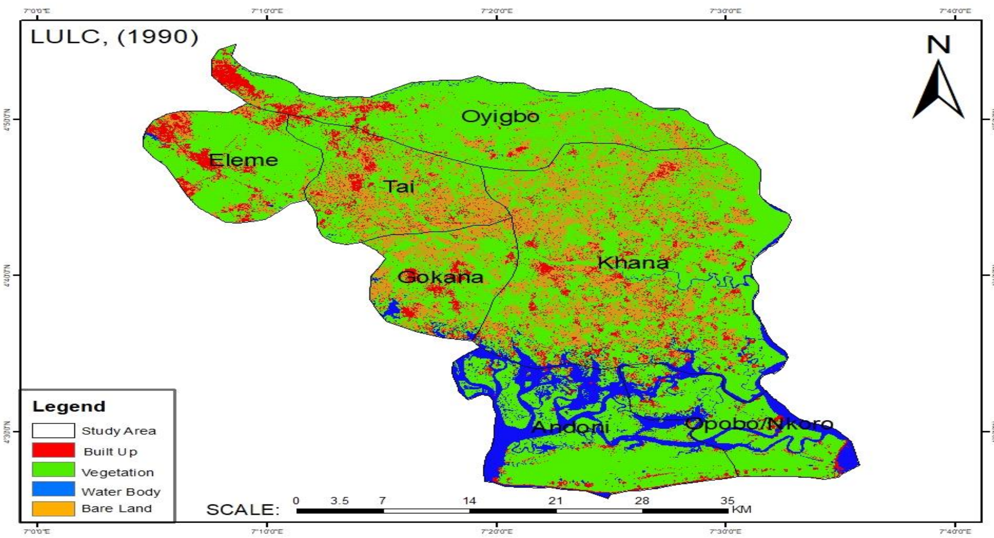

Fig 2: Land use Land Cover Analysis (1990)
Source: Researcher's GIS/Remote sensing (2025).

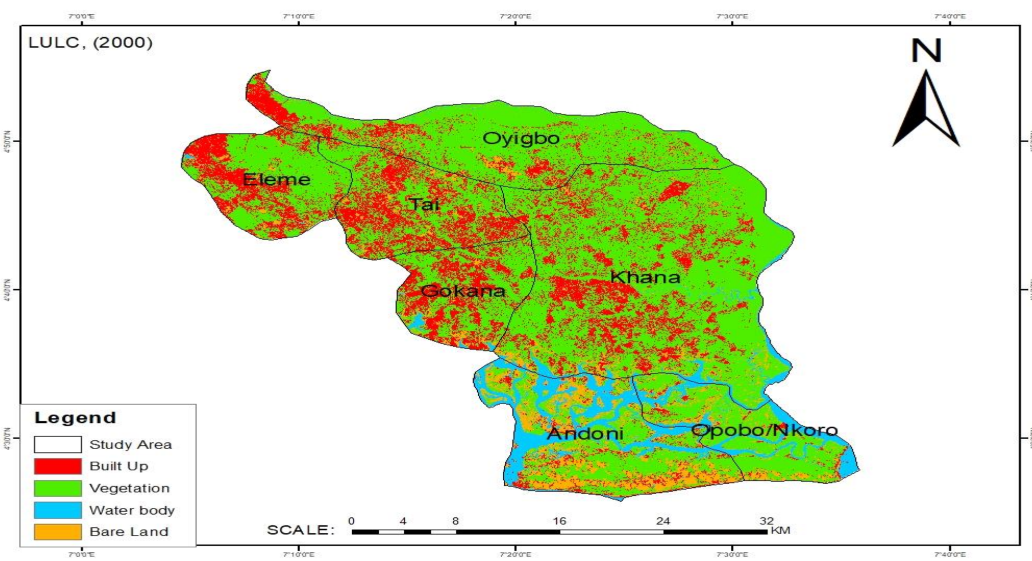

Fig 3: Land Use Land Cover Analysis (2000)
Source: Researcher's GIS/Remote sensing (2025).

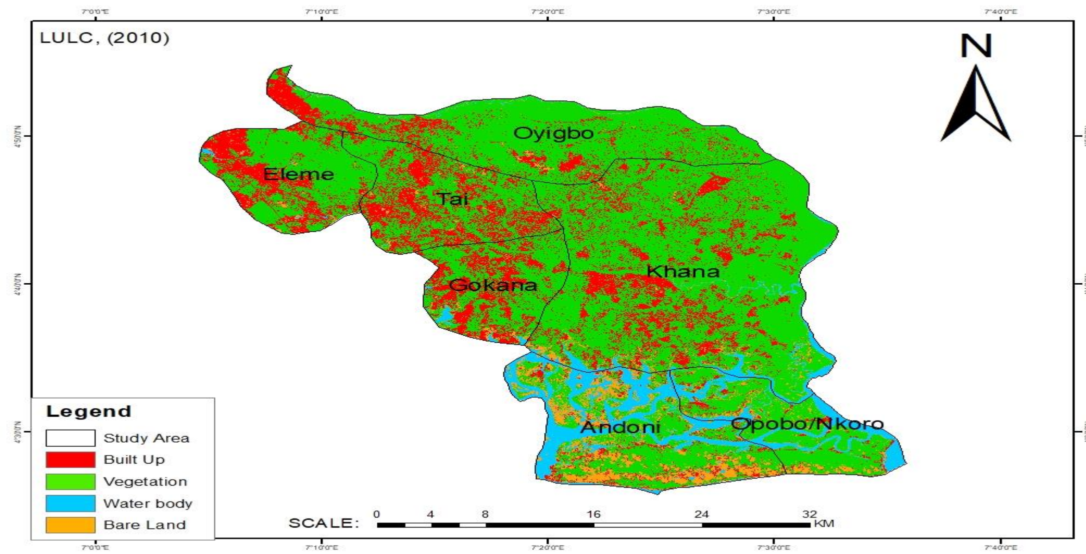

Fig 4: Land use Land Cover Analysis (2010)
Source: Researcher's GIS/Remote sensing (2025).

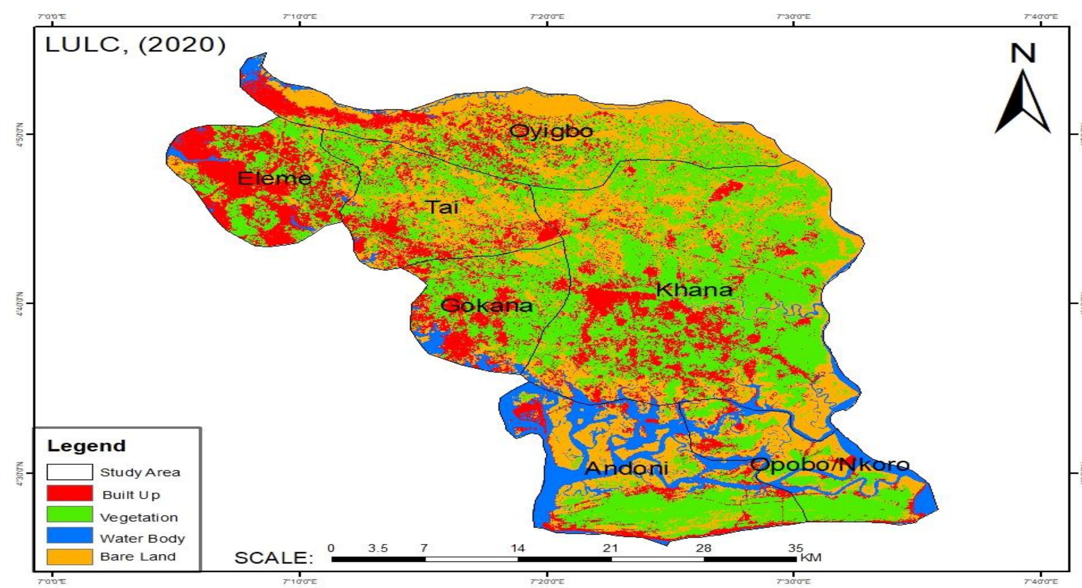

Fig 5: Land use Land Cover Analysis (2020)
Source: Researcher's GIS/Remote sensing (2025).

The analysis of the various land uses is shown in Tables 3, 4 and 5, with the associated graphs as shown in Charts 1, 2 and 3, respectively. The various maps as shown in Figs 1, 2, 3 and 4 are the maps of the land use land cover (LULC) analysis carried out from (1990-2000), (2000 – 2010) and (2010-2020) in the study area, which is in Rivers South-East Senatorial district, comprising Andoni, Eleme, Gokana, Khana, Oyigbo, Opobo/Nkoro and Tai, LGA's. The analysis reveals the varying changes that have occurred over 30 years, broken down into 10-year intervals. The study examined four land uses within the study area: built-up areas, Vegetation Cover, Water bodies, and bare land. The total area covered by the study area is 1770831 sq. km. From the result of the land use land cover analysis (LULC), vegetation cover in the year (1990) covers an area of 1122728 sq. km. with a %age of 63.40 %, built-up areas in the same year cover an area of 166848 sq. km. with a %age of 9.40 %, Water body occupied an area of 155405 sq. km. which translates to 8.77 % while bare land covers an area of 325850 sq. km. with a %age of 18.40 %. This is quite different from what is recorded in the year (2000). It was discovered that vegetation cover decreased from its 1990 level to 644398 sq. km in 2000, representing a percentage decrease of 36.38% compared to the 63.40% recorded in 1990. This translates to a (27.02%) reduction in the size of the vegetation in the study area. On the other hand, the built-up areas experienced an increase from 9.40% in 1990 to 25.16%, representing a 15.76% increase in the built-up areas. As the demand for timber increases, the rise in population and human habitation, along with the recent surge in estate development to convert vegetative land into built-up areas, has led to an expansion of built-up areas and a decline in vegetation cover. This indicates that the development within the study area has led to a decrease in vegetation cover, resulting in forest decline. Forested areas are being converted to other land uses. Interestingly, this affected the size of the land area in the built-up area, which was initially 166848 sq. km but increased to 445648 sq. km. However, the analysis reveals a slight reduction in the water body. This is a water body that has decreased slightly, from 8.77% in 1990 to 7.55% in 2000, covering an area of 155,405 sq. km in 1990 and 133,720 sq. km in 2000. This slight reduction can be attributed to the increase in activities that have also occurred in the study area. Bare land, on the other hand, initially covered 325850 sq. km with a percentage of 18.40%, but drastically increased to 547065 sq. km with a percentage of 30.89%, resulting in a 12.48% increase in bare land within the study area. This increase is associated with the activities that have gone on within the study area for a period of (20 years) because of the decrease in forests in the study area; other activities that have gone on within the study area, such as lumbering, have resulted in the conversion of the forested area to a bare land in the study area. This is evident from the forest decline that has occurred in the study area due to human activities.

Interestingly, it is evident that a total of 56.46% of changes occurred in the various land uses between 1990 and 2000 in the study area. Similarly, the analysis carried out on the LULC from 2010 to 2020 also reveals that the built-up area, which was initially 40.92% in 2010, increased to 65.39%. This translates to a 24.47 % increase. The vegetation cover, which was previously 21.39%, was reduced to 21.21%, resulting in a 0.18% decrease in vegetation cover. Further analysis reveals that the water body, which was initially 8.97% in 2010, decreased to 7.73% with an associated percentage decrease of 1.24%. Bare land, on the other hand, which accounted for 28.70% in 2010, decreased drastically to 5.61% with an associated percentage decrease of 22.06%. This climate is the reason for the decline in forested areas observed in the study area over time. This means that the forested areas are being cleared for farming purposes, lumbering, and other activities. Built-up areas (for Developmental purposes) are not linked to the reason for the forest decline; instead, farming and lumbering contribute significantly to the reduction of vegetal cover in the study area.

This analysis aligns with the study conducted by Gyawali et al. (2022) on assessing land cover change. He posited that LULC is very useful in monitoring and quantifying the impacts of forest decline and the level of changes that have occurred over time. As a result, the current study and analysis corroborate Bisong (2001), who had earlier reported in 1992 that mangrove deforestation

is one of the single most significant factors that could cause species extinction in the region over the next fifty years. Thus, it is feared that deforestation of the mangrove forest would eliminate 51.5% of species.
To date, urban population expansion has been observed in almost every nation worldwide, and it has been cited as one of the primary causes of rapid changes in land use and land cover (LULC) (Rawat & Kumar, 2015). Currently, there is a transition of multiple natural land covers, especially forested areas, into urban areas for various developmental purposes (Liu et al., 2014; Rawat & Kumar, 2015). According to these studies, losses of forests and grasslands over the past three centuries have been 19% and 8%, respectively, although human development has only occupied 6% of the Earth's surface. The continuous conversion of forest cover into other land uses can lead to an increase in surface temperature, relative humidity, evaporation rates, and unpredictable rainfall, which in turn influence biodiversity, water quality, soil quality, and ecosystems (Kafy et al., 2020).
On the other hand, deforestation has been well established in the literature as one of the most significant causes of forest decline in Nigeria, which is closely linked to the high level of urbanisation. Deforestation is considered a significant issue and a substantial threat to achieving global carbon neutrality. Over the last few decades, tremendous changes have been observed and recognized in land use and land cover worldwide (Lambin & Meyfroidt, 2021; Liu et al., 2014), including a significant reduction in forest area. Generally, the reduction of forests is mainly caused by the expansion of agricultural land (both commercial and subsistence) (Zeng et al., 2018), timber demand (Pintilii et al., 2017), and mining development (Van et al., 2016; Asner et al., 2013). Zhao et al. (2016) stated that deforestation has multiple environmental consequences, with particularly critical impacts on the climate.

Conclusion

The results of land use and land cover, as well as fragmentation, are visible over time. There has been a severe reduction in bare land within the study area. This drastic reduction is attributed to the conversion of other land cover and use to areas for agricultural purposes. This assertion aligns with the statistical analysis conducted in the study, which reveals a significant variation in land cover use in the study area over 30 years.

Recommendation

The recommendations of this study are anchored on the following:

1. Laws should be enacted to help preserve and make a proper pattern for land use.
2. The government should encourage Community-based Natural Resources Management (CBNRM) in the Senatorial District.
3. Policies and regulatory measures should be enforced and should be such that they encourage local people and institutional participation in forestry management and conservation.
4. The government and the Communities should encourage re forestation (operation cut one, plant two trees). This would assist in improving the sustainability of natural resources as well as provide livelihood opportunities in the Senatorial District.
5. The forested areas should be adequately monitored by the relevant authorities.

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