






ASSESSMENT OF LANDUSE AND LANDCOVER CHANGES AND ITS IMPLICATIONS TO FLOODING ALONG OMAMBALA FLOOD PLAIN, ANAMBRA STATE

 **Agulue Emmanuel^{1*}**

 **Okoye Nnabuike²**

 **Samuel Oji Iheukwumere³**

 **Kelechi Friday Nkwocha⁴**

^{1,2}Department of Geography, Nwafor Orizu College of Education, Nsugbe Anambra State, Nigeria.

¹Email: emmaagulue@gmail.com

³Department of Geography and Meteorology, Nnamdi Azikiwe University Awka Anambra State, Nigeria.

³Email: oji_iheukwumere@yahoo.com

⁴Department of Geography, University of Maiduguri, Bornu State, Nigeria.

⁴Email: kelechinkwocha@unimaid.edu.ng



(+ Corresponding author)

ABSTRACT

Article History

Received: 11 February 2020

Revised: 16 March 2020

Accepted: 20 April 2020

Published: 7 May 2020

Keywords

Landuse

Landcover

Land conversion

Flooding

Disaster

Omambala

Floodplain

Anambra State.

This paper assessed the landuse and landcover changes and its implications to flooding along Omambala floodplain in Anambra State. The paper aimed at identifying the landuse and landcover types in Omambala floodplain in relations to their temporal dynamics, the extent of landuse change and its implication to recurring incidence of flood disaster in the study area over a period of 20 years starting from the year 1998 to 2018. Multi-temporal Landsat TM and ETM+ imageries were obtained at 10 years interval; 1998; 2008 and 2018 to observe the pattern of landuse and landcover along the floodplain over the period of study. Population data of study area were obtained from National Population Commission on four time points as to understand the rate of land conversion and modification of the floodplain. Visual interpretation method was used to map landuse and landcover into five classes namely: waterbody; built-up; sparse vegetation; bare surface and dense vegetation. The result of the analysis of the imageries showed a considerable change in the pattern of landuse and landcover classes within the period under study. There was also a considerable population growth leading to progressive conversion of natural vegetation to other human activities with Built-up lands sparse vegetation and bare surface on the increase as well as their attendant consequences. However, the study concluded that various anthropogenic landuse activities especially poor farming system leading to increasing sparse vegetation, bare surface and built-up area are major factors that affects natural vegetation thereby worsening the incidence of flooding in the study area. The research therefore recommends relocation of settlements, greening of space already turning bare, effective floodplain management and continues monitoring of changes on land characters to ensure environmental sustainability and to forestall recurring incidence of flooding along the floodplain.

Contribution/Originality: This study is one of very few studies which have investigated land-use and land-cover changes and its implications to flooding along Omambala flood plain, Anambra State. The research demonstrated the ability of GIS and remote sensing in capturing spatial-temporal data for land-use, land-cover changes and flood incidence studies.

1. INTRODUCTION

Floodplains are naturally low, flat land areas often ill drained and marshy, stretching from either side of a river to the bottom of the river valley walls. Flooding occurs during periods of high discharge, or due to an intense precipitation over short period or normal rainfall over long period of time. Studies have shown that certain human activities exacerbate the chances of flooding and make it worse when it comes. Anthropogenic activities such as land use/ land cover change, channel modification, deforestation and urbanization within the floodplains have influenced the occurrence of this disaster (Brebante, 2017). These, especially the expansion of impermeable surfaces through the urbanization processes has decreases the soil moisture retention capacity, resulting in more surface run off and hence more sudden torrential floods (Panahi, Alijani, & Mohammadi, 2010).

Land cover as defined by Barnsley and Barr (2000) is the physical materials on the surface of a given parcel of land such as grass, concrete, tarmac, water. Barnsley and Barr (2000) also defined land use as the human activity that takes place on, or makes use of that land like residential, commercial, and industrial activity. Land use / Land cover (LULC) changes are major issues of global environmental change (Anil, Sankar, Rao, Prasad, & Sailaja, 2011).

According to Brebante (2017) flooding has become one of the most common type of hydrological disasters that affect various countries in varying degree. Worldwide, flooding results to population displacement, damage to properties, and disruption of economic activities and loss of life. Omambala floodplain in the recent time is one the vulnerable areas in the world being ravaged by recurring incidence of flood disaster. For instance, in 2012 alone the effects of the ravaging flooding were considered a national disaster. In all, seven million people were affected; 2.3 million people were victims of internal displacement while three hundred and sixty-three people were reportedly killed. Records revealed that houses and other public and private properties, infrastructure and facilities worth billions of naira were fully or partly submerged and destroyed. Government in her intervention effort in the state provided 24- Internally Displaced People's refugee camps and supplied relief materials. International donor agencies like UNICEF, UN and EU as well as non-governmental organizations and philanthropists, also supported with relief materials worth billions of naira (Efobi & Anierobi, 2013).

Culturally, Omambala area is known for extensive agriculture but it has been observed that anthropogenic land use pattern within the floodplain is increasing massively in the recent time at the expense of the natural vegetal cover which in turn has increased incidence of flood disaster in the area. This perception concurs with Agarwal, Green, Grove, Evans, and Schweik (2002) that the basic and significant process affecting the land covers are driving mostly by human actions but also producing changes that impact humans over time. Again, pressure arising from population increase, need for more housing and space for other commercial activities is seen to have caused massive deforestation, increased land consumption, modification and alteration of the previous land cover in the area, a situation that was much slower in the time past.

Consequently, information about land use change in the floodplain has become very necessary as to update land cover maps and for effective management and planning of the resources for sustainable development (Alphan, 2003). Researchers have used different methods to evaluate the relation between the land use/cover types and the run off changes (Panahi et al., 2010). For instance, De Roo, Odijk, Schmuck, Koster, and Lucieer (2001) utilized a simple linear precipitation—run off model to study the effects of the land use/cover changes on the floods of Muse and Oder Basins. But with the advent of air-and space-borne remote sensing, it has become possible to acquire pre-and post-project land use and land cover data in consistent manner. In addition, the advent of geographic information system (GIS) has equally made it possible to integrate multisource and multi-date data for the generation of land use and land cover changes involving such information as the trend, rate, nature, location and magnitude of the changes (Adeniyi & Omojola, 1999; Ezeomodo & Igbokwe, 2013).

In this study however, attempt was made to map out the status of land use and land cover patterns of the study area between the years 1998, 2008 and 2018 with a view to detecting the extent of land use / land cover changes that have taken place. This study also attempted to determine the land consumption and conversion rate in the

study area, with the growth of population and demands on the available land space over time and predicted possible changes that might take place in the area in future using Geographic Information System and Remote Sensing data.

1.1. Aim and Objectives

This research aimed at assessing the landuse and landcover change and its implications to flooding along Omambala floodplain in Anambra state. This aim will be achieved using the following objectives:

- (a) To determine the Landuse and Landcover type in Omambala floodplain.
- (b) To assess the changes in Landuse patterns of Omambala floodplain between 1998-2018.
- (c) To determine the land absorption and land conversion rate in Omambala area.
- (d) To make a projection into possible Landuse and Landcover change by the year 2028.

2. MATERIAL AND METHOD

2.1. The Study Area

The term “Omambala” is derived from River Omambala and its tributaries, area within the coverage Omambala floodplain. The area is a low lying terrain and the river mouth of Omambala where the river discharges into the Niger.

This study area encompasses three contiguous local government areas of Anambra East, Anambra West and Ayamelum. Geographically, it is located between latitude $6^{\circ} 40'0''$ N and latitude $6^{\circ}50'0''$ N and longitude $6^{\circ}40'0''$ and longitude $7^{\circ}5'0''$ Figure 1. It has an estimated land area of 1376.49 km².

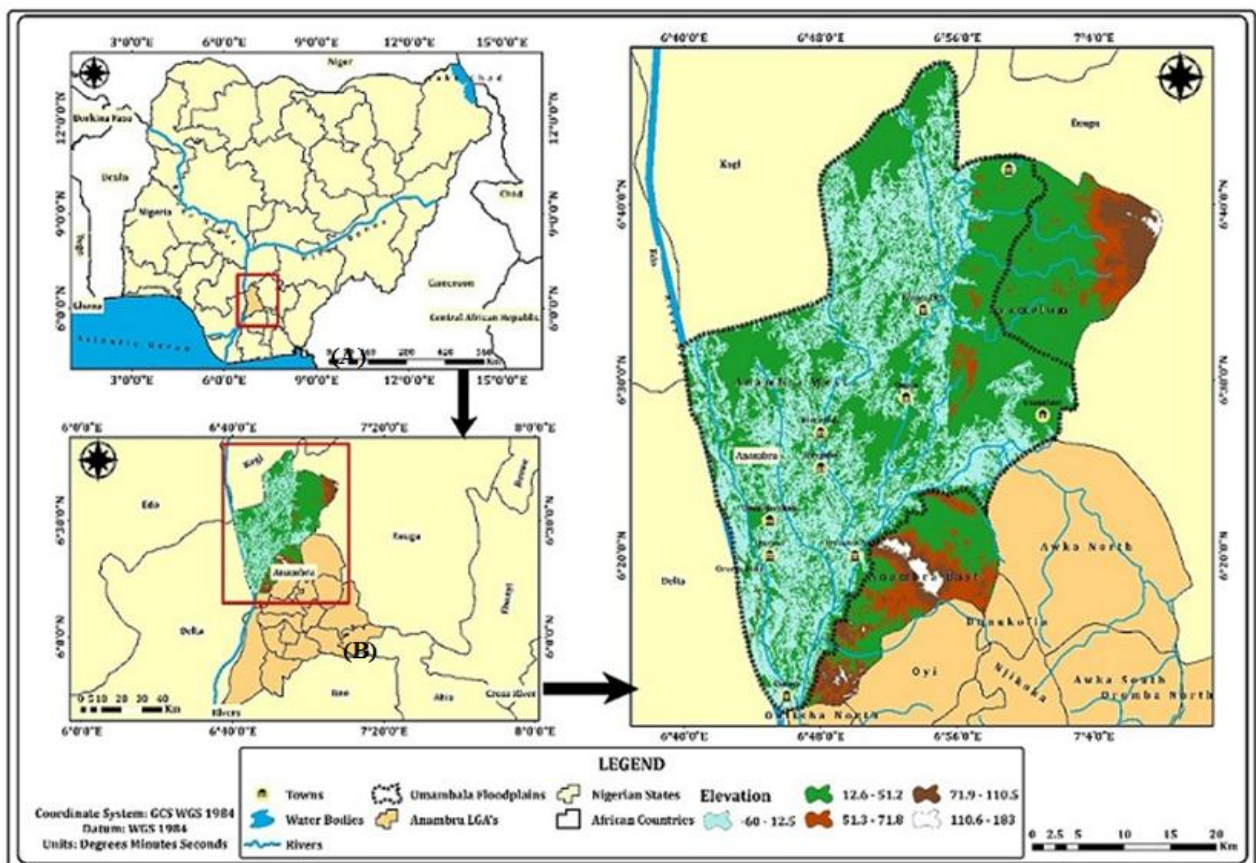


Figure-1. Map of Omambala flood area. Inset A: Map of Nigeria showing Anambra State. Inset B: Map of Anambra showing the study area.

Omambala area falls within the tropical climate which accounts for the prevailing moist rainforest vegetation. The area is generally affected by maritime weather conditions due to its riverine location and high rainfall associated with the tropical rainforest. Rainfall starts from the month of April to October reaching its climax in the

month of June and September. The remaining four months make up the dry season with harmattan wind blowing over the area. The Mean annual rainfall is about 1805mm while the maximum and minimum temperatures are 32.1°C and 23.5°C respectively.

Geologically, the area lies in the recent deposits of the Holocene (Quaternary), occupying and extending to the active flood plains of the river Niger and Omambara tributaries and the sand stone formations of the upper-middle Eocene (Tertiary).

Broadly, two main topographic zonation of soils may be distinguished in the area, namely: the alluvial soils of Omambala and the Niger flood plains. The alluvial soils are grayish in colour and are mainly silt-clays. By virtue of the topography of the area during rainy months, the soils are used for growth of vegetables, yam, potatoes and other hydrophilic crops.

Population of the three local government areas of Ayamelum, Anambra West and Anambra East by 2006 census were 158,152; 167,303; and 152,149 respectively, totaling 477,604 persons in the entire area.

The vegetation of Omambala area is mainly riparian and fresh water swamp forest but human incursion into its natural vegetation in the recent time has been enormous thereby modifying and turning the area into a derived savanna environment. Most of the original vegetation has been replaced and modified as a result of agriculture, built-up environment and other human activities.

2.2. Image and Processing

This study involved primary and secondary data collection. The topographic map of Omambala area was obtained from the Ministry of Land and Survey, Awka. The LANDSAT Thematic Mapper (TM) for 1998, Enhanced Thematic Mapper Plus (ETM+) for 2008 and Operational Land Imager (OLI) for 2018 satellite imageries of the study area were obtained from the online archives of the United States Geological Survey (USGS). The census data were obtained from the National Population Commission office, Awka. Then field visits to site was carried out to obtain ground control points for geo-reference and ground truthing sampling. The object-oriented approaches were used for mapping detailed land uses. This approach considers group of pixels and the geometric properties of image objects. It segments the imageries into homogenous regions based on neighboring pixels' spectral and spatial properties. It is based on a supervised maximum likelihood classification. Thus, an object-oriented method has been applied in this project in to avoid the mixed pixel problems.

2.2.1. Classification and Post-Classification Overlay

Classification and post-classification overlay was carried out and thematic land-cover maps for the years 1998, 2008 and 2018 were produced for the study area by supervised classifications using a maximum likelihood classifier. Four major land cover classes were mapped see [Table 1, 2 and 3](#): Built-up areas (BA), bare/open surface (BP), Dense vegetation (DV), Farmland/Sparse vegetation (SV) and water bodies (WB); to be able to detect possible details, change trajectory of post classification comparison was used to map the patterns and extents of land use and land cover in the study area as well as determine the magnitude of changes between the years of interest; 1998, 2008 and 2018, respectively.

2.2.2. Assessment of Classification Results Using Error Matrix

The error matrix-based accuracy assessment method is the most common and valuable method for the evaluation of change detection results. Thus, an error matrix and a Kappa analysis were used to assess change accuracy, see [Table 4](#). Kappa analysis is a discrete multivariate technique used in accuracy assessments ([Congalton & Mead, 1983; Jensen, 1996](#)).

2.2.3. Population Data

Population data for year 1998, 2008 and 2018 were gotten through population estimation and from 1991 and 2006 census base, thus applying the population estimation formula below:

$$N_t = N_0 * e^{rt} \quad (1)$$

Where N_t =Population sought for

N_0 =Base population from 1991 and 2006 census figures.

e = (exponential), i.e. 2.7182818284590.

r =population growth rate (2.8% and 3.2% for 1991 and 2006 census respectively).

t =time period of growth.

2.2.4. Land Conversion Rate and Land Absorption Coefficient

The Land Conversion Rate (L.C.R) and Land Absorption Coefficient (L.A.C) were determined for the study area using the equations as shown below:

$$LCR = \frac{A}{P} \quad (2)$$

Where, A is the Areal extent of the study area in (ha).

P is the Population

$$LAC = \frac{A_2 - A_1}{P_2 - P_1} \quad (3)$$

Where, A_1 and A_2 are the areal extents for the early and later years respectively; P_1 and P_2 are population figures for the early and later years respectively.

However, Land Conversion Rate (L.C.R) is the measure of compactness which indicates a progressive spatial expansion of a city while Land Absorption Coefficient (L.A.C) is a measure of change in the consumption of new urban land by each unit increase in urban population (Olaleye, Abiodun, & Asonibare, 2012; Paria & Bhatt, 2012; Yeates & Garner, 1976).

3. RESULT PRESENTATION

Between 1998 and 2008, Bare surface area increased significantly from 62.4km² (4.5%) to 70.3km² (5.1%) within the floodplain. Built-up area occupied about 8.0km² (0.9% of the floodplain) in 1998 but by 2008 the size increased to 30.8km² (2.2%) (See Figure 2 to Figure 4; Table 1 and Table 2). Area occupied by dense vegetation is seen to regress. As indicated in Table 2; Figure 5, area covered by dense vegetation declined to about 460km² (33%) in 2008 against 589.7km² (43%) recorded in 1998, losing about 130km² to other land uses. Farmland/sparse vegetation appreciated most such that by 2008 the area it occupied has risen to 758.8km² (55%) from the previous 651.8km² (47%) it occupied in 1998. Water body also reduced in size. By 1998, the area occupied by water body was 63.6km² but the area declined to 56km², amounting to about 4.1% of the entire floodplain. Land area occupied by water body is seen to have lost 7.6km² to increasing bare surfaces, farmland/sparse vegetation and built-up within a decade Figure 7.

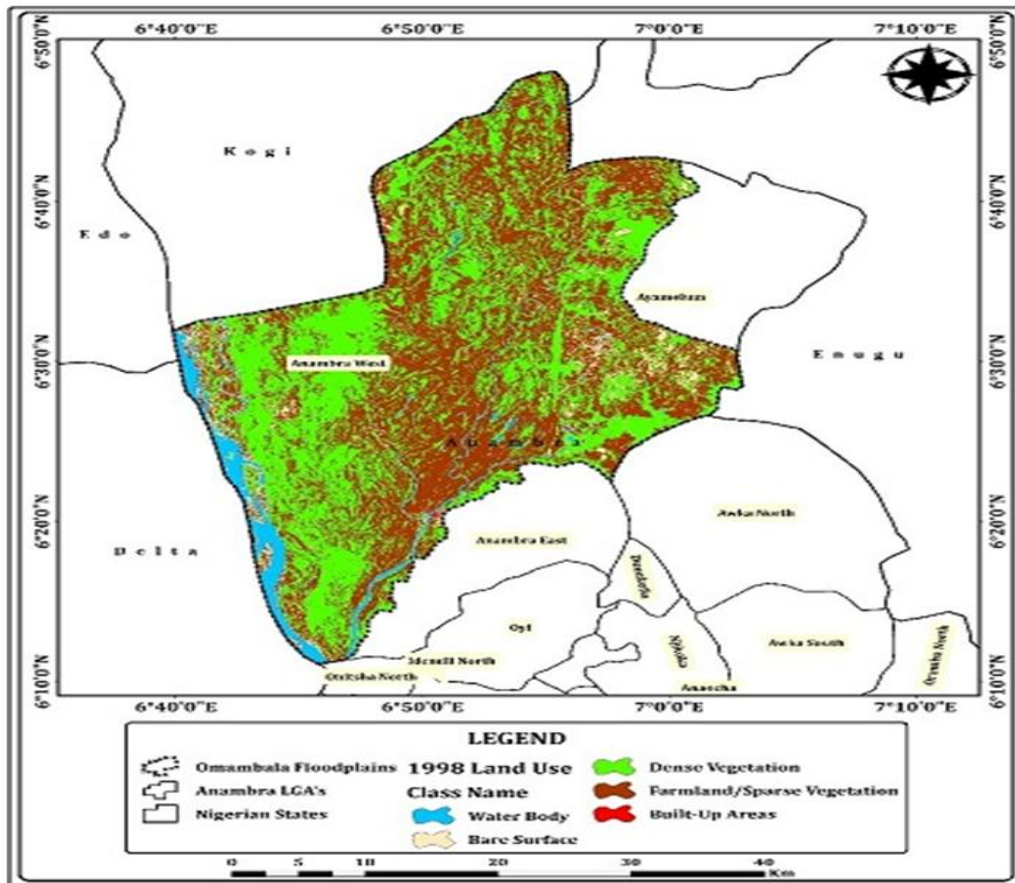


Figure-2. Land use and land cover for 1998.

Table-1. LULC classes for 1998.

1998		
Class Name	Area (sq.km.)	Percentage
Bare Surface	62.48	4.54
Built Up Areas	8.01	0.58
Dense Vegetation	589.66	42.84
Farmland/Sparse Vegetation	651.81	47.35
Water Body	63.63	4.62

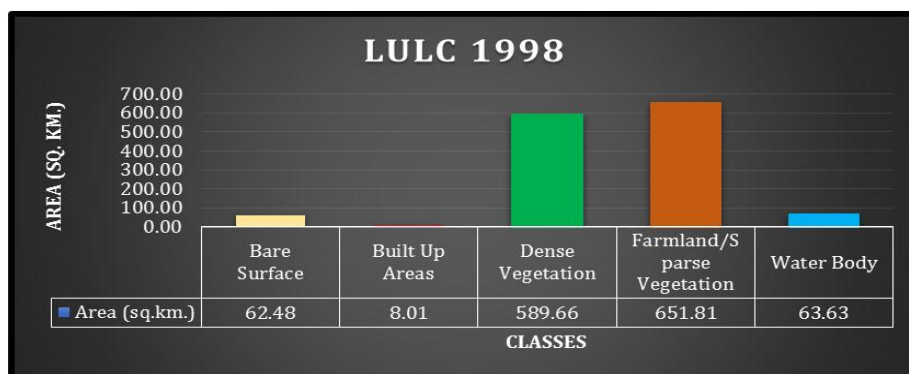


Figure-3. Bar graph representing LULC for 1998.

3.1. Land Use and Land Cover Change between 1998-2018

Similarly, between 2008 and 2018, Areas covered by bare surface continued to increase within the floodplain such that by 2018 it occupied about 89.4km² constituting 11.5% of the entire floodplain. Built-up area is seen to have maintained a steady increase in land area from the previous record of 30.8km² in 1998, to 56.1km² in 2018, equivalent to 4.7% of the land area. On the contrary, dense vegetation declined in size. By 2008, the area was 460 km² but in 2018, it has reduced to 306.2km² (20.2%). In all, dense vegetation cover lost about 154km² in a decade.

Farmland/sparse vegetation maintained a steady increase in land area within the floodplain. By 2018, the land area increased to 878.1km² (61%) from the previous record of 758.8km² in 1998. On the contrary, Waterbody declined in its size such that by 2018 it had lost about 45.7km²(2.5%) to other land uses/covers, amounting to loss of (10.3%) its previous size see Table 3.

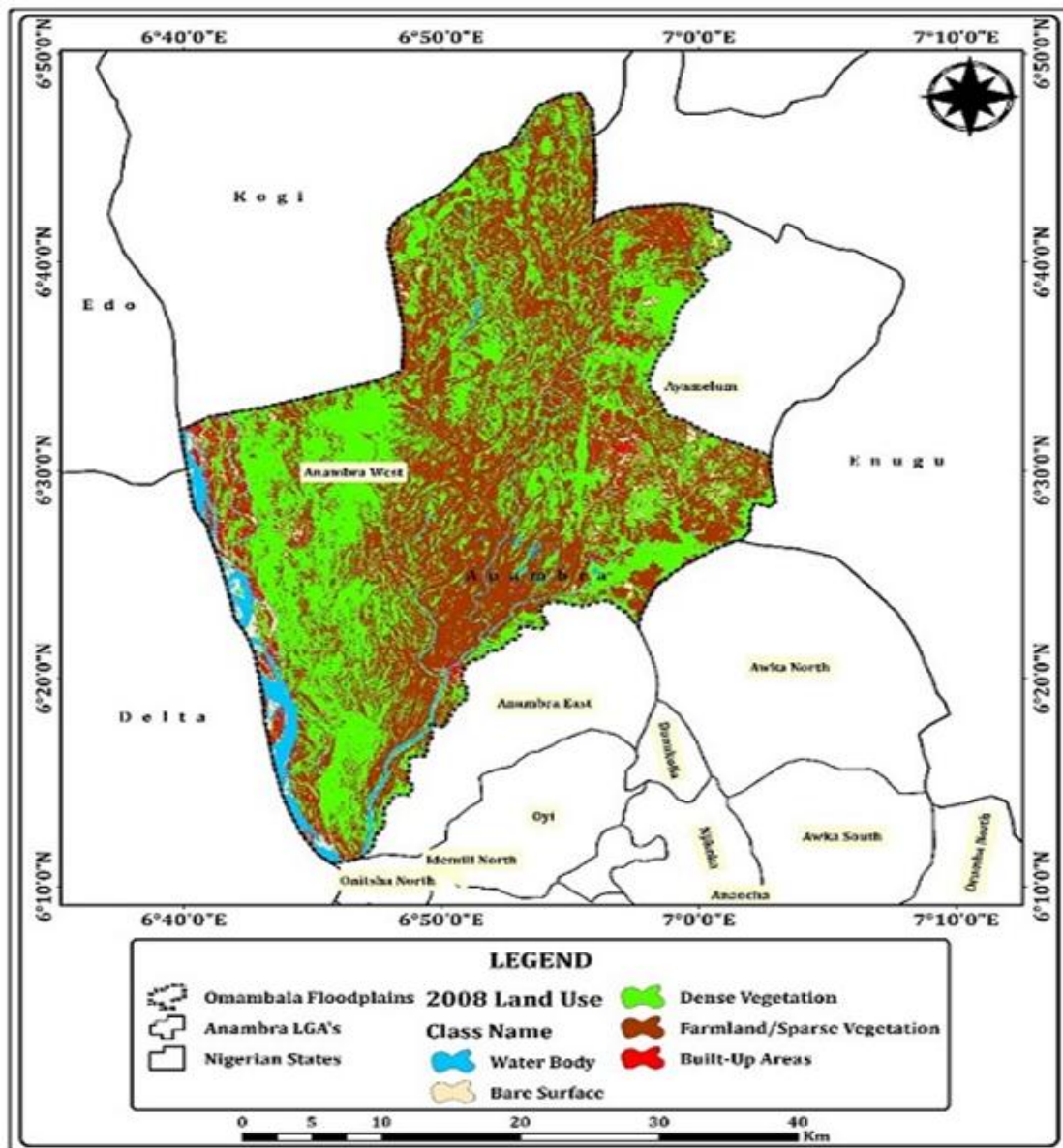


Figure-4. Land use and land cover for 2018.

Table-2. LULC classes for 2018.

2018		
Class Name	Area (sq.km.)	Percentage
Bare Surface	70.28	5.11
Built Up Areas	30.75	2.23
Dense Vegetation	459.75	33.40
Farmland/Sparse Vegetation	758.79	55.13
Water Body	56.01	4.07

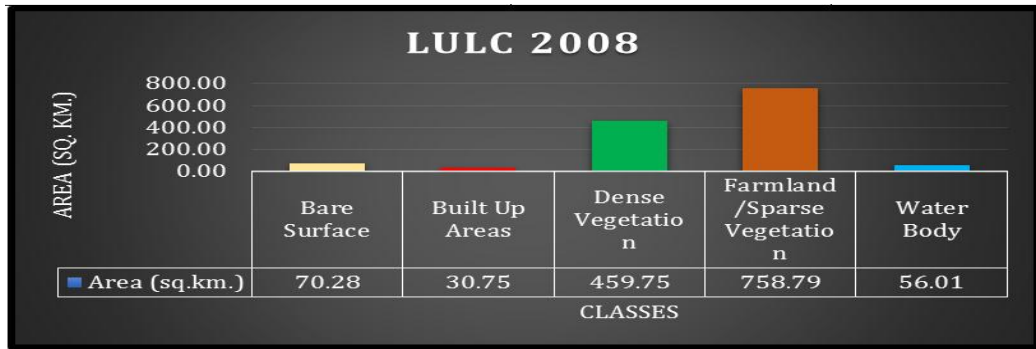


Figure-5. Bar graph representing LULC for 2008.

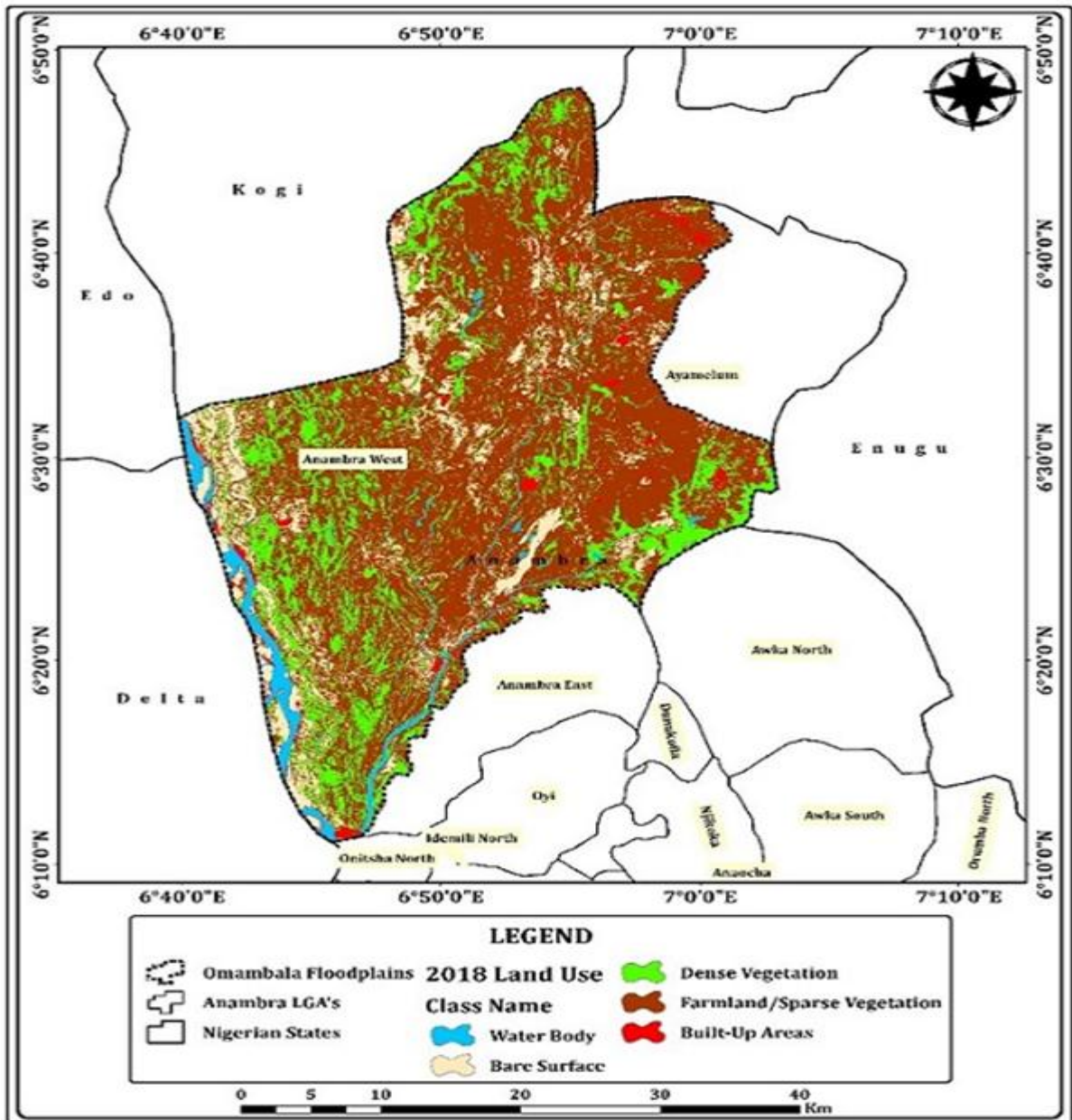


Figure-6. Land use and land cover for 2018.

Table-3. LULC classes for 2018.

2018		
Class Name	Area (sq.km.)	Percentage
Bare Surface	89.35	11.46
Built Up Areas	56.12	4.74
Dense Vegetation	306.24	20.23
Farmland/Sparse Vegetation	878.11	61.00
Water Body	45.70	2.54

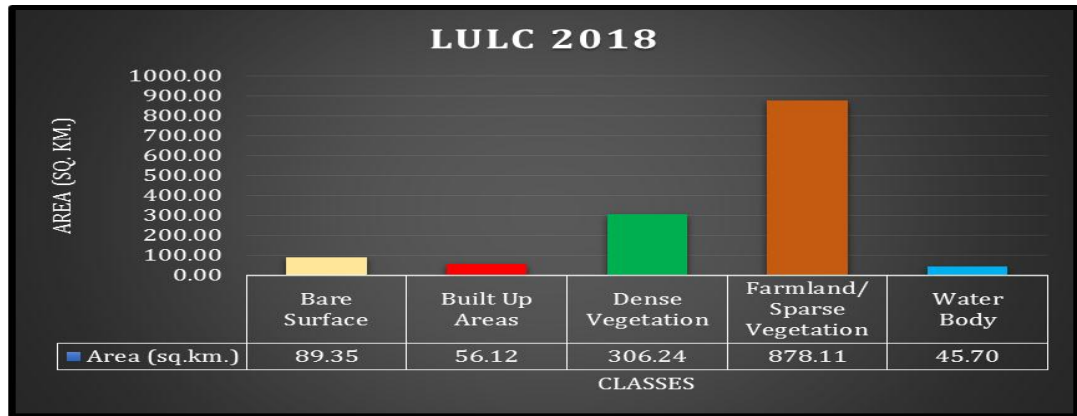


Figure-7. Bar graph representing LULC for 2018.

Table-4. Error matrix (kappa).

Year	Overall	Kappa
1998	0.84	0.88
2008	0.78	0.82
2018	0.89	0.91

In order to evaluate the result of classification, an error matrix was generated which was summarized by the Kappa Index of Agreement (KIA). From the Error matrix Table 4 above, the accuracy of the classified images for the periods were all above 80% and according to Eastman (2009) land cover classification accuracy of 80% and above are considered accurate.

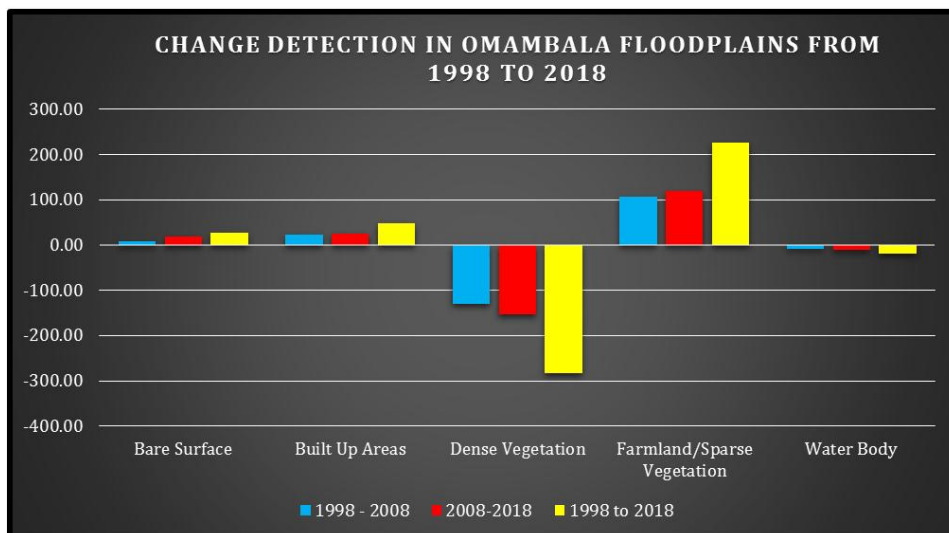


Figure-8. Change detection for probable landuse/landcover for 2018.

3.2. Land Transformation

Omambala floodplain is being transformed as shown Table 5 by the changes in the state of the land use land cover types under human pressures for socioeconomic activities. This is expressed by the increase in the land

consumption rate (LCR) which is an indication of spatial expansion of built-up and a measure of compactness. LCR showed progress increase from 0.0023 in 1998 to 6.038 in 2008 and subsequently to 8.004 in 2018 Table 5. Similarly, the Land Absorption Coefficient (LAC), a measure of change in the consumption of new land by each unit increase in population has declined from 18.3 between 1998 to 2008, to 13.2 between 2008 and 2018. This retrogressive change confirmed a slight drop in the demand for land within the floodplain, possibly due to persistent flood disaster. It also indicates that the increase in population between 1998 and 2008 is responsible for the increase in the areal expansion of the built-up expansion. The same argument holds for the areal expansion of built-up surfaces between 2008 and 2018, which is seen to have declined relatively in the land absorption coefficient during the period.

Table-5. Land conversion ratio and land acquisitions.

Year	Area(Ha)	Population	LCR	Period	LAC
1998	800.725	341,106	0.0023	1998-2008	18.3
2008	3074605	509,173	6.038	2008-2018	13.2
2018	5612457	701197	8.004		

4. DISCUSSION

The seeming improvement in the bare surfaces was obtained from sand-filling and increased built-up in certain areas originally covered by waterbody and from dense vegetation covers which were deforested, excavated in some places and laid bare. Explicitly, built up land uses either residential or commercial were actually increasing. Again, the size of water body was seen to have reduced within the period under study. Reduction in the size of water body due to continuous deforestation of the riparian (dense) vegetation particularly for more cultivable agricultural land exposes the river and its distributaries to high evapotranspiration. Again, the fact that bare land is increasing indicates that the level of agriculture based and other vegetation reduction based activities that emit carbon dioxide would continue to increase and consequently increasing the local atmospheric greenhouse gas (GHG) loading (Yasodharan, Balachandar, Rutharvel, Muruganandam, & Kumaraswamy, 2011). The increasing concentrations would have implications for "local warming" with variable impacts on the local climate, especially temperature and increase in rainfall patterns.

Again, the expansion rate in the growth of built up, bare land and concrete surfaces within the floodplain concurs with Acheampong and Anokye (2013) that population pressure and associated demand for residential accommodation are usually anticipated phenomena in peri-urban areas.

In classifying the landuses and landcovers, some of the land use types were identified from ground truthing. However, these were embedded in the dense vegetation and places of farmland/sparse vegetation cover, with farms characterized by yam, cassava, and assorted types of vegetables that dominate some areas in the study area. This points to the fact that forest cover invariably loses quality in abundance whenever there is competition for the land use cover, in proportion to the other land uses, comparatively (Ravetz, Fertrier, & Nielsen, 2013). Sparse vegetation and mostly bare soil are created during the clearing and burning of the vegetation, in preparation for cultivation. As far as forest cover as a sink to carbon dioxide is concerned, the enhanced emissions of anthropogenic sources could increase the carbon dioxide loads in the immediate local atmosphere (CIFOR, 2012). Furthermore, studies (Jiang & Tian, 2010; Oluseyi, Fanan, & Magaji, 2009; Weng, Lu, & Schubring, 2004) have variously reported that this rapid depletion of vegetation cover of any type could have a wide range of impacts such as in the reduction of the natural cooling effects of shading and evapotranspiration of plants and shrubs. The resultant impact of this is the tendency towards the development of urban heat island (UHI) effect which develops when increase in built up area characterized by impervious surfaces (Takuechi, Hashim, & Thef, 2010) is sustained without considering proper conservation practices like greening and reforestation. This often leads to changes in the hydrological cycle with important reference to reduction in the infiltration capacity of the surface. Thus, when natural surfaces are replaced

by more impermeable man-made surfaces such as buildings, paved roads and concrete which have very low infiltration capacities, the hydrological consequence is enormous and often resulting to increase in peak discharges and total volume of runoff. This of course has been established as one of the causes of persistent flood disaster in Omambala today.

However, the population of study area has witnessed tremendous increase. Based on the population estimate, the population of the entire Omambala was 341,106 by 1998. By 2008 the population has increased to 509,173 and subsequently to 701,197 by the year 2018. This implies that it increased by 168,067 persons in 2008 and 192,024 persons by the year 2018. Similarly, Land Conversion Rate (LCR) which indicates a progressive spatial expansion of the area, measures with the built-up surfaces is seen to have increased appreciably within the period under study. Thus, 0.002, 6.04, and 8.00 were recorded for the years; 1998, 2008 and 2018 respectively. While Land Absorption Coefficient (L.A.C), a measure of change in the consumption of new land by each unit increase in the population experienced a slight decrease from 18.3 originally recorded between 1998 – 2008 to 13.2 between 2008-2018. This decrease is believed to have stemmed out continuous loss of lives and properties to the menace of flooding in Omambala area in the recent time.

This, however, is a wakeup call for the relevant planning agencies especially the State ministry of environment, State river basin authority, State physical planning and development board as well as other stakeholders to be more responsible in their duties by enforcing a better flood management and to ameliorate this potential forceful impact of urbanization as being experienced today in Omambala floodplains.

Table-6. 10-year markov chain projection of the LULC classes.

2028					
Given class below:	Probability of changing to in sq. km. :				
	Water Body	Builtup Areas	Bare Surface	Farmland/Sparse Vegetation	Dense Vegetation
Water body	69.14	24.38	0.34	43	3.14
Builtup areas	0	49.58	2.9	33.36	14.15
Bare surface	0.03	24.38	16.72	41.14	7.73
Farmland/sparse vegetation	9.71	29.2	4.79	42.42	23.57
Dense vegetation	0.06	53.18	8.04	40.75	30.96

5. SUMMARY AND CONCLUSION

This research demonstrated the ability of GIS and remote sensing in capturing spatial-temporal data. Attempt was made to capture as accurate as possible five land use/land cover classes as they change through time. Five classes were distinctly identified for each study year but more emphasis is placed on built-up surfaces, bare surfaces and farmland/sparse vegetation within Omambala floodplain because there are directly influenced by anthropogenic activities and are seen to have exacerbated chances of flooding in the area. Concentration was on the floodplain alone, areas below 12m above sea level. In achieving this, land consumption and land Absorption coefficient were introduced into the research work. An attempt was also made at generating a formula for estimating population growth using the recommended national population commission of 2.8 and 3.2 growth rate respectively. However, the result of the work shows continuous transformation of areas on natural (dense) vegetation into farmland/sparse vegetation. Bare surface was also increasing rapidly. Built-up was moderate but poses great danger to dwellers during flooding rapid between the period under study. Marcov projection of ten years was adopted for change detection and to ascertain the likely land use/land cover of the area from 2018 to 2028, it was found that the dynamics of landuse/landcover of the area will maintain similar pattern see [Table 5](#); [Figure 8](#).

6. RECOMMENDATION

1. Greening and placing strict laws on sand excavation of areas in the floodplain that are turning bare.
2. Permanent relocation of settlements within the floodplain to upper and safer areas.

3. Proper education on eco-friendly systems of agriculture within the floodplain.

Funding: This study received no specific financial support.

Competing Interests: The authors declare that they have no competing interests.

Acknowledgement: All authors contributed equally to the conception and design of the study.

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