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Spatio-temporal Modelling of Land-use/Landcover Dynamics in Owerri West, Imo State Using Geospatial Technique

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In recent times, the pressures from uncontrolled land use has resulted to several environmental problems including flooding, pollution, erosion etc. thereby posing a trait to environmental sustainability in Owerri west. Therefore, this research evaluated Land-use and Landcover changes in Owerri west local LGA in Imo state using multi-dated satellite Imagery. The major aim of the study was to carry out analysis of land-use/land cover development trends, thereby detecting the changes that have taken place between the year 2000 to 2020. Software used include ERDAS Imagine, ArcGIS10.5 and Microsoft excel. Three Landsat images, 5(TM), 7 (ETM+) and 8 (OLI)

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images of 2000, 2010 and 2020were acquired, pre-processed and classified using supervised classification algorithm. Progressively, accuracy of the classified result and change detection analysis was performed to investigate the changes that has taken placebetween this period. The spatial and temporal analyses indicate that, all LULC classes altered from their initial state within these epochs. The result of the study shows that the built-up areas have been on a significant constant positive expansion covering 22.57% ,36.11% and50.30% of the study area in 2000, 2010 and 2020respectively. Forest decreased from 31.32% to 20.54% and finally to 13.03%.Sparse vegetation decreased from 23.86% to 23.35% and to 15.28%. Exposed surface decreased from 12.24% to 10.04% and increased to11.08%.Water body decreased gradually from9.99%, to 9.97% and 9,89%%. The study further predicted that beyond the year 2050 thick vegetation may vanish and replaced by urban expansion and this is of grave consequences to the eco-environment. Therefore, this study suggests the establishment of forest reserves and planting of trees within the study area.

Keywords: Environmental monitoring; landsatimageries; land-use/Land-cover; change detection.

1. INTRODUCTION

Land is vital to the survival of all life on earth and it is very important that we quantify and understand the various changes that take place on it [1]. Land-use change is a known phenomenon in the existing literature of land, urbanization, development control and its resultant implications to socio-economic development and wellbeing of the affected populace are issues of concern to policy makers and urban managers [2]. In recent times, the pressures from uncontrolled land use, rural to Urban sprawl and environmental degradation continues to be a trait to the natural eco-environment [1]. As a result of human activities, the Earth surface is being significantly altered in some manner and his use of land has had a serious negative effect on the natural environment thereby resulting to accelerated growth in settlement expansion [2,3]. Adequate geographic information of facilities and natural resources is required to be able to prepare and sustain the environment. Limited natural resources and their wide utilization with increasing population is a major concern. Conservation of natural resources is of prime importance for sustainable development and to mitigate the demand and supply gap between resources [4]. Land-use/Land cover monitoring is so significant that neglecting it will lead to serious negative impact on the environment therefore there is the need for timely and accurate documentation of land covers because of its dynamics and global impact [5,6]. Environment monitoring helps to understand the changes that are currently taking place, detect their major drivers and predict future trends [7].

Base on the numerous traits posed by uncontrolled environmental changes, there is need to adopt the most reliable technologies to monitor and sustain our environments. Remote Sensing and GIS offer quick and efficient approach to the classification and mapping of land use/land covering geographic space [8]. The basic premise in using Satellite Images for change detection is that changes in land cover result in changes in radiance values that can be remotely sensed [9]. A geographic information system (GIS) allows geospatial analysts to investigate spatial patterns within the geographic domain and to understand the relationships that exist between the eco-environment and human activities. Technology involving the integration of geographical information system (GIS) and remote sensing technique is designed in such a way that multi-dimensional data can be entered, manipulated, checked, analyzed and displayed as data referenced to the earth [10]. The specific aim of this research is to examine the spatial and temporal dynamics of land use/land cover in Owerri west using geospatial technique [11-13].

1.1 Study Area

Owerri West is a Local Government Area of Imo State, Nigeria. Its headquarters are in the town ofUmuguma. Owerri West was carved out of the former Owerri Local Government Area in 1996.It has an area of 303.199 km2 and a population of and a population of 99,265 based on the 2006 census. It is geographically located at latitude 5°29'1.07" N and longitude 7°01'59.70" E.

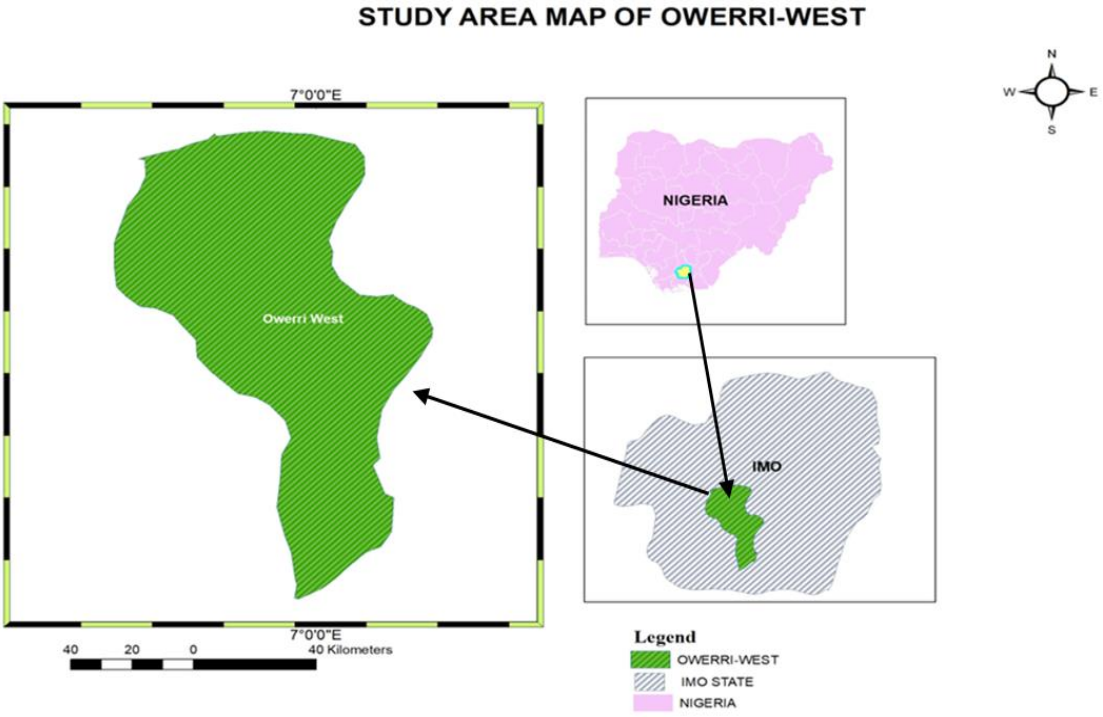

Fig. 1. Location map of the study area

2. MATERIALS AND METHODS

2.1 Data Description

Data used in this study include Landsat satellite imagery of three (3) epochs i.e. Landsat imagery of 2000, 2010 and 2020. These datasets were obtained from the Global Land Cover Facility (GLCF). Other datasets includeadministrative map of Imo state from which the study area was extracted. This was obtained from ministry of land and survey Imo state.Geo-physical points data wereobtained through ground truthing.Software used include ERDAS Imagine, ArcGIS 10.5 and Microsoft Excel 2012.

2.2 Methodology

Image processing was done using ERDAS Imagine software. It involves those operations that are normally required prior to the main data analysis and extraction of information. Radiometric correction was carried out followed by geometric correction. Radiometric correction assists in removing inconsistencies in the measured brightness valuewhile geometric correction ensures that the locations of features in the image match their real-world coordinates. Progressively, image enhancement was carried out to improve the appearance of the imagery to assist in visual interpretation and analysis.Thereafter, mosaicking and sub-setting were done to generate/extract the spatial extent of the study area from the merged image tilesin ArcGIS 10.2 window.Prior toimage classification, ground truthing was carried out to identify and developed land use/land cover categories. Appropriate number of ground control points belonging to various land use land cover classes was acquired in the field across the study area. Based on this a training fille was created which was used for cluster the study area into feature categories using maximum likelihood supervise classification algorithm. Progressively, accuracy assessment was also carried out using captured ground control points and historical map information of the study area as references. This study was carried out as per the methodology presented in Fig. 2. Change detection analysis was done to determine the change and percentage changes of the six classes of land use/land cover across the periods. Change detection is a process that measures how the attributes of a particular area have changed between two or more time periods. Change detection often involves comparing imageries of an area taken at different times. In this study, land use/land cover change processes in the

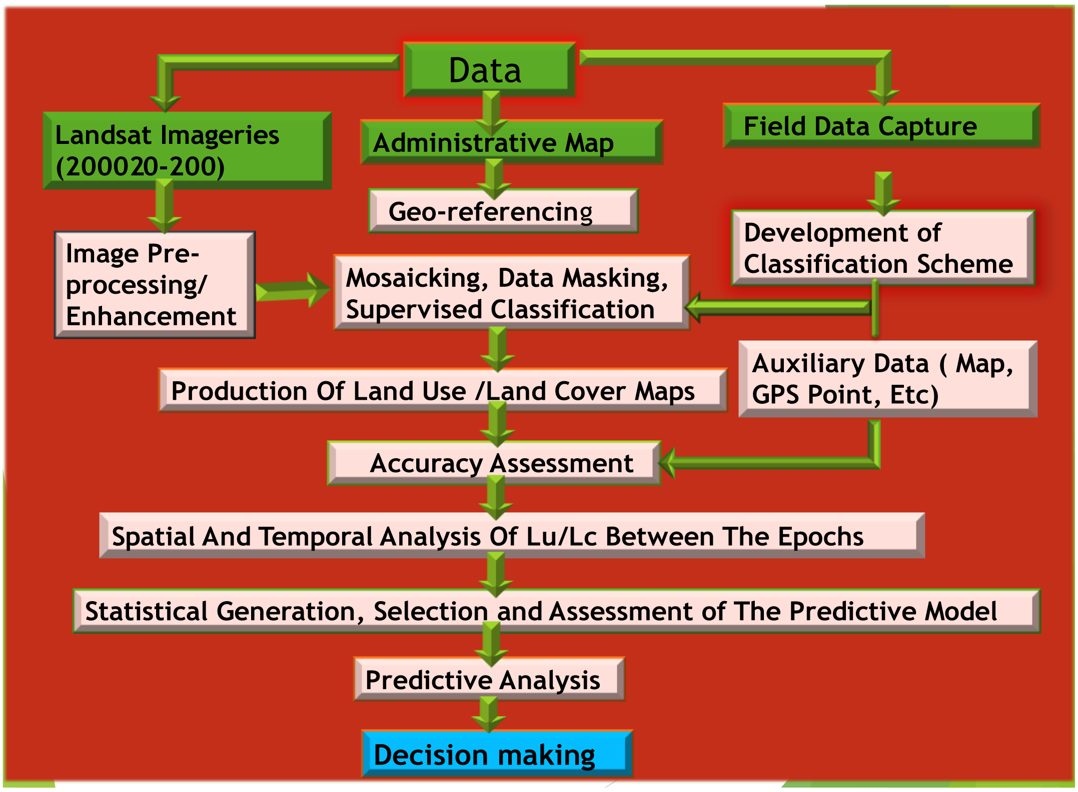

Fig. 2. Methodological flow chart

periods of 2000-2020 were detected by applying the post-classification comparison method. In this study analysis of spatial extent of feature coverages and observed change detection were graphically presented in percentage and absolute value.

3. RESULTS AND DISCUSSION

Figs. 3a, 3b and 3carethe spatial extents of the various land use categories in percentage and absolute value in 2000. The Land use/land cover categories identified are forest, vegetation, built up areas, open (exposed) space and water bodies, (Fig. 3a). In the year 2000 out of the total area forest had the highest percentage 31.32%, vegetation has 23.86%, built up area 22.57%, open surface12.24% and water body 9.99% (see Fig. 3b). These corresponds to absolute values of 94.66sq.kms, 72.364sq.kms, 68.438sq.kms, 37.120sq.kms and 30.31sq.kms respectively (see Fig. 3c).

The classified land use/land cover distribution maps of the years 2010 is presented in Fig. 4a. As can be seen in Fig. 4b, in 2010 out of the total area, forest had 20.54%, vegetation has 23.35%, built up area 36.11%, open surface 10.04% and water body 9.97%. These correspond to spatial extents of 62.770sq.kms, 70.823sq.kms, 109.501sq. kms, 30.460sq.kms and 30.236sq.kms respectively (see Fig. 4c).

Fig. 5a is the land use land cover character of the study area in 2020. Within this period, out of the total area, forest occupied13.03%, vegetation has 15.28%, built up area s covered 50.30%, open surface 11.80% and water body 9.89% (Fig. 5b). Thesemetrics correspond to spatial extents of 40.595sq.kms, 45.275sq.kms, 152.536sq.kms, 35.795 and 29.995 respectively and this is graphically represented in Fig. 5c.

When the trend is compared between 2000 and 2020, it can be seen that built up areas are on the increase while other feature classes are decreasing. This is graphically shown in Fig. 6 and corroborated by Table 1. It can also be observed that temporal variation exhibited by built up and forested feature classes are high. Furthermore, there had been a continuous conversion of non-built-up surfaces to built-up; A situation which is considered to be responsible for environmental degradation within the study area.

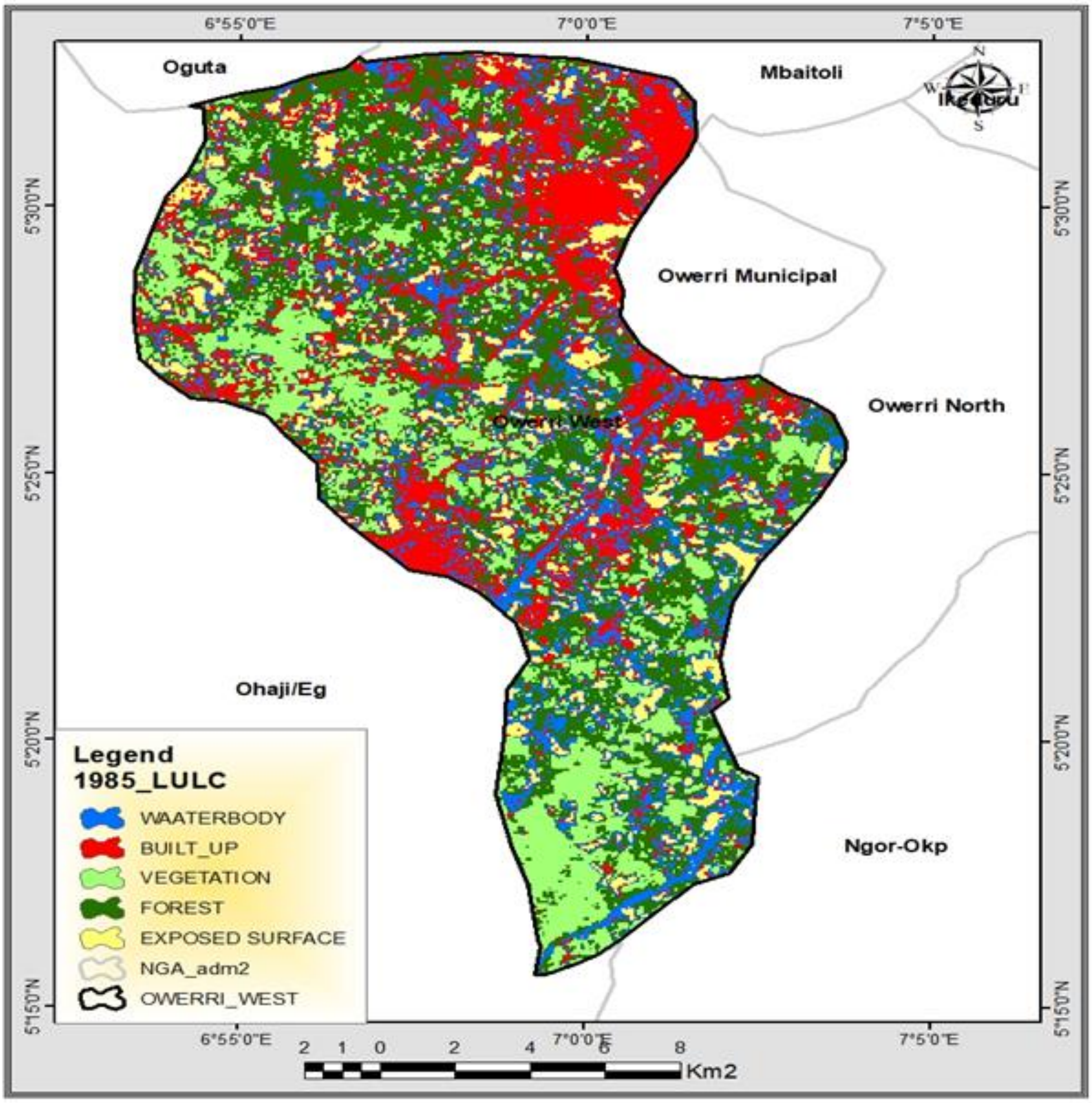

Fig. 3a. Land use/Land cover Map of the study area in 2000

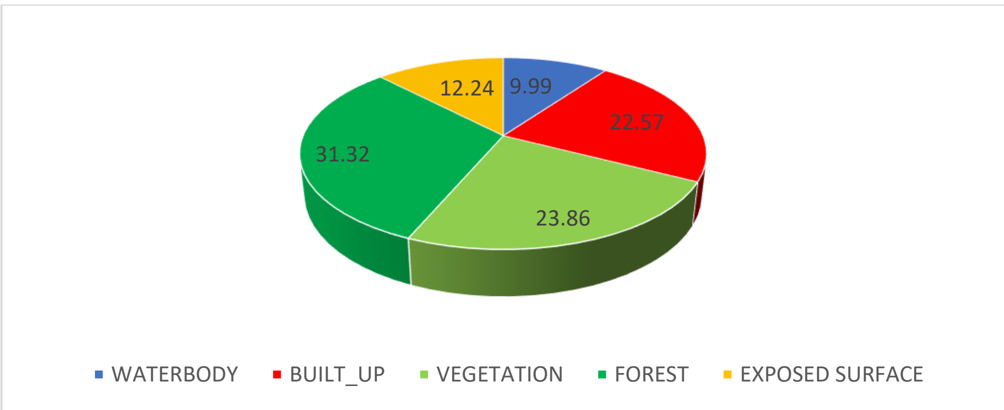

Fig. 3b. Percentage Extent of LU/LC of the study area in 2000

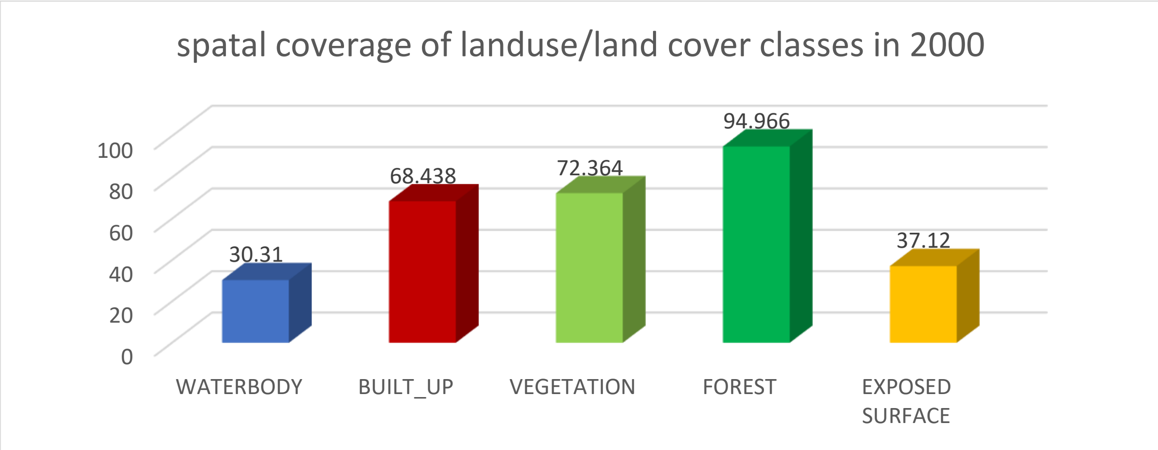

Fig. 3c. Spatial Extent of LU/LC of the study area in 2000

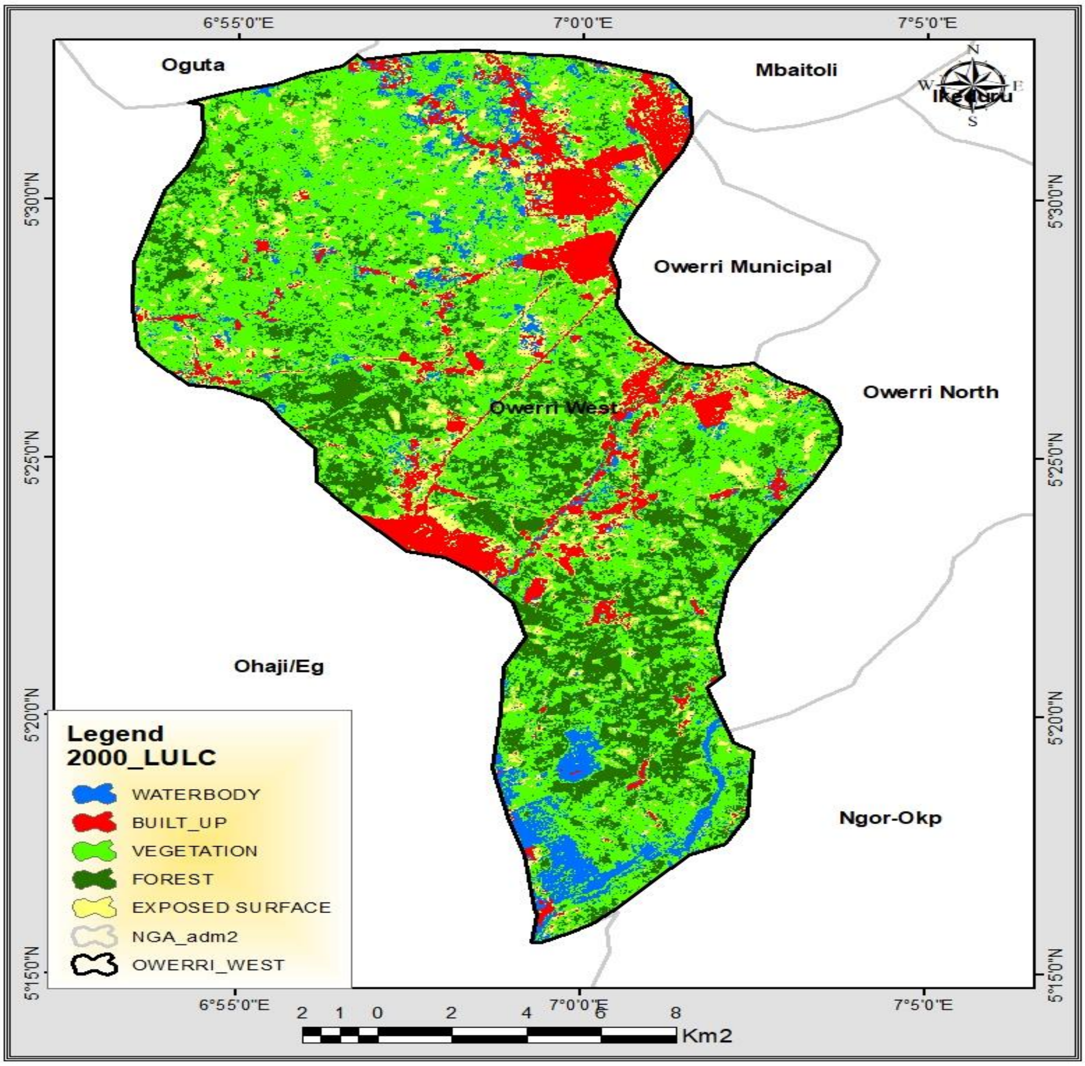

Fig. 4a. Land use/Land cover Map of the study area in 2010

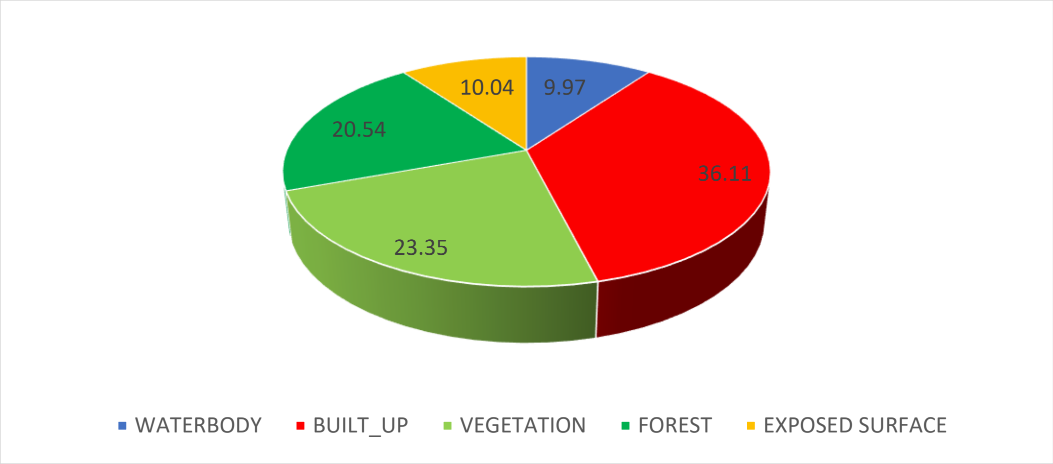

Fig. 4b. Percentage Extent of LU/LC of the study area in 2010

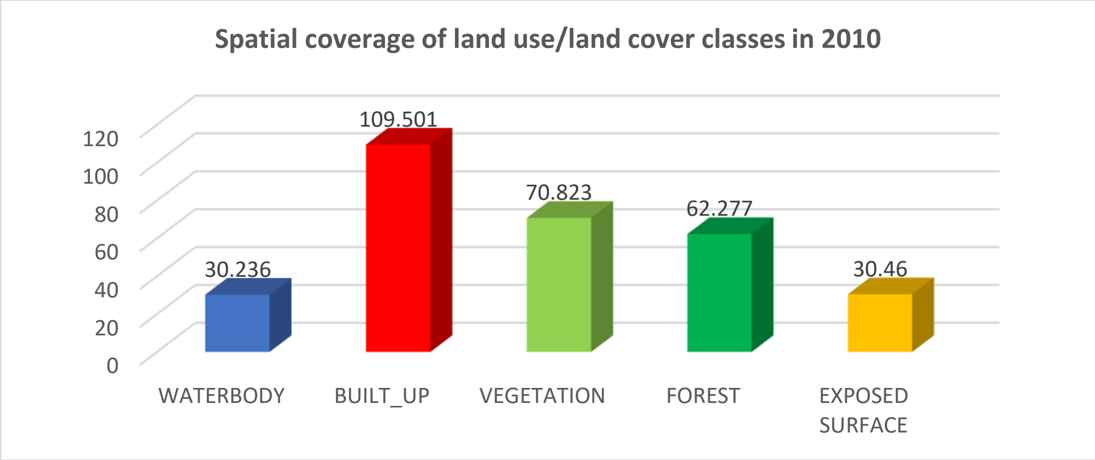

Fig. 4c. Spatial Extent of LU/LC of the study area in 2010

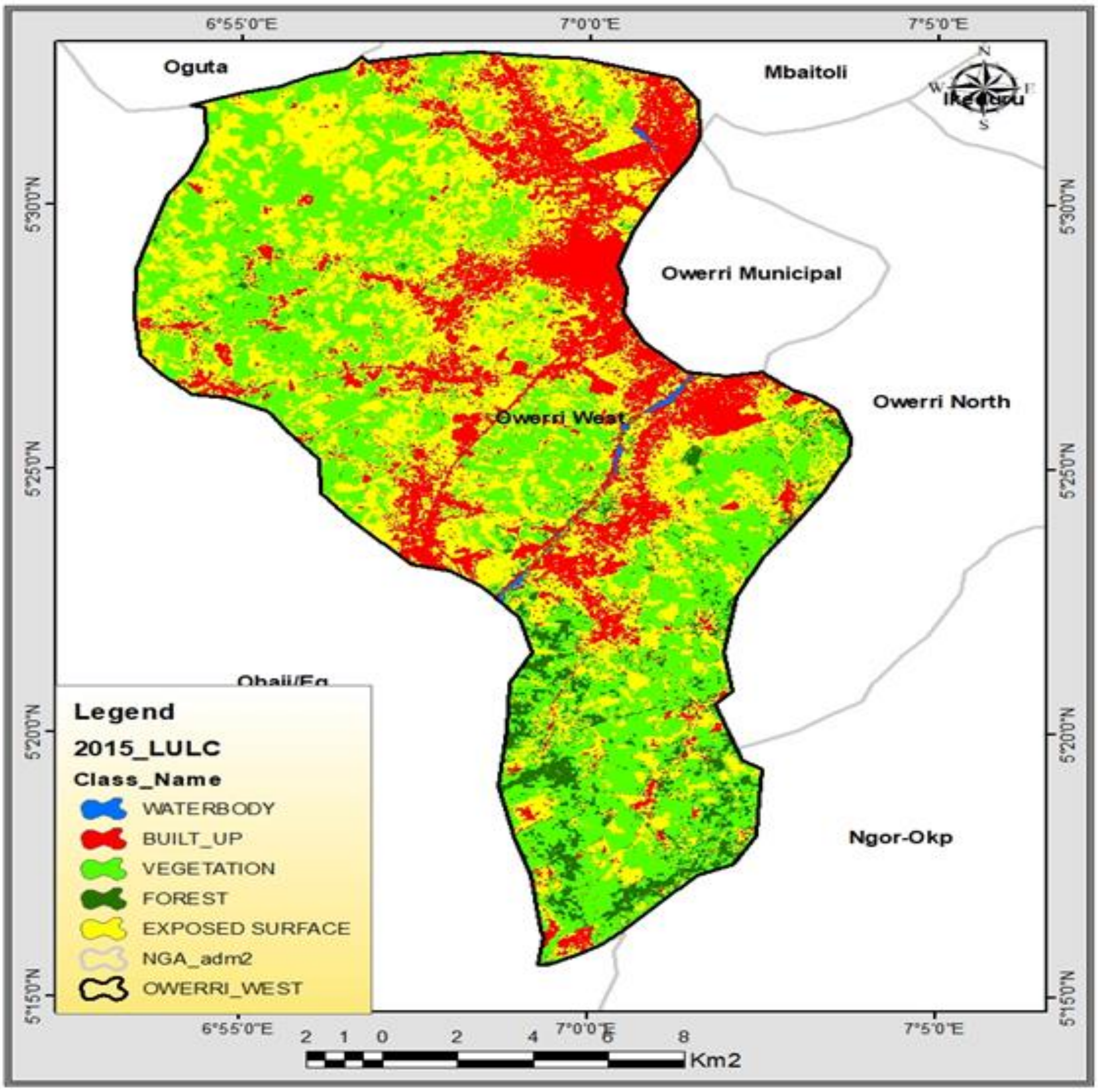

Fig. 5a. Land use/Land cover Map of the study area in 2020

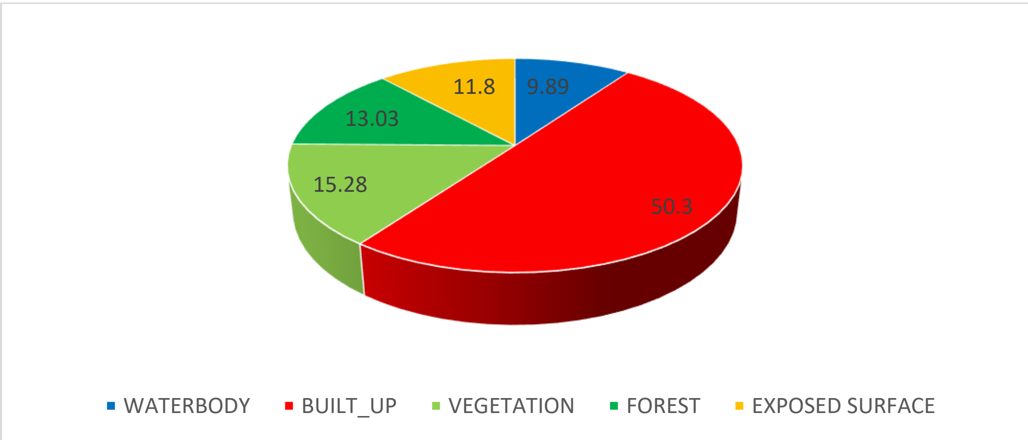

Fig. 5b. Percentage Extent of LU/LC of the study area in 2020

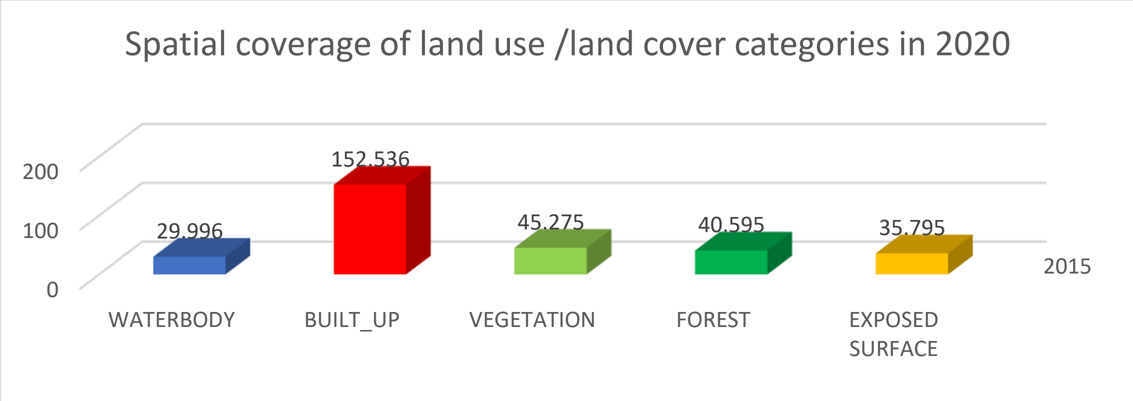

Fig. 5c. Spatial Extent of LU/LC of the study area in 2020

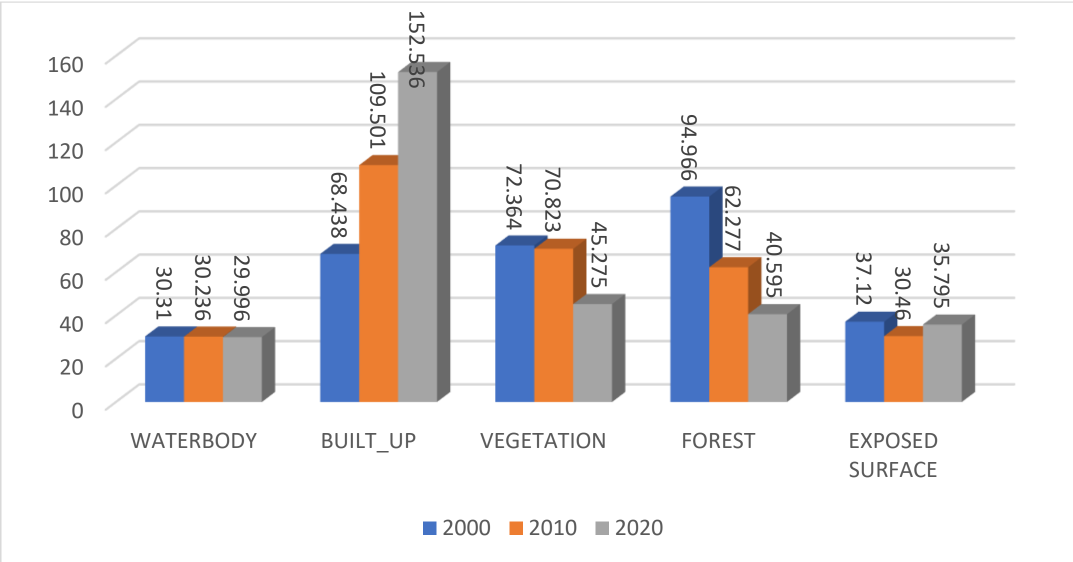

Fig. 6. Trend of LU/LC within the Study Area

Table 1. Summary of LULC change of the study area between 2000 and 2020

Classes	2000 AREA _Km²	%	2010 Area_Km²	%	2020 Area_Km2	%	% change. 2000 - 2020	Remark
Waterbody	30.310	9.99	30.236	9.970	29.996	9.89	-0.10	Decreasing
Built_Up	68.438	22.57	109.501	36.11	152.536	50.30	27.73	Increasing
Vegetation	72.364	23.86	70.823	23.35	45.275	15.28	-8,58	Decreasing
Forest	94.966	31.32	62.277	20.54	40.595	13.03	18.29	Decreasing
Exposed Surface	37.120	12.24	30.460	10.04	35.795	11.80	-0.44	Decreasing
Total	303.199	100	303.199	100.	303.199	100.		Decreasing

Table 2. Summary of overall classification accuracy

Year	Overall Classification Accuracy	Overall Cappa Coefficient
1980	76.14%	0.7552
1990	78.22%	0.7433
2000	80.06%	0.7633
2010	77.54%	0.7321
2020	78.21%	0.7941

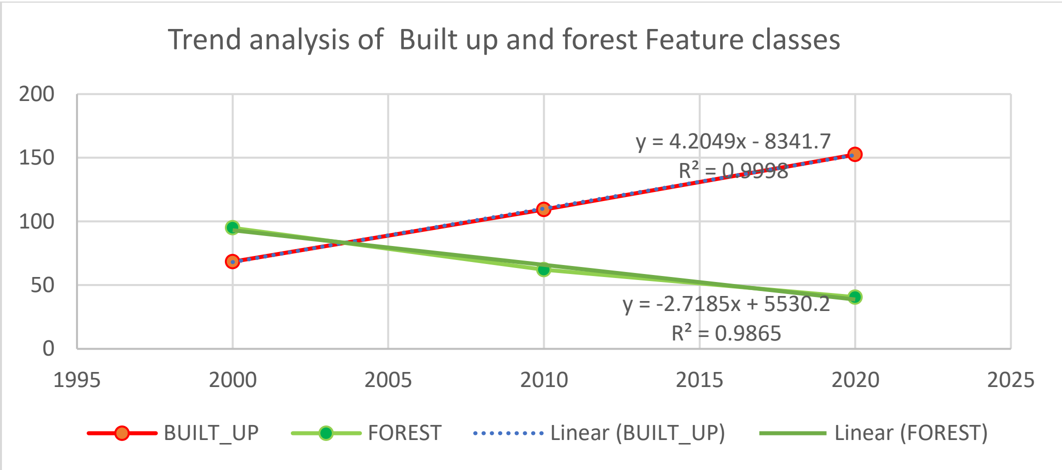

Fig. 7. Correlation plot of built up and forest feature classes

Table 3. Estimated spatial coverage of built up and forest feature classes between 2030 and 2050

year	**Forest Areas**		**Predictive error (R)**			**Predictive error (R)**
	Observed area	**Predicted area**		**Observed area**	**Predicted area**	
2000	94.966	93.200	1.766	68.438	68.1	0.338
2010	62.277	66.015	-3.738	109.501	110.149	-0.648
2020	40.595	38.83	1.765	153.536	152.198	1.338
2030	----	11.645	----		194.247	---
2040	----	-15.54	----		236.296	---
2050	----	-42.725	----		278.345	--

All the three classified LULC images of 2000, 2010, and 2020 were subjected to accuracy assessment. The producer's accuracy showed a value of range 73.24% to 79.36%, users accuracy value range of 75,88% to 77.21%, over all accuracy range of 76.14% to 80.06% and Kappa statistics range of 73.21% to 79.41%. As per Sophia et al. [13] kappa statistics of 61% to 80% are categorized as substantial in the rating criteria of kappa statistics. Since the entire kappa co-efficient of the years fall within this range, there is strong agreement between the classified maps and the ground referenced information. This means that the imageries were accurately classified (see Table 2).

Based on high rate of variation observed in built up and forest feature classes their historical trend were plotted (see Fig. 7) and the equation of their trend were extracted as a base for estimating their future behaviors for the next 30 years(see Table 3). With reference to Table 3 it can be seen that beyond 2030 the spatial coverage of forest feature class showed negative value which indicates extinction conversely, spatial coverage of built-up feature class in 2050 is estimated to cover 278.345km^2 and this constitute 91.91% of the study area. These situations are considered to be of grave consequences to the eco-environment, entire populace of the study area and the neighboring communities.

4. CONCLUSSION AND RECCOMMENDA-TIONS

In this study, spatio-temporal analysis of land-use/land cover dynamic in Owerri west has been empirically carried out between 2000 and 2020. Future trend of land-use/land cover categories which show significant variation has been successfully estimated for the year 2030 - 2050using model that approximates their historical behaviors. Though, spatial and temporal analysis indicated that from 2000 to 2020 all the Land use/land cover classes changed from its initial state butfindings revealed that Built up environment is the fastest growing Land use class in the study area in spatial and temporal terms while forest feature class is declining at alarming rate. Precisely it was estimated that by the year 2050 built up environment will occupy 91.91% of the study area while forest will be totally in extinction. This situation is considered to be of grave consequences to the eco-environment as some of the challenges will be traffic jams, increase in crime rates, land litigations, juvenile delinquencies food scarcity, increase in greenhouse effect becausewithout vegetation, the production of oxygen (O2) and consumption of the Carbon IV Oxide (CO2) by the trees would be impossible. Therefore, this study recommend that the current trend should be managed through effective land use policies and proper planning. There should be forest reserves areas and planting of trees within the study area. Besides, constant environmental monitoring should be carried out in the study area and in Nigeria as a whole using very high-resolution satellite imageries.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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