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# Analysis of land-use/land-cover dynamics in Ibadan metropolis, Oyo State, Nigeria

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**ABSTRACT**

One of the most important domains of human-induced environmental change has been identified as land transformation. Determining what feature of the land is changing to what, i.e., which land-use class is moving to the other, is a key part of change detection. With the availability of a broad spectrum of geospatial data and complex computing gadgets available to the geospatial world, land-use change detection for effective decision making is now simplified. Therefore, using Landsat TM, ETM+, and OLI, this work examined and tracked spatiotemporal variations in LULC patterns over the city of Ibadan, Nigeria, across three epochs (1999, 2009, and 2019). The build-up area seems to be the key driver for land usage, according to the findings of this research. The study suggests that the state government of the study region monitor urban sprawl and growth regularly, preferably using geospatial techniques to improve decision-making.

## 1. Introduction

The earth's surface is naturally covered with many land cover types, which are mostly distributed according to climatic patterns (Youneszadeh et al., 2015).

Land-use and land-cover (LULC) are two notions commonly used alternately when discussing LULC on the earth's crust (Hua, 2017; Mishra et al., 2020). Categorically, land-use affects Land cover and vice versa. The physical qualities of the earth's surface, such as plant, water, soil, and other physical features caused by human activities such as towns are referred to as Land Cover, while land-use refers to land exploited by humans for economic growth (Hua, 2017; Rawat & Kumar, 2015). LULC is a consequence of anthropogenic activities on the earth surface (Hao et al., 2021). In summary, the modification of the earth's lithosphere by the continuous activities of humans is referred to as LULC (Hassan et al., 2016).

LULC has certain implications that are not limited to increased land surface temperature, atmospheric pollution, etc. (Aliyu et al., 2020a). Therefore, for the long-term development and management of natural resources, accurate data on the rate of land-use pattern changes and urban expansion is critical (Das & Angadi, 2021). Based on this premise, the study analyses the variation in land-use-land cover dynamics in Ibadan Metropolis, Oyo state, Nigeria.

## 2. Study area

Ibadan City (Fig. 1) is located in the South-Western part of Nigeria. It lies between Latitudes 7º 20' 00'N and 7º 30' 00'N and Longitudes 3º 46' 00'E and 3º 60' 00'E. Ibadan metropolis covers an area of about 3080 km². By 2006 population census put the total population of Ibadan to 1,338,659 while the average population density was 435 persons per km² (Taiwo, 2021).

## 3. Method

### 3.1. Data acquisition

The study utilized Landsat satellite images. The Landsat satellite images were acquired for three epochs; 1999 (Landsat 5 TM), 2009 (Landsat 7 ETM+) and 2019 (Landsat 8 OLI) covering a period of 20 years. The images were checked to identify the scenes that had the minimum percentage of cloud cover before being acquired for the research. All the images were obtained

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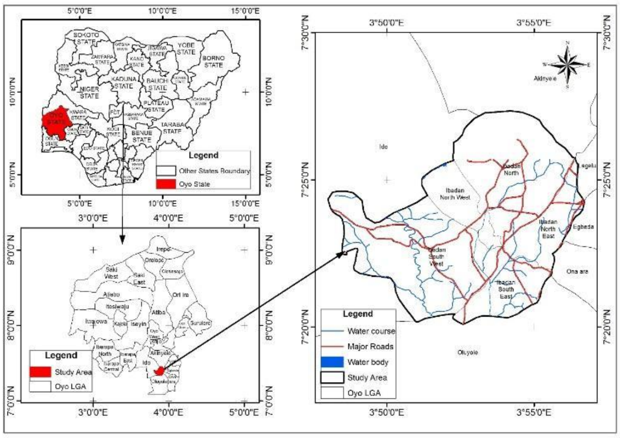


**Figure 1.** Study area showing the project location

### 3.2. Pre-processing and classification of images

Pre-processing of Landsat images before classification is very fundamental. Image pre-processing and classification. Since the data used were ortho-rectified, there was no need for geometric and radiometric correction. However, the datasets were registered to the geographic coordinate system (UTM Zone 31).

All bands of Landsat TM, ETM+ and OLI, excluding the thermal band, were considered for Layer stacking. The nature of these different bands had to be considered to decide which three-band combination would be most helpful for classification and visual interpretation. The false colour composite was employed in this project.

A supervised classification was performed on false colour composites (bands 4, 3 and 2 for Landsat 5 and 7 then bands 5, 4 and 3 for Landsat 8) into the following land-use and land-cover classes; Agricultural land, Built-up area, Forest cover, Grassland and Bare surfaces (see Table 1) (Anderson et al., 1976). Information collected during the field surveys was combined with the digital satellite image which was derived from SAS-planet software and used to assess the accuracy of the classification.

**Table 1.** Classification Scheme

| S/N | Land-use/Land-cover | Description |
|---|---|---|
| 1 | Agricultural land | Lands used for farming (Plantation, cropland orchard) |
| 2 | Built-up land | Lands used for residential, industrial, commercial, etc. |
| 3 | Grassland/forest cover | Lands covered with natural vegetation |
| 4 | Bare surfaces | Lands devoid of vegetation, exposed soil |
| 5 | Water body | Areas with lakes, rivers, streams. |

## 4. Results

### 4.1. Accuracy assessment of the classification

Accuracy analysis was undertaken using a confusion matrix otherwise referred to as the error matrix shown in Table 2. For each of the classes, statistical measures such as producer's accuracy and user's accuracy were used to calculate the overall accuracy and kappa index for the classification.

The overall accuracy of Landsat 5 TM (1999) was found to be 98% with a kappa index of 78%. Also, the overall accuracy of Landsat 7 ETM+ (2009) was found to be 98% with a kappa index of 79%. Finally, the overall accuracy of Landsat 8 OLI (2019) was found to be 99% with a kappa index of 79%.

**Table 2.** Classification accuracy assessment report

| Land Cover Class | 1999 | | 2009 | | 2019 | |
|---|---|---|---|---|---|---|
| | Producer's Accuracy (%) | User's Accuracy (%) | Producer's Accuracy (%) | User's Accuracy (%) | Producer's Accuracy (%) | User's Accuracy (%) |
| Forest cover | 100 | 100 | 100 | 100 | 100 | 100 |
| Grass land | 100 | 94 | 98 | 100 | 100 | 100 |
| Built-up Area | 94 | 98 | 100 | 94 | 100 | 94 |
| Bare Land | 100 | 100 | 94 | 94 | 100 | 100 |
| Agricultural land | 98 | 100 | 96 | 100 | 94 | 100 |
| Overall Accuracy | **0.98** | | **0.98** | | **0.99** | |
| Kappa Statistic | **0.78** | | **0.79** | | **0.79** | |

### 4.2. Changes in land cover between 1999 and 2019

Figs. 2, 3 and 4 show the LULC map of the study period for the area investigated for years 1999, 2009 and 2019 respectively. In 1999, built-up and agricultural land uses occupied about 45.71% and 31.65% of the total area, respectively. Additionally, Forest cover occupied only 8.24% of the total area. Bare land occupied 0.18%. Grassland occupied the third to the least class with 14.21% of the total area.

However, in 2009, the built-up area increased from 45.71% to 57.55% of the total area. This placed the built-up area as the class that witnessed the highest increase in 2009. The reason for the increase might be due to the influx of people in the area for businesses, industrial activities, academic purposes, to say the least. Thus, the built-up area witnessed a very high increase with a percentage annual rate of change of 11.83% between 1999 and 2009. Agricultural area reduced from 31.65% in 1999 to 27.22% in 2009. It was further observed that agricultural land decreased with a percentage annual rate of change of -4.44% of the total area. This decrease is due to an increase in the population of the area which led to increasing land-use for built-up areas. It was further observed that grassland decreased from 14.21% in 1999 to 11.56% of the total area in 2009. This may be attributed to the fact that the forest area was removed for built-up purposes. Further observation revealed that bare land decreased from 0.187% in 1999 to 0.12%. The negative change witnessed by bare land from 1999 to 2009 may be attributed to settlement and other activities. Finally, Forest cover also decreased from 8.24% in 1999 to 3.56% in 2009.

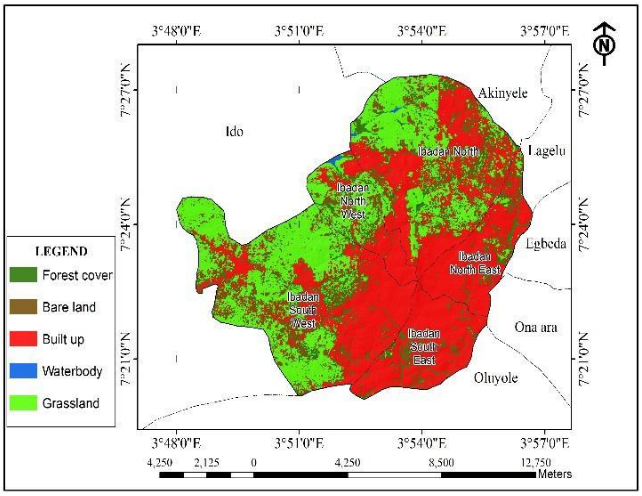


**Figure 2.** Land-use/land-cover Classification of Ibadan in 1999

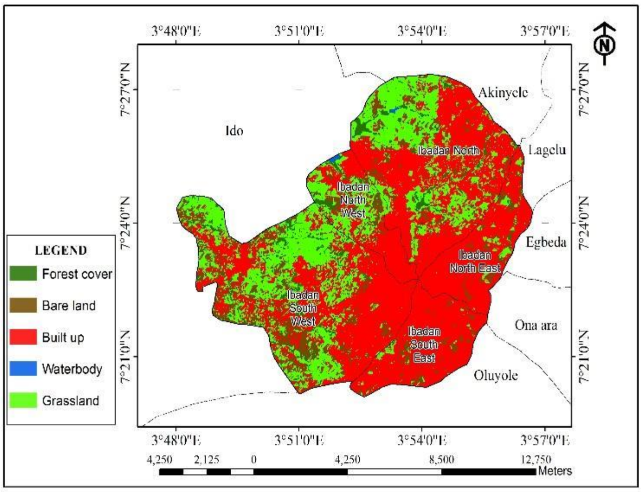


**Figure 3.** Land-use/land-cover Classification of Ibadan in 2009

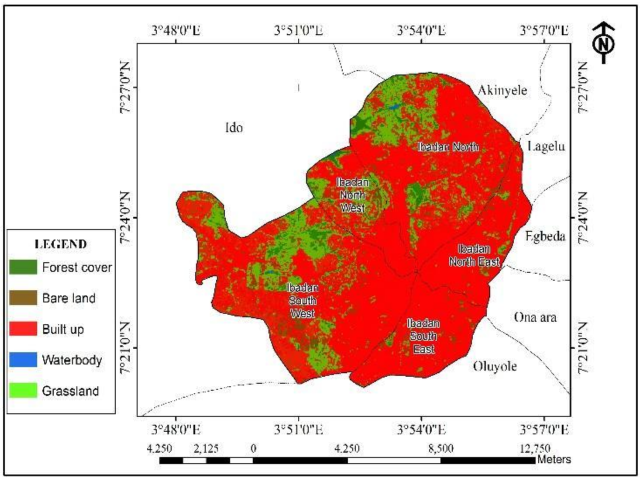


**Figure 4.** Land-use/land-cover Classification of Ibadan in 2019

In 2019, the built-up area increased from 57.55% to 76.39% with an annual rate of change of 18.85%. This annual increase is higher than all the other classes put together. The increase in the population of the area may be attributed to improvement in social and economic activities which has drawn people to the area for settlements. Meanwhile, agricultural land decreased from 27.22% to 16.09% with an annual rate of change of -11.13%. This decrease may not be unconnected with the increase in the population of the area which has transformed the Agricultural land to built-up and other human activities. It was also observed that Forest cover increased slightly from 3.56% to 3.81% with an annual rate of change of 0.26%. This may be attributed to the fact that natural forest was removed every year for farming activities and after harvesting, the farmlands were left fallow and eventually taken over by vegetation. As the population of the area increases, it is natural to expect a decrease in bare land in some areas. In this research, the bare land category decreased from 0.12% to 0.06% in 2019 with a rate of change of -0.12%. This increase may be attributed to the influx of people in the area who engage in other activities.

This analysis shows that there has been a steady increase in the built-up area between 1999 and 2019, which is of course as a result of expansion in residential areas coupled with more anthropogenic activities over the region resulting from dynamic population growth. The finding of this study also correlates with LULC studies conducted in other regions/states within Nigeria (Aliyu et al., 2020b).

## 5. Discussion

Fig. 5 shows the percentage summary of the LULC classification of Ibadan from 1999 to 2019. It further reveals that as human activities increased, the vegetation and other features began to decrease. This is because vegetation and bare lands were being replaced by built-up and other anthropogenic activities.

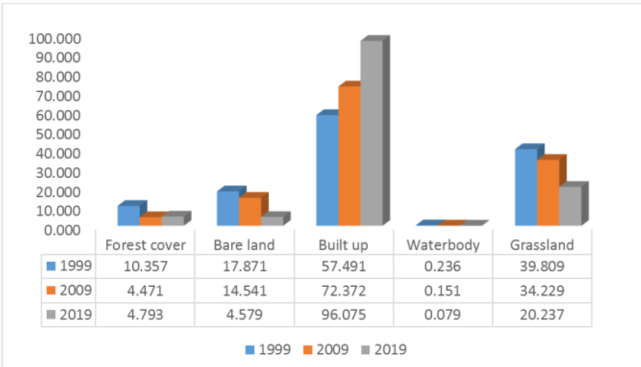


**Figure 5.** Land-use/land-cover Classification of Ibadan from 1999 to 2019

According to the classification of Landsat datasets of 1999, 2009 and 2019, the following classes; agricultural land, built-up, grassland, forest cover and bare land were mapped as land cover in the area. However, on visiting the site during ground-truthing, it was observed that areas that were classified as built-up consisted of the following; roads, residential areas, commercial areas, educational institutions, public offices and waste disposal sites, amongst others. The expansion in built-up areas, therefore, implies an expansion in settlements, roads, and offices, commercial and educational areas. Further observation revealed that some of the areas mapped as bare lands were originally vegetation and areas affected by deforestation. These areas after being used for several years were left as fallow fields which appeared as bare land on the satellite images.

Based on these observations, it is evident that the main anthropogenic drivers in the study area are built-up areas. This is evident in Fig. 5. Within the built-up area, a series of anthropogenic activities were identified which includes roads, residential areas, commercial areas, educational institutions and public offices, amongst others.

## 6. Conclusion

This study assessed and monitored the spatiotemporal changes in LULC pattern across the metropolis of Ibadan, Nigeria at three epochs 1999, 2009 and 2019 using Landsat TM, ETM+ and OLI. The result of this study reveals that the major driver for land use is the build-up area.

The study recommends regular monitoring of urban sprawl and development by the state government of the study area especially with the aid of geospatial techniques for better decision making. This would go a long way in managing the excess and intrusion into

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