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"Urban Expansion and Land Use Land Cover Change Analysis in Oyi Local Government Area, Anambra State"

Urban Expansion and Land Use Land Cover Change Analysis in Oyi Local Government Area, Anambra State

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Abstract
Nigerian cities have been experiencing rapid urban expansion over the last few decades, contributing much to the region's land cover transition into the metropolitan area. The study aims to employ geospatial techniques to investigate land use and land cover changes in Oyi Local Government Area of Anambra State. The Lands at Thematic Mapper, Enhanced Thematic Mapper plus and Operational Land Imager satellite imagery for 1998, 2003, 2008, 2013, 2018, and 2023 were downloaded from the USGS Earth Explorer website. The Arc GIS 10.8 was utilized for the compilation, analysis, and distribution of geographic data, and the image classification was carried out using this software. Idrisi Selva 17 was used for change detection analysis and transition rates analysis. The images were then divided into five major categories namely farms/shrubs, built-up area, riparian vegetation, bare surfaces, and forested area using a maximum likelihood supervised classification. The results of the study revealed a significant increase in built-up areas from 1.5 sq.km in 1998 to 42.9 sq.km in 2023. This expansion occurred at the expense of dense vegetation, which decreased from 94.9 sq.km to 18.6 sq.km, and sparse vegetation/farms/shrubs, which saw a net change from 48.4 sq.km to 86.8 sq.km with inter-epoch variations. Bare land decreased overall from 4.9 sq.km to 1.3 sq.km. The change detection analysis highlights that 33.2 sq.km of dense vegetation and 6.8 sq.km of sparse vegetation were converted to built-up areas. Findings reveal the urgent need for sustainable urban planning and environmental monitoring to mitigate the adverse impacts of unplanned expansion. Hence, the study recommends that the Anambra State Geographic Information System and Anambra State Physical Planning Board strictly and periodically monitor urban growth to ensure sustainable development and environmental protection.

Keywords: Urban Expansion, Land Use Land Cover Change, Remote Sensing and GIS, change detection, sustainable development, vegetation change.

1.0 Introduction

Urbanization, a common trend worldwide, is the process of population concentration in urban areas, resulting in the growth and expansion of cities and the transformation of rural or undeveloped areas into urban settlements. The United Nations (2019) estimated that more

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than half the world's population live in urban areas, which is forecasted to exceed 65% by 2050. These patterns are faster in developing countries. Such growth patterns have been observed to different extents in practically all regions of the world (UN-Habitat 2016) but have been especially pronounced in Africa and Asia in the past decades (Seto et al. 2012; UNDESA, 2019). According to the United Nations, by 2050, Africa will have experienced about 90% urbanization (UN, 2016; UNDESA, 2019). The population in Africa could double between 2020 and 2050, with two-thirds of this growth (950 million people) expected to occur in urban areas (OECD/SWAC, 2020). Consequently, Africa exhibits the fastest urban growth (OECD/SWAC 2020), with an annual built-up area growth rate of more than 6% in the period 1990–2000 (Angel *et al*., 2011). In Nigeria, the pattern, trend, and characteristics of urbanization have been particularly significant (Aliyu and Amadu, 2017). Nigeria's towns and cities have grown phenomenally, with the urban growth rate consistently above 2% per annum (UNDESA, 2019), and more than half of the population already lives in urban areas (NPC, 2006; World Bank, 2020). Consequently, Nigerian cities' areas have rapidly expanded, often unplanned and uncontrolled (Cities Alliance, 2007). To accommodate this growing population, the physical extent of urban areas has expanded rapidly.

Urban expansion is a consequence of urban population growth, typically concentrating on the periphery of cities and towns(Angel, 2023). Angel (2023) defined urban expansion as the physical extension of the geographical footprints of towns, cities, and metropolitan areas into the surrounding countryside, encompassing surrounding villages and towns in the process. As cities grow, they extend outwards, increasing the area and converting more land to urban use and frequently redefining urban boundaries. Bloch *et al.* (2015) stated that the emerging reality is a mismatch between the extent of the land cover occupied by the built fabric and Nigerian municipalities' existing administrative and institutional boundaries. Urban expansion is frequently not constrained within municipal limits but often overlaps or spills between various Local Government Areas (LGAs) or even federal states (Fox*et al.*, 2018). This phenomenon has been notably apparent in many regions of Nigeria, including the Anambra State. Onitsha metropolis and environs have been growing at a continuous rate of 2.83% (National Population Commission, 2006), having a large number of public sectors, private sectors, industrial establishments, infrastructural, and large residential clusters which are now providing a large number of opportunities to different social classes of our society.

The Onitsha region has drawn people from all parts of Anambra and even South Eastern Nigeria. Due to this, Onitsha and its environs have witnessed phenomenal population growth in the past years and rapid urban expansion into the surrounding suburban and peri-urban areas (UN-Habitat, 2012). This is because Onitsha City has a small landmass, and the population explosion has given rise to insufficient housing and developmental needs. Therefore, people move to nearby suburban and peri-urban areas, including towns in Oyi Local Government Areas.In the Oyi Local Government Area of Anambra State, the rapid urbanization over the past few decades has transformed the socioeconomic landscape (Ikedigwe*et al.,* 2024). Oyi Local Government Area is experiencing rapid urban growth, resulting in significant changes to its landscape and environment. This growth, driven by economic expansion, has led to the loss of natural vegetation, farmland, forest reserves, and biodiversity. A deep understanding of urban growth patterns in rapidly urbanizing areas like Oyi Local Government area is essential for driving sustainable development. Urbanization is a driver of economic opportunities but also poses significant environmental and social challenges (Adebayo *et al*., 2024).The ability to properly manage urban expansion is a key factor in achieving sustainable development goals and improving the quality of life in cities. Remote Sensing (RS) and Geographic Information System (GIS) provide tools for detailed and effective landscape management. This research, therefore, aims to investigate the changes in land use and land cover in the Oyi Local Government Areafrom 1998 to 2023 and to determine the trend of urban expansion using GIS techniques.

2.0 Materials and Methods

2.1 Study Area

The study,Oyi Local Government Area of Anambra State, lies within the coordinates of latitude 6°10′ N and 6°19′ N of the equator, and between longitudes 6°50′ E and 6°58′ E. Oyi Local Government Area is made up of five communities: Awkuzu, Nkwelle-Ezunaka, Nteje, Ogbunike, and Umunya. It is bounded by Anambra East LGA by the north and west, Njikoka and Dunukofia LGAs by the East, Idemili North LGA by the south, and Onitsha North LGA by the southwest. It has a land area of about 149.6 sq.km.The climate falls within the tropic wet and dry type based on Koppen's classification and belongs to the tropical rainforest vegetation belt.The population of Oyi, according to the 2006 national population census figures, is 168,201 persons and projections for 2023 at a growth rate of 2.83% show that a total of 262,873 persons reside in the area.

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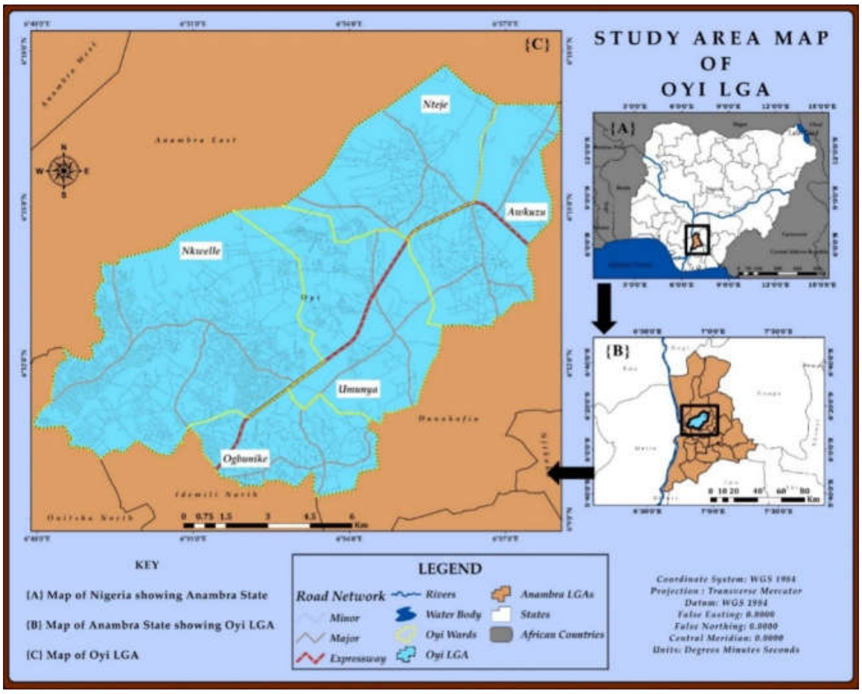

Figure1: Map of the study area

2.2 Data Collection

The LANDSAT data were downloaded from the USGS Earth Explorer website. These include Landsat TM (Thematic Mapper), ETM+ (Enhanced Thematic Mapper plus) and OLI (Operational Land Imager) satellite imagery for 1998, 2003, 2008, 2013, 2018, and 2023, all of which have a resolution of 30 meters except for OLI, which has a resolution of 29m.Considerable effort was put into selecting cloud-free data sets and to get data near the same date and the same season because of seasonal difference effects on the images for classification and change detection. The images have spectral ranges of 0.45-2.35 micrometer (µm) with bands 1 to 7 and 8 respectively, while the Operational Land Imager (OLI) extends to band 12. They are used for the LULC analysis. Each of the bands are tailored for detecting different features depending on the combination of three different bands; band 2 (green), band 3 (red), band 4 (infrared), band 5 (mid infrared), band 6 (thermal infrared), band 7 (mid infrared) and band 8 (panchromatic).The administrative shapefile of Nigeria containing states and L.G.A's were acquired from the Office of the Surveyor General of the Federation (OSGOF). It is a projected vector shapefile that was used to specify the boundary of the study area.

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2.3 Data Analysis

Pre-Processing of LANDSAT Satellite Imagery

In this study, several sequential steps of data preprocessing were performed using Arc GIS 10.8 software packages. These steps comprised radiometric, atmospheric, and geometric corrections in addition to sub-setting. Preprocessing also involved the selection of the appropriate band combinations to be used in image classification.To reduce radiometric errors, images were calibrated using the radiometric correction tool in Erdas Imagine, where raw data from the sensors (DNs) were converted to top-of-atmosphere reflectance. For atmospheric correction, a dark object subtraction model was applied in the current study as it is relatively the simplest and most widely used empirical method for classification and change detection applications. The imageries were projected to the Geographic Coordinate System, WGS 1984 and corrected for geometric errors from the sources. Then, the images were clipped to the study area's administrative boundary to enhance accuracy.

Supervised Image Classification

Image classification is an important remote sensing technique used to catalog all pixels in an image or raw remotely sensed data into a finite number of individual LULC classes to produce beneficial thematic maps and information. The image classification process is normally conducted to assign different spectral signatures from the dataset to several classes based on reflectance attributes of the diverse types of LULC. Different types of classification techniques exist, but the Supervised Classification technique using the Maximum Likelihood classifier, which is the most widely used in remote sensing research, was utilized as it is easy to implement, fast, enables clear interpretation of results and is highly accurate.For the Landsat TM, ETM+ and OLI, a False Colour Composite (FCC) operation was performed using the ArcGIS 10.8 software and the images were combined in the order of band 5, 4 and 3 for Landsat TM and ETM+ while that of Landsat OLI was in the order of band 6, 5 and 3 due to change in sensor. A supervised classification scheme with the Maximum Likelihood Classification algorithm is then used for the classification.

LAND USE AND LAND COVER (LULC) SPATIOTEMPORAL DYNAMICS IN OYI LGA

The LULC classes detected from and utilized for this analysis are – Bare Lands, BuiltUp Area, Dense Vegetation, Sparse Vegetation. These classes are examined for their spatiotemporal changes within Oyi LGA. Table 1 describes the physical and visual characteristics of the observed LULC classes.

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Table 1: Description of LULC Classes

CLASS	DESCRIPTION
Sparse Vegetation	Shrubs, grassland, cultivated/fallow farmlands, agricultural lands
Bare Lands	Bare soil, excavation sites, quarry sites
Dense Vegetation	Tropical rainforests, tree clusters, natural vegetation, mixed forest, gardens, parks and playgrounds, riparian vegetation, marshy land, and swamps
Built-Up Area	All infrastructure - residential, commercial, mixed use and industrial areas,villages, road network, pavements, and man-made structures.

Transition Map

Using the Land Change Modeller (LCM) tool in IDRISI Selva, the observed LULC classes from the classification results are modelled to display the rates of transition from one class to other classes.

3.0 Results and Discussion

Results

LULC characteristics in Oyi Local Government Area

Table 2: LULC distribution in Oyi Local Government Area

	1998		2003		2008		2013		2018		2023	
CLASS	Area (Sq.km.)	%	Area(Sq.km.)	%	Area(Sq.km.)	%	Area(Sq.km.)	%	Area(Sq.km.)	%	Area(Sq.km.)	%
Bare Surfaces	4.9	1	0.01	0	0.00		1.3		3.3		1.3	
Built-Up Area	1.5	3	2.8		23.1		30.8		34.6		42.9	
Dense Vegetation	94.9	64	92.9		73.2		34.3		27.6		18.6	
Sparse Vegetation	48.4	32	53.8		53.2		83.1		84.1		86.8	
TOTAL	149.6	100	149.6	100	149.6	100	149.6	100	149.6	100	149.6	100

In 1998, it was observed that bare lands in Oyi LGA covered just 4.9 sq.km. of the area, while built-up areas covered 1.5 sq.km., indicating low levels of infrastructural development during this period (Fig. 2). Sparse vegetation covered 48.4 sq.km. of the area, thus suggesting an area with large swathes of agricultural land, grasslands, shrubs, and fallow lands in 1998. Dense vegetation covered 94.9 sq.km. of the study area, indicating that the area had large swathes of forests and tree clusters during this period. This class was by far the most dominant class in 1998.

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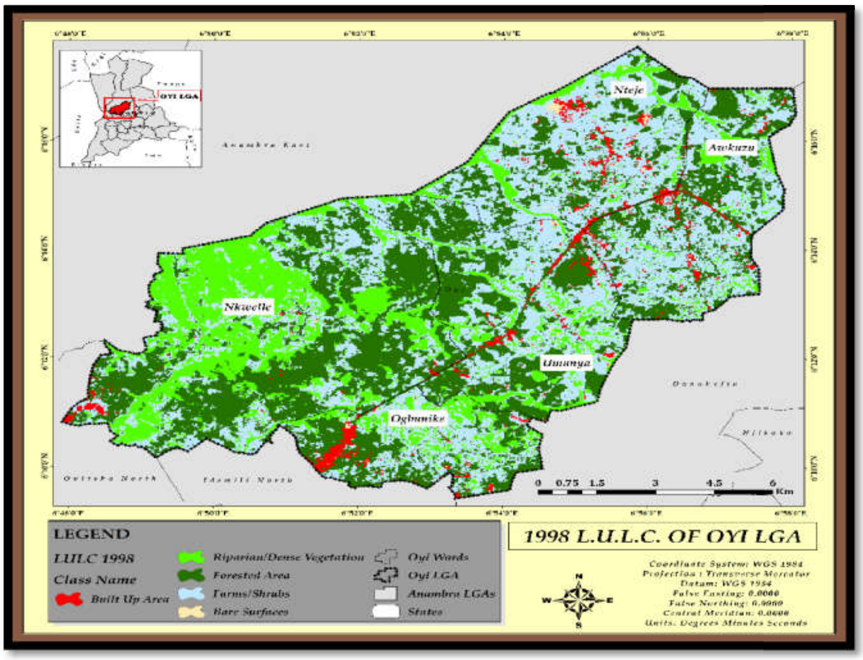

Figure 2: LULC map of 1998

After a 5-year interval, it was observed that in 2003, bare lands reduced in spatial extent to 0.01 sq.km., while built-up areas increased to 2.8 sq.km. during the same period. Dense vegetation experienced a slight reduction in spatial extent to 92.9 sq.km. The Sparse vegetation class observed an increase, growing to cover 53.8 sq.km. of the study area. Despite the reduction in spatial extent, the dense vegetation class remained the predominant class in the region.

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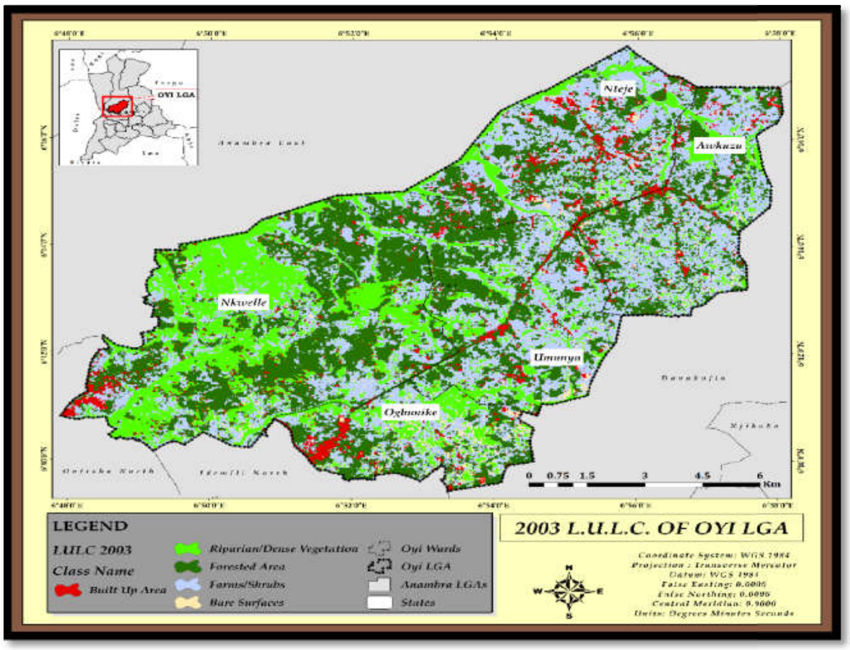

Figure3: LULC map of 2003

By 2008, bare lands were largely undetectable (Fig. 4), but built-up areas covered 23.1 sq.km., indicating significant infrastructural development in Oyi LGA during this period. Sparse vegetation observed a slight reduction in spatial extent as they reduced to cover 53.2 sq.km. of the study area. Dense Vegetation reduced significantly to cover 73.2 sq.km. of the region.

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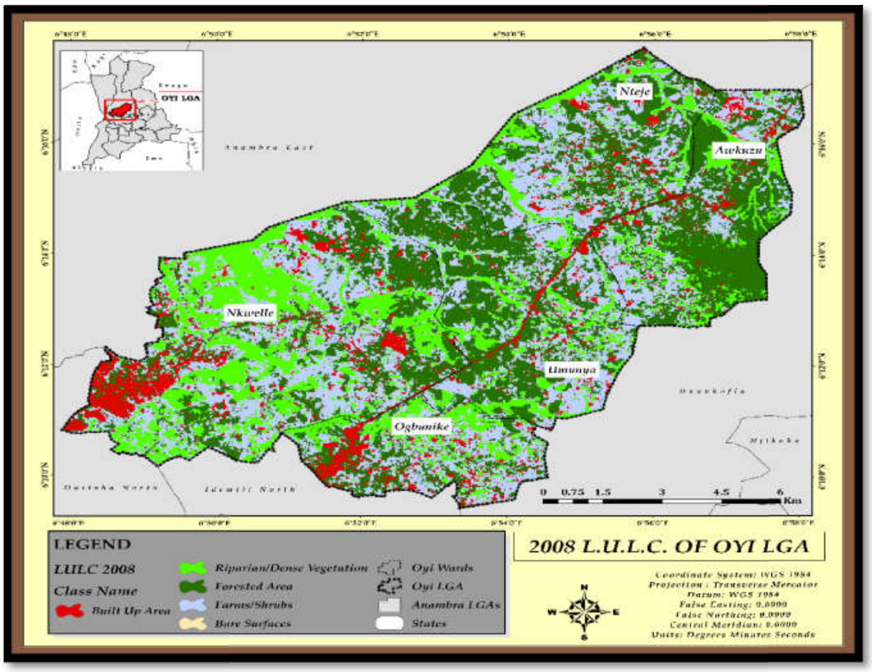

Figure4: LULC map of 2008

By 2013, bare lands increased to cover 1.3 sq.km. of the area, while built-up areas increased further to cover 30.8 sq.km. of the study area (Fig. 5). The Dense Vegetation in the area observed a significant reduction, as it covered just 34.3 sq.km. of the study area during this period.

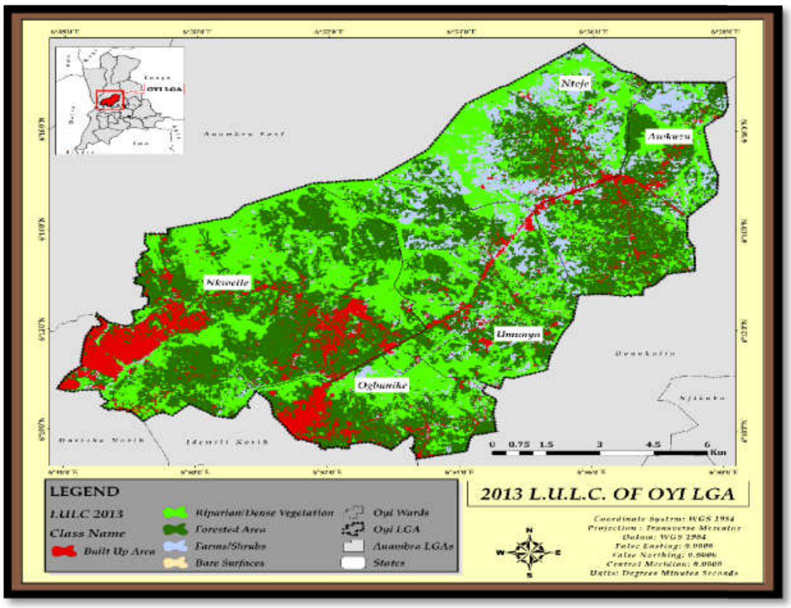

Figure5: LULC map of 2013

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By 2018, bare lands covered 3.3 sq.km. of the study area, with Built-up areas extending further to cover 34.6 sq.km. of the region (Fig. 6). The Farms/Shrubs covered 84.1 sq.km. of the region during this period. The Dense Vegetation class also covered 27.6 sq.km. of Oyi LGA by 2018.

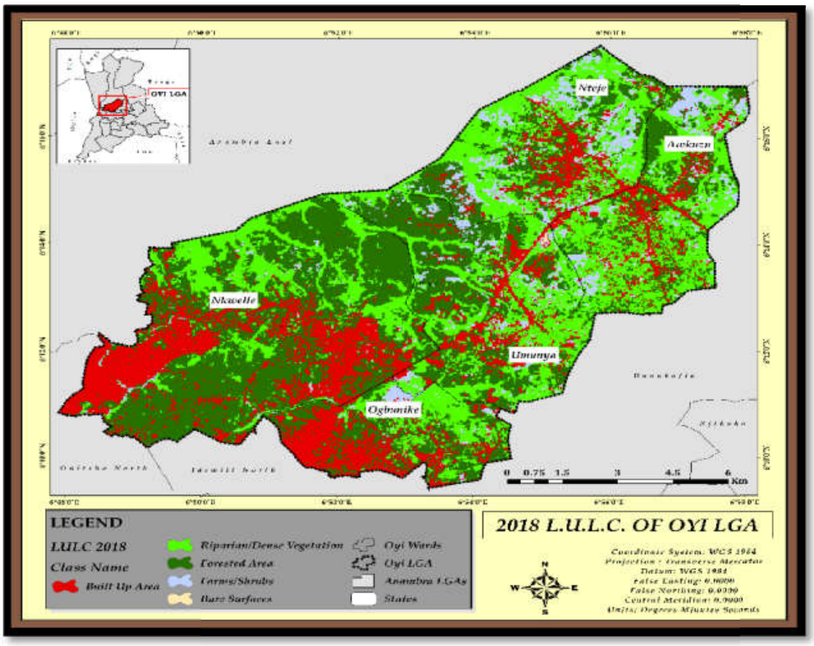

Figure6: LULC map of 2018

By 2023, significant changes occurred as the aftermath of the 2022 flooding and its impacts on land use in the region are observed. Bare lands reduced to 1.3 sq.km. in the study area, while Built-Up Areas significantly grew to cover 42.9 sq.km. of the study area (Fig. 7). Sparse vegetation increased concurrently with the Built-Up Areas, to cover 86.8 sq.km. Dense Vegetation covered 18.6 sq.km. of the region in 2023.

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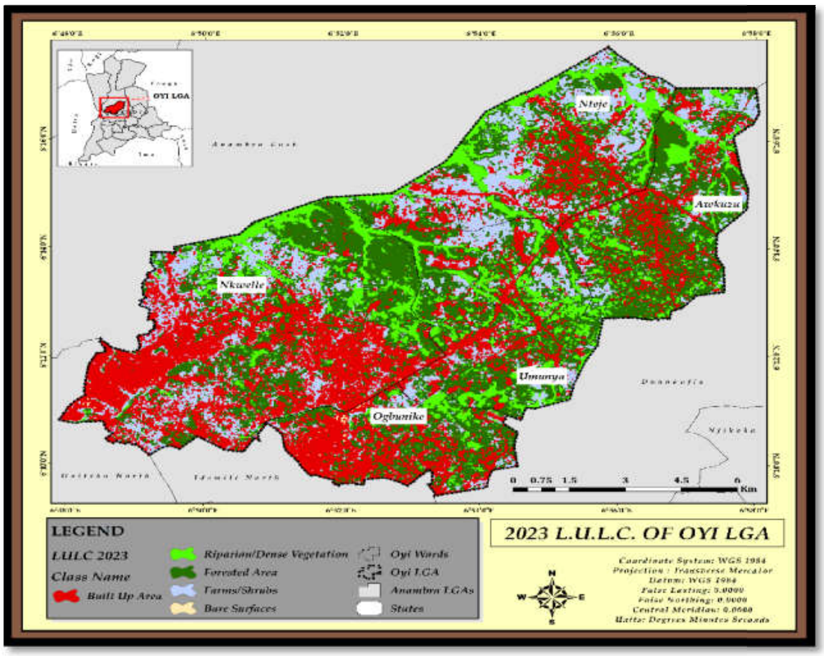

Figure 7: LULC map of 2023

The total spatiotemporal dynamics of the LULC in Oyi LGA are displayed below in Fig. 8, and the aforementioned variations are displayed sequentially. The consistent increase in the spatial extent of the built-up class indicates further development in the coming future.

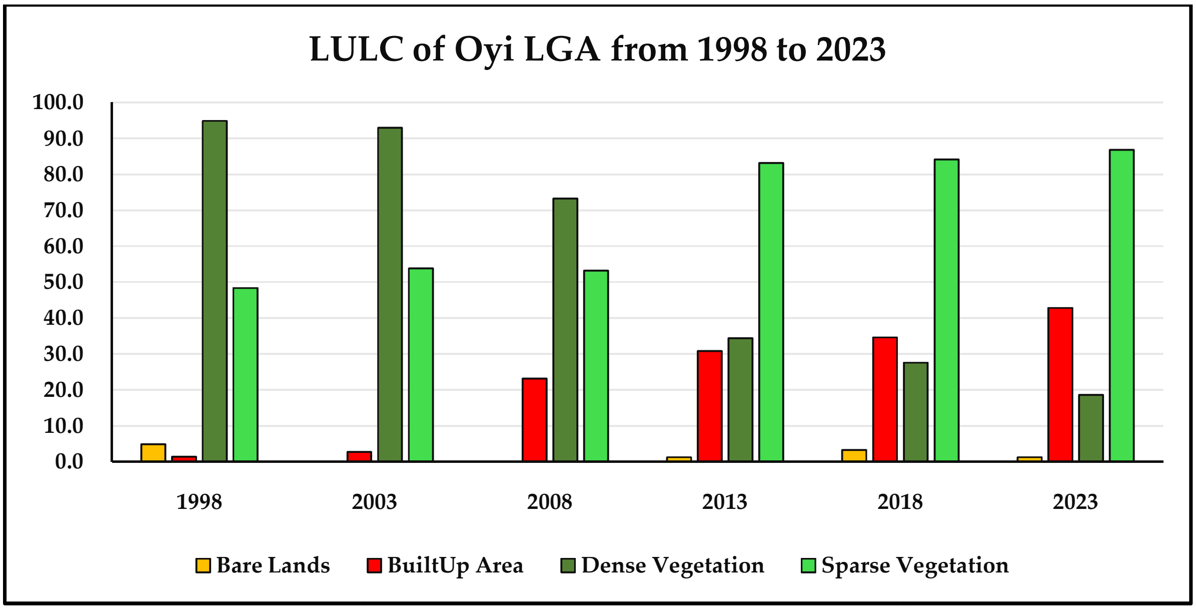

Figure 8. Total LULC of Oyi LGA from 1998 to 2023

CHANGE DETECTION IN LULC CHARACTERISTICS

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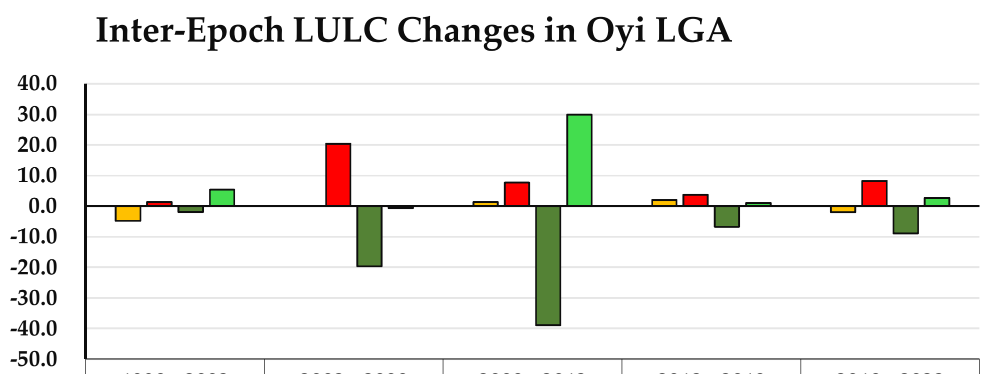
To accurately determine the level of changes that occurred in the region between classes and epochs, a change detection analysis is deployed and this reveals that from 1998 to 2003, bare lands were reduced by 4.9 sq.km. (Fig. 9). Built-Up Areas increased by 1.3 sq.km. Dense Vegetation lost 2 sq.km. of its spatial extent during this period, with sparse vegetation increasing by 5.4 sq.km.



	1998 - 2003	2003 - 2008	2008 - 2013	2013 - 2018	2018 - 2023
Bare Lands	-4.9	0.0	1.3	2.0	-2.0
BuiltUp Area	1.3	20.4	7.7	3.8	8.2
Dense Vegetation	-2.0	-19.7	-38.9	-6.7	-9.0
Sparse Vegetation	5.4	-0.7	29.9	1.0	2.7

Figure 91: Inter-epoch Change Detection of LULC Classes in Oyi LGA

From 2003 to 2008, bare lands experienced no change. Built-up areas further increased by 20.4 sq.km. during this period. Dense Vegetation reduced further by 19.7 sq.km., while sparse vegetation observed a loss of 0.7 sq.km.

Furthermore, from 2008 to 2013, bare lands increased by 1.3 sq.km. Built-Up Areas increased by 7.7 sq.km., while dense vegetation lost 38.9 sq.km. of its spatial extent during the same period. Sparse vegetation increased by 29.9 sq.km. during this period.

By the next epoch of 2013 to 2018, bare lands increased by 2 sq.km. Built-Up Areas increased by 3.8 sq.km., indicating an era of further infrastructural development, as it coincided with the end of Gov. Peter Obi's excellent tenure in terms of infrastructure, and the beginning of Gov. Willie Obiano who completed most of the projects his predecessor could not finish. Dense vegetation lost 6.7 sq.km. of its spatial extent, while sparse vegetation further increased by 1.0 sq.km.

Between 2018 and 2023, bare lands reduced by 2.0 sq.km. Built-Up Areas further increased by 8.2 sq.km. Dense Vegetation observed a loss of 9.0 sq.km., while sparse vegetation gained 2.7 sq.km. of its spatial extent during this period.

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These results thus depict that from 1998 to 2023, bare lands lost a total of 3.6 sq.km. of its spatial extent, while Built-Up Areas observed a total increase of 41.4 sq.km., marking it out as the most improved class in the area (Fig. 10). The Built-Up Areas grew from the lowest class in terms of spatial extents in 1998, to the second highest class in 2023, with trends suggesting that it may become the dominant class within Oyi LGA in the near future. Dense vegetation lost a total of 76.3 sq.km. of its spatial extents, the class with the most losses. The sparse vegetation class observed a total increase of 38.4 sq.km. in its spatial extent during this period.

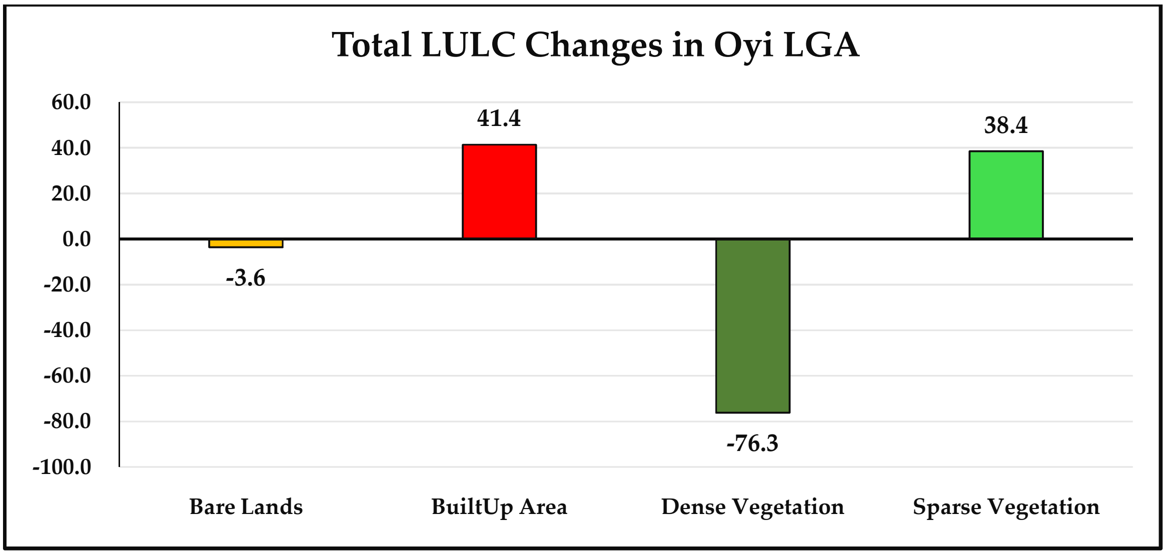

Figure 10. Net Changes of LULC classes in Oyi LGA from 1998 to 2023

LULC CONTRIBUTION TO BUILT-UP AREA CHANGES

Due to the total increase in Built-Up Areas, it is necessary to ascertain the classes that contributed the most to the development to further instruct the relevant agencies and stakeholders on the potential relationship between urbanization and environmental degradation. It is thus observed that from 1998 to 2003, bare lands lost 0.44 sq.km. to Built-Up Areas. Dense vegetation lost 0.6 sq.km. of its spatial extent to Built-Up Areas, while sparse vegetation also lost 0.3 sq.km. of its spatial extent to Built-Up Areas. These contributions combined to constitute the total change of 1.3 sq.km. increase observed by the Built-Up Areas class between 1998 to 2003.

From 2003 to 2008, Built-Up Areas gained 0 sq.km. from the bare lands in Oyi LGA, while also gaining 15.5 sq.km. of spatial extent from dense vegetation, the major contributor during this period. It further gained 4.9 sq. km. from sparse vegetation. These contributed to the total change of 20.4 sq.km. increase observed by the Built-Up Areas class during this period.

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From 2008 to 2013, Built-Up Areas gained 0.43 sq.km. of its extent from the bare lands class. It gained 6.8 sq.km. from the dense vegetation class, the major contributor to urban development during this period while gaining 0.48 sq.km. of its extent to sparse vegetation in Oyi LGA. These contributed to the total increase of 7.7 sq.km. in spatial extent observed by the Built-Up Areas class from 2008 to 2013.

Furthermore, from 2013 to 2018, the built-up area gained 0.4 sq.km. of its spatial extent from the bare lands in Oyi LGA. It thus gained 2.9 sq.km. from dense vegetation in Oyi LGA, further gaining 0.5 sq.km. from the sparse vegetation class in the region. These contributed to the significant increase of 3.8 sq.km. observed by the Built-Up Areas in Oyi.

Between 2018 and 2023, the built-up area gained 0.2 of its extent from bare lands. The Built-up areas further gained 7.4 sq. km. from the dense vegetation class, while also gaining 0.6 sq.km. from the sparse vegetation in the region. These all contributed to the total 8.2 sq.km. increase observed by the Built-Up Areas class from 2018 to 2023.

Based on these results, from 1998 to 2023, the total contribution to the changes observed by the Built-Up Areas in Oyi LGA are as follows – Bare lands lost 1.5 sq.km. of its spatial extent to Built-Up Areas. Dense vegetation are the major contributors to urban development in the region, as they lost a significant total of 33.2 sq.km. to the Built-Up Areas in Oyi LGA from 1998 to 2023. The sparse vegetation in the region thus lost 6.8 sq.km. of its extent to the Built-Up Areas.

To display these contributions, a transition map is generated and it depicts the significant transitions that the various land use classes have undergone to urban surfaces from 1998 to 2023 (Fig. 11). The Dense vegetation classes are the most impacted by the urban transformation occurring in Oyi LGA during this period, especially in regions such as Nkwelle and Ogbunike, who experienced significant urban development as population pressure from the neighboring Onitsha Metropolis spilled development into the regions surrounding it. Despite this, further significant changes occurred in all the other wards within Oyi LGA.

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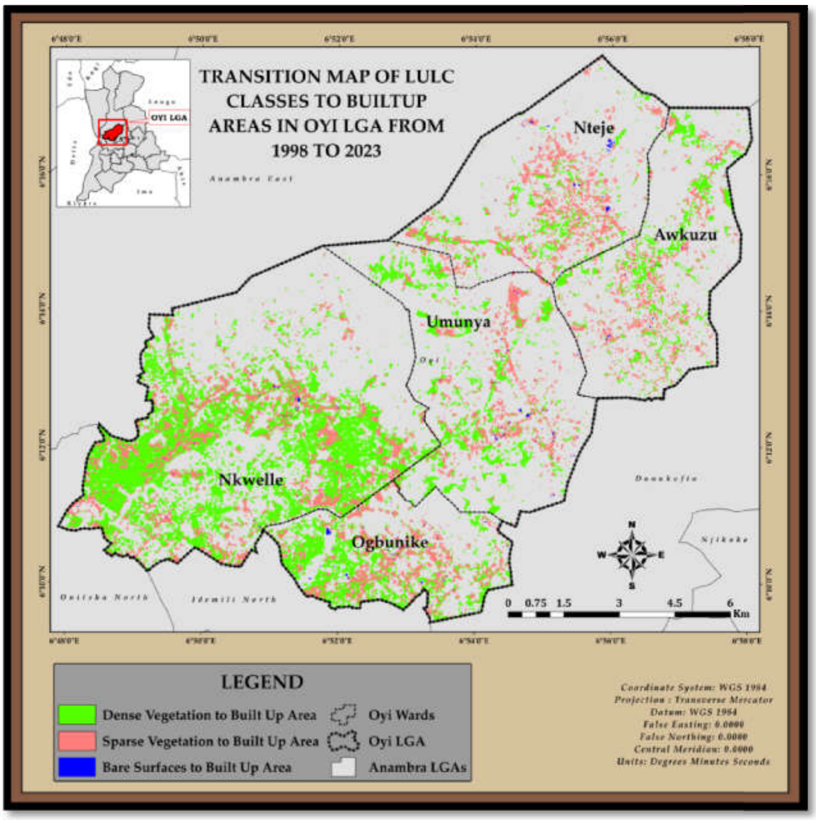

Figure 11: Transition to Built-Up Area Map of Oyi LGA

SPATIAL TREND OF BUILT-UP AREA CHANGE

To further determine the trend of urban expansion, it is imperative to deploy the spatial trend of change tool. In landscapes dominated by human intervention, patterns of change can be complex, and thus very difficult to decipher. This tool provides the ability to map trends with a best fit polynomial trend surface to the pattern of change. This module intends to provide a means of generalizing about the pattern of change. The numeric values do not have any special significance. The surface is created by coding areas of change with 1 and areas of no change with 0 and treating them as if they were quantitative values.

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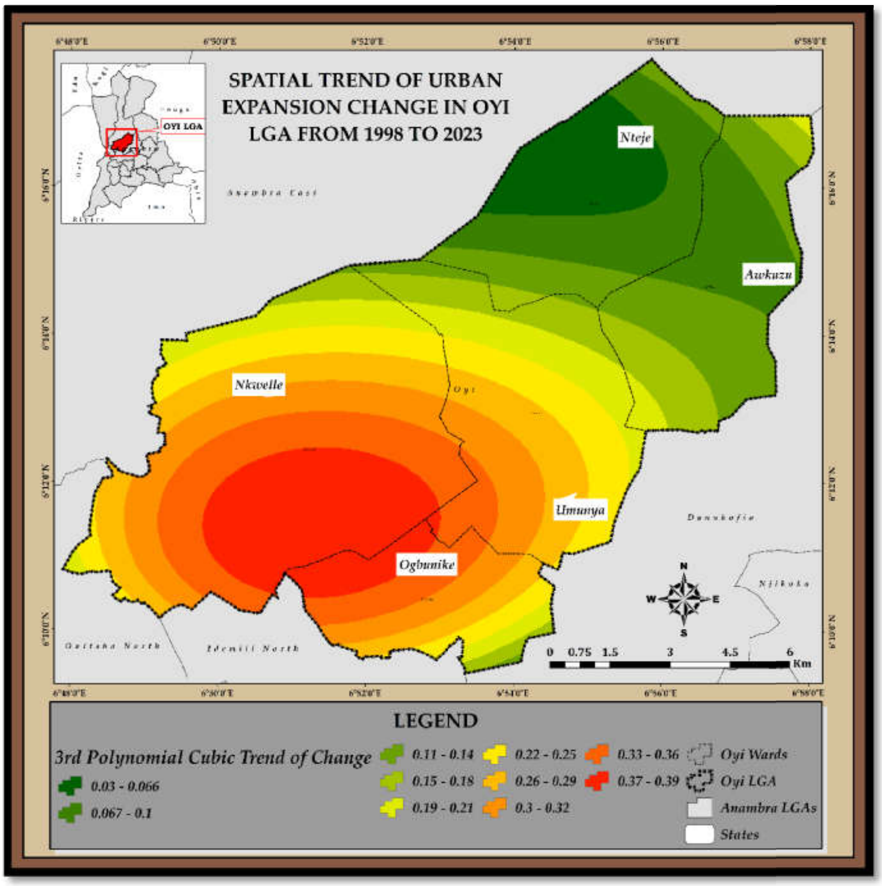

Figure 122: Spatial Trend of Urbanization Change

Fig. 12 further corroborates assertions made about the urban sprawl occurring from the Onitsha Metropolis located towards the southwest of Oyi LGA, as the area is at the epicenter of most of the urban transformations going on in Oyi LGA. Based on the trend of urbanization it is probable that urban regions will cover most of the region as more people move from the rural regions to the urban areas in search of better socioeconomic opportunities, and more movement from the Onitsha Metropolis to areas with cheaper accommodation continues. According to the UN (2018), about two-thirds of the global population will live in urban areas. This posits that the increasing trend of urbanization and migration from rural areas to urban areas will continue for the foreseeable future, especially as the wealth distribution remains uneven in much of the global south. Also, the trend of migration to nearby locations due to limited spatial availability in Onitsha will increase the inward infrastructural development occurring in the region.

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3.2 Discussions

Table 2 summarizes the findings for 1998, 2003, 2008, 2013, 2018, and 2023 regarding the land use andland cover categories observed in Oyi local government area.Meanwhile, Figures 2, 3, 4, 5, 6, and 7 illustrate the land use and land coverpatterns for the years 1998, 2003, 2008, 2013, 2018, and 2023,respectively.

This study meticulously examined the spatiotemporal dynamics of Land Use and Land Cover (LULC) in Oyi Local Government Area (LGA) between 1998 and 2023. It reveals a landscape undergoing significant transformation. The initial state in 1998 portrayed a region dominated by dense vegetation, indicative of a largely natural environment, interspersed with substantial areas of sparse vegetation, suggesting active agricultural practices.Built-up areas were minimal, reflecting limited infrastructural development at that time. This aligns with the findings of Agulue (2018) who assessed the land use and land cover changes in Dunukofia and Oyi local government areas. However, the subsequent decades witnessed a consistent and substantial expansion of built-up areas, indicating rapid urbanization and infrastructural development. This aligns with the findings of Fatai (2021),Anwana*et al* (2021), Mohammed (2021),and Umar *et al.* (2023) who found that there has been a significant increase in built-up areas across some peri-urban areas of Nigeria. This surge in urban growth is driven by population increase and regional development, particularly influenced by the proximity to the Onitsha Metropolis, which appears to be a major catalyst for urban sprawl.

Conversely, the study documented a steady decline in dense vegetation, signifying deforestation and the loss of natural habitats. This loss is directly correlated with the expansion of built-up areas, indicating that urban development is a primary driver of deforestation in the region. This also aligns with the findings of Agulue (2018) and Mohammed (2021) whi indicated that there is a significant decrease in dense vegetation. The fluctuations observed in sparse vegetation, with an overall increase, suggest potential shifts in agricultural practices. The variability in bare lands, possibly influenced by erosion, excavation activities, and natural disasters such as flooding, underscores the dynamic nature of land cover changes in response to both anthropogenic and environmental factors.Change detection and transition analyses, utilizing tools like the Land Change Modeller (LCM), quantified the inter-epoch LULC changes and highlighted the conversion of dense vegetation to built-up areas as the primary source of urban expansion. The spatial trend analysis further corroborated this, illustrating the urban sprawl originating from the Onitsha Metropolis.

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4.0 Conclusion and Recommendations

The analysis of land use and land cover in the Oyi Local Government Area over twenty years revealed a significant rise in built-up areas, coupled with a decline in vegetation and farms/shrubs. The expansion of built-up areas resulted from the transformation of natural vegetation into urban settlements and impermeable surfaces. From the findings of this study, it is recommended that monitoring systems should be implemented by the Anambra Geographic Information System (ANAMGIS) for the built environment. This is essential to enable planners and decision-makers to anticipate and address potential issues proactively amidst a changing environment.Also, Anambra Statere quires immediate action from urban planners, local authorities, and the state government to create and enforce effective planning regulations, as this study highlights the urgent need to control unplanned expansion and ensure sustainable development.

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