



**Research Article**

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# Geospatial Analysis of Land use Land Cover Change in Osogbo, Nigeria

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## ABSTRACT

Osogbo became the administrative headquarters of Osun State, Nigeria, in 1992, and since then, the city has experienced unprecedented rapid urban growth and development. This study attempted a geospatial analysis of land use land cover (LULC) change in Osogbo, Nigeria, from 1988 to 2018 to improve land use management. The methodology adopted for the study involved data acquisition and pre-processing, extraction and validation of LULC information. Atmospheric and topographic correction methods were used for pre-processing operations. Four LULC types were identified for the study which included Built-up Area, Vegetation, Water/Wetland and Bare Surface. Global Positioning System (GPS) was used to obtain the coordinates of some land use features for boundary demarcation and ground-truthing, while secondary data used included Landsat 4-5, 7 and 8 imageries, respectively. Maximum Likelihood Classification was used to classify imageries to identify the land use types. The minimum classification accuracy for all land use was 88.2%. Results showed that the built-up area increased from 29.59km<sup>2</sup> to 63.20km<sup>2</sup> while vegetation decreased from 102.09km<sup>2</sup> to 39.84km<sup>2</sup>, water body decreased from 2.85km<sup>2</sup> to 1.75km<sup>2</sup> while the bare surface increased from 11.24km<sup>2</sup> to 38.11km<sup>2</sup> from 1988 to 2018. Understanding this trend will help policymakers and planners mitigate the major challenge of indiscriminate land utilisation in Osogbo. The need for urban land development planning agencies to monitor, regulate and control the pattern of development and public education on proper land use, which helps city authorities to keep abreast with the changes that may occur, suggested.

**Keywords:** *Geospatial analysis, Land use, Land cover, Changes, Urban growth, Osogbo*

### 1.0 INTRODUCTION

Land cover change is one of the most important drivers of the current global climate issues due to human interaction with natural systems (Karanam et al., 2013; Yakubu et al., 2020). It is a continuous change in every town and city of the world today, which directly and indirectly influences human activities, and the changes rarely follow an ideal pattern.

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Given the important contributions of land in providing environmental goods and services for human sustainability (Showqi *et al.*, 2014; Yakubu *et al.*, 2020), there has been an increased interest in land use land-cover (Lawrence & Chase, 2010). The average rate of deforestation, according to Global Forest Assessment made by FAO, is -1.3% from 1990 to 2000, -1.1% from 2000 to 2010 and -1.2% from 1990 to 2015 (FAO, 2015).

Land use varies with its different purposes in any given area and time. Such purposes could be for settlement, agricultural, industrial, and residential, among other activities. The tropical ecosystems are continuously threatened by organic and chemical pollution from agriculture and industries, and the resultant degradation of the natural resources has taken on an alarming aspect (Benidick, 1999).

Land cover refers to the physical and biological cover over the surface of the land, including water, vegetation, bare soil and/or artificial structures (Ellis, 2007). That is, it signifies the spatial distribution of the different land cover classes, which can be measured in both quantity and quality. Land use, on the other hand, is the social and economic purposes and contexts for which lands are managed. Land use and its changes require integrating natural and social scientific methods to determine which human activities are occurring in different parts of the landscape, even when the land cover appears to be the same (Lambin *et al.*, 2001). Such changes in land use in various spatial and temporal domains are material expressions, which also indicate environmental and human dynamics and their interactions mediated by land availability (Lambin *et al.*, 2003). It is the changes of the natural environment into managed environment such as field, settlement, industrialisation and agricultural practice.

The expansion of a city into its adjoining periphery is often characterised by the transformation of natural land covers into impervious surfaces. Such transformation is often accompanied by an alteration of the surface energy budget, which significantly influences the local, regional, and global climate (Polydoros *et al.*, 2018). It was estimated that surbanisation attracted about 54.5% of the global population residing in cities, and this is expected to increase to 66% by

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2050 (United Nations, 2014; MacLachlan et al., 2017). Several factors responsible for the country's rapid urban growth pattern include natural increase arising from high birth rate; rural-urban migration; creation of states and local governments; establishment of a tertiary institution, commercial and industrial centres and tourism resorts among others (Yakubu et al., 2020).

Osogbo assumed the status of state capital in 1991, having two local government areas: Osogbo and Olorunda. Its population, based on 1991 census, was 106,386. Over the years, Osogbo has witnessed tremendous growth spatially and in population. Its population based on 2006 census was 155,507, and in 2018 it was projected to be 213,838, with a total land area of about 2,875 square kilometres before it became the state capital. The establishment of small and large-scale industries and businesses contributed greatly to the growth of Osogbo. Osogbo thus became a major trading and distribution centre for people within and outside its immediate environment, making it a center of attraction and growth.

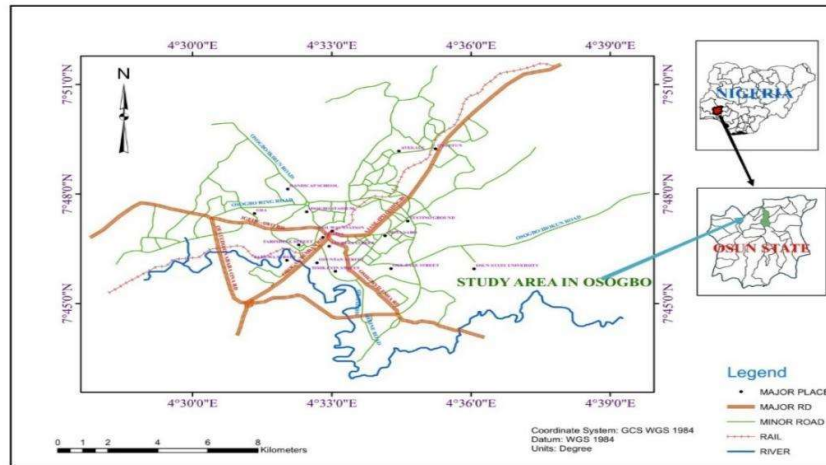
Understanding the characteristics of urban expansion in cities like Osogbo can promote sustainable urban development now and in the future. With the United Nations Sustainable Development Goals (SDGs) providing a global development pathway Anderson *et al.* (2017), an appreciation of urban expansion dynamics in Osogbo has become increasingly important and tenable. This study centred on geospatial analyses of land use/land cover change in Osogbo, Nigeria, from 1988 to 2018 to improve land use management.

## **2.0 MATERIALS AND METHODS**

### **2.1 *The Study Area***

Osogbo is located between Longitudes 4° 28' 43'' and 4° 40' 12''E and between Latitudes 7° 42' 10'' and 7° 51' 10''N (Fig. 1). It is an area of about 4700 hectares with a population of 155,507 (NPC, 2006) projected to 213,838 in 2018. Osogbo has grown over time to become a regional commercial and industrial centre. The rapid spatial expansion of Osogbo is attributable to population growth, industrial development and political influence (Agbola, 1992; Aguda *et al.*, 2012).

Osogbo has an average rainfall of 1150mm which lasts from April to late October or early November. The dry season lasts from December to March which is the period of intense heat.



The climate is less humid and hot than it is in greater part of southern Nigeria. It lies in the deciduous forest area which spread towards the grassland belt at the northern part of the state. Osogbo is situated on a raised land lying over 500m (800ft) above sea level and is drained by River Osun and its tributaries such as Rivers Ogbaagba, Gbodofon, Okoroko, Olohunkoro, and other streams (<http://www.osogbocity.com>).

Fig. 1: Map of Osogbo, the Study Area

## 2.2 Data Acquisition

The technique employed for this study was essentially through satellite imagery with the aid of remote sensing and geographic information system, administrative maps, population data, ground control points captured within Osogbo and personal observations were equally explored for relevant information.

Remotely sensed data were mainly satellite images: Landsat.TM for 1988 and 1998 and Landsat ETM for 2008 and 2018 downloaded from EarthExplorer® website <https://earthexplorer.usgs.gov/>. An



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administrative map of Osogbo was obtained from the State's Ministry of Lands and Physical Planning. Population figure was obtained from National Population Commission's 2006 Census Figures. Table 1 shows the summary of the data acquired and their sources. The coordinates of ground control points were taken through field observation using a global positioning system (GPS) for ground-truthing and geo-referencing to improve the geometric accuracy of the objects.

Landsat images were subjected to various pre-processing operations. The images were corrected for radiometric cloud cover, and filtered at the point of data collection using EarthExplorer's additional criteria to reduce the cloud cover to 0%. Atmospheric changes were rectified using the atmospheric and topographic correction (ATCOR3) method (Balthazar *et al.*, 2012). Furthermore, false colour composites of images were processed from Landsat images by selecting bands 4, 3, and 2, which conform to near-infrared red (NIR), red (R) and green (G) planes respectively. Training areas were identified and sampled in order to obtain the spectral characteristics of the different land-use classes (Enaruvbe & Atedhor, 2015).

### **2.3 Data Processing**

In this study, a supervised classification method using the maximum likelihood classifier was used to generate four land use classes which include the following: built-up areas, vegetation, water bodies and bare surface. Supervised classification has been adjudged the best method for classifying multi-spectral images (ITC-ILWIS, 2001), while Maximum Likelihood Classifier was chosen because it returns a higher level of accuracy than other classifiers (Sandhya & Joshi, 2013). To further aid the classification of change in vegetation cover, a normalised difference vegetation index (NDVI) was computed using the Landsat red and near-infrared bands in order to separate a vegetated surface from a non-vegetated surface.

**Table 1: Data and their Sources**

Type of data	Year	Image Resolution (mm)	Source
Landsat 5	1988 and 1998	30	www.earthexplorer.usgs.org
Landsat 7	2008	30	www.earthexplorer.usgs.org
Landsat 8	2018	30	www.earthexplorer.usgs.org
Population of Osogbo	1988 - 2018		2006, NPC
GPS coordinates of 22 control points	June 2019		Acquired via field observation

*Source:* Authors' Compilation

Classification accuracy assessment was conducted for each image to ascertain the level of correspondence between the pixels of the classified images and the reality on the ground. The overall percentage accuracy ranged from 88.2% to 90.4%.

The land use land cover for the study area was classified into four using supervised classification (Maximum likelihood classification) by assigning training signatures to the features. The grouping was obtained from Landsat 4 - 5 (TM), Landsat 7 ETM + class 1 and Landsat 8 OLI/TIRS C1 Level-1 for years 1988 and 1998, 2008 and 2018, respectively. The area and percentage of each land use were calculated using change detection analysis.

The satellite data have 30m spatial resolutions, and the TM and ETM Plus images have a spectral range of 0.45 - 2.35 micrometres with bands 1, 2, 3, 4, 5, 6, 7 and 8, while the Operational Land Imager (OLI) extends to band 11. Spatial and statistical analyst extensions in ArcGIS 10.2 version were used to perform the spatial analyses, while supervised classification was performed using Erdas Imagine software for the years under investigation.

Image compositing follows the false colour composite operation performed using Erdas imagine software, and the Landsat bands were combined in the order of band 4, band 3 and band 2 for Landsat TM and ETM+. Image classification involves false colour composite, further classified using the maximum likelihood classification technique. A supervised classification was performed by creating a training sample. Based on a spectral signature curve, various land use classes were created: built-up area, vegetation, water body, and bare land. The classified map was generated for 1988, 1998, 2008 and 2018.

#### **2.4 Change Detection Analysis**

Change detection of the feature involves analysis of a series of images of different dates. To detect changes, the DN (Digital Number) values of one image were subtracted from the other. At places where changes are minor, the result would be close to zero. Another possibility was to take the ratio of two images. When there was no change at a place, the ratio would be close to one; at places of change, the ratio could be higher or lower number as the case may be. The simple equation calculates the magnitude of change (K):  $K = F - I$

$$\text{Area in km}^2 = \frac{\text{Num of pixels} \times \text{resolution of image}}{100,0000}$$

Change (A) is calculated by the formula:  $A = \frac{F-I}{I} \times 100$  where:

K = magnitude of change

A = percentage of change

F = first date

I = Reference date

### **3.0 RESULTS AND DISCUSSION**

The land use under consideration in this study includes built-up, vegetation, wetland/water body and bare surface/rock outcrop. Table 2 shows measurements in kilometre square and the equivalent percentage

of each of the identified four land uses. In contrast, Figures 2a, b, c and d show the output processing of Osogbo satellite images from 1988 – 2018.

Table 2: Distribution of land use land cover classes in Osogbo from 1988 - 2018

Year	Built-up Area	Vegetation	Wetland/ water body	Bare land / rock-outcrop	Total
1988	29.59 km <sup>2</sup> (20.57%)	100.12 km <sup>2</sup> (69.63%)	2.85 km <sup>2</sup> (1.98%)	11.24 km <sup>2</sup> (7.82%)	143.8km <sup>2</sup> (100%)
1998	36.97 km <sup>2</sup> (25.71%)	74.08km <sup>2</sup> (51.51%)	2.67km <sup>2</sup> (1.86%)	30.08km <sup>2</sup> (20.92%)	143.8km <sup>2</sup> (100%)
2008	48.67 km <sup>2</sup> (33.94%)	59.42km <sup>2</sup> (41.26%)	1.75km <sup>2</sup> (1.22%)	33.96km <sup>2</sup> (23.58%)	143.8km <sup>2</sup> (100%)
2018	64.77 km <sup>2</sup> (45.04%)	39.84km <sup>2</sup> (27.71%)	1.08km <sup>2</sup> (0.75%)	38.11km <sup>2</sup> (26.50%)	143.8km <sup>2</sup> (100%)

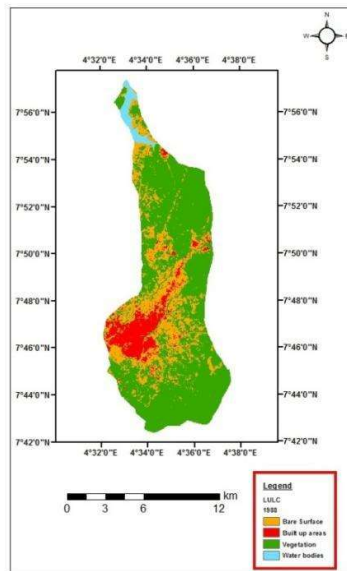


Fig. 2a: LULC in 1988

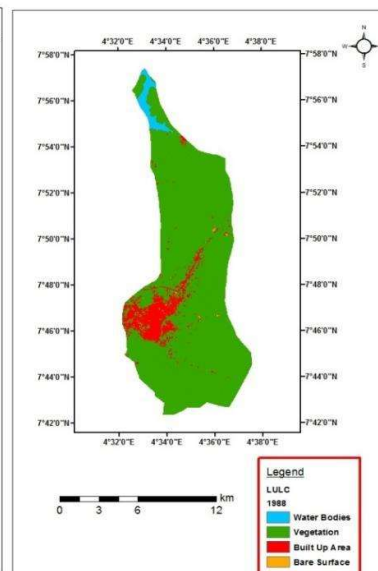


Fig. 2b: LULC in 1998

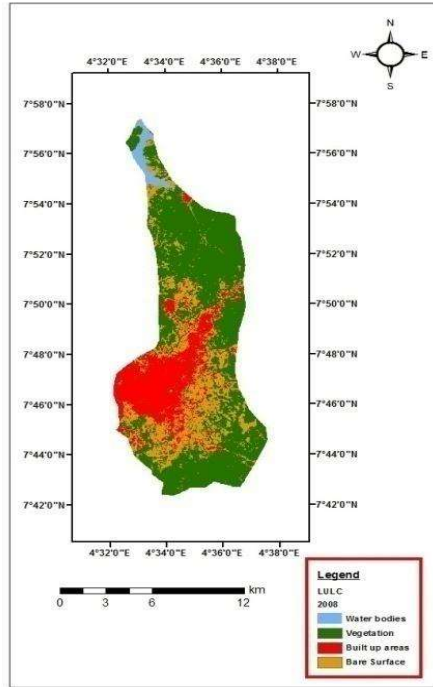


Fig. 2c: LULC in 2008

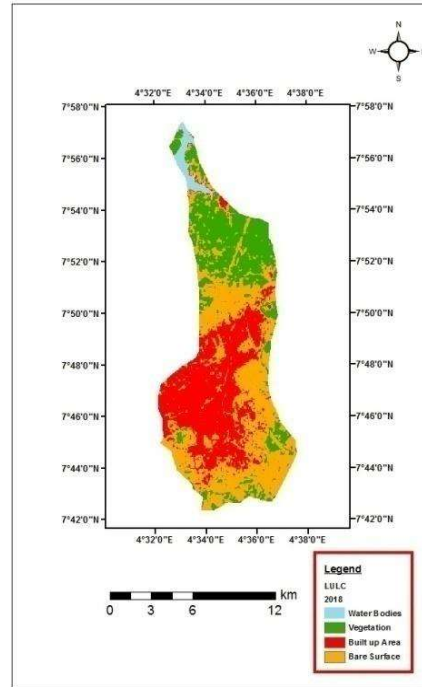


Fig. 2d: LULC in 2018

### 3.1 Built-Up Areas

As indicated in Table 2, a considerable transformation has been identified in land use between 1988 and 2018, as evident in Figures 2a - d, where heavy built-up areas spread outwards and increased from year to year. The area covered by a build-up in 1988 was 29.59km<sup>2</sup> (20.54%). At this period, the human settlement was very small due to limited socio-economic activities in the area. In 1998 it increased to 36.97km<sup>2</sup> (25.67%); in 2008, the urban built-up area increased to 48.67km<sup>2</sup> (33.94%), while in 2018, it increased to 63.20km<sup>2</sup> (43.88%). Yakubu *et al.* (2000) observed similar changes in a built-up area in Akure, Nigeria, with 15.04 km<sup>2</sup> in 1985, 50.01km<sup>2</sup> and 185.63 km<sup>2</sup> in 2015, respectively. Factors contributing to the continuous increase in built-up areas are immigration, increasing economic and commercial activities, increase in birth rate and

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employment opportunities, rural-urban migration among others which greatly contributed to the demand for residential and commercial accommodation. This aligns with the United Nations observation that urban expansion in most cities has outpaced the population growth rate (World Cities Report, 2016). The wide gap between urban growth and population growth would not only put pressure on the urban infrastructure but also has implications for the city's sustainability (Samuel and Atobatele, 2019).

### **3.2 Vegetation Cover**

As indicated in Table 2, vegetation decreases through the years under review. The area coverage by vegetation in 1988 was 100.12 km<sup>2</sup> (70.89%) which drastically decreased to 74.08 km<sup>2</sup> (51.57%) in 1998, 59.42 km<sup>2</sup> (41.26%) in 2008 and 39.84 km<sup>2</sup> (27.66%) in 2018 respectively. Comparatively, Yakubu et al. (2000) observed a decreased figure of 247.57 km<sup>2</sup> in vegetation between 1985 and 2015 in the Akure metropolis. An increase in population and human activities, such as the construction of roads and buildings, roads, and industries, led to a decrease in vegetation in Osogbo. Vegetation decreases rapidly due to indiscriminate felling of trees and deforestation. In essence, all activities carried out on the land usually effect changes in its cover in one way or another which is currently accelerating and causing widespread environmental problems (Yakubu *et al.*, 2000). For instance, a study conducted by Frimpong (2011) showed how fast the forest cover has given way to built-up due to human encroachment.

### **3.3 Water Body**

Similar to the decline in vegetation, the water bodies reduced from 2.85 km<sup>2</sup> (1.98%) in 1988 to 1.08 km<sup>2</sup> (0.75%) in 2018. The decrease in the amount of water bodies could be due to land reclamation for construction, while some areas previously covered by water become bare due to drying due to high demand. The high demand on urban land for human settlements and other uses has made some water bodies part of the built-up area. Similarly, in 2015, Yakubu et al. (2000) obtained a decrease in water bodies from 90.17 km<sup>2</sup> in 1985 to 86.44km<sup>2</sup>.



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### 3.4 Bare Land Surface

The bare land surface refers to the exposed surface without vegetative cover. It includes footpaths, roads, playgrounds, motor parks, bare ground, and other land not covered with vegetation. In 1988, the classification showed that the exposed surface was 11.24 km<sup>2</sup> which greatly increased to 38.11 km<sup>2</sup> in 2018 due to the massive construction of roads and bridges in Osogbo (see Table 2). Thus, as the land and/or its resource is utilised, the cover is modified, hence the land cover change.

Conversion of the original land cover in the area to other land use type has either reduced or increased the various land use types within the time frame of this study. Land cover change assessment confirmed a drastic reduction in vegetation and water bodies while the built-up and bare land/rock outcrop witnessed expansion within the three decades. It could be deduced that built-up and bare land areas continued to make more gains over vegetation and water bodies as uninhabited lands are utilised for human structures. Over the centuries, there has been great expansion of the built-up areas for socio-economic activities and other essentials of life but the rate, extent and intensity of the change today is much more than ever in history, causing the current environmental challenges of today, which ranged from climate change, pollution and biodiversity loss from local to global scales.

### 4.0 CONCLUSION

This study used geospatial techniques to evaluate land use and land cover changes in Osogbo, Nigeria, from 1988 to 2018. The study provided quantifiable information on the extent of land use changes in the area. Losses in vegetation cover were due to rapid urban growth accompanied by a rise in the built-up area which covered 29.59km<sup>2</sup> in 1988 and increased drastically to 63.20km<sup>2</sup> in 2018 while vegetation covers decreased from 102.09km<sup>2</sup> in 1988 to 39.48km<sup>2</sup> 2018. Urbanisation is a process that cannot be halted. There is a need to engage appropriate strategies for sustainable management of the rapidly growing Osogbo with sustainable urban green policies. Hence, urban managers and planners should embark on re-designing Osogbo so that gardens, parks,



orchards and open spaces are accommodated into the city's physical plans. These will allow the free flow of air while providing shade that will contribute to city cooling.

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