GEOSPATIAL ANALYSIS OF THE LAND USE AND LAND COVER CHANGES OF ILORIN METROPOLIS BETWEEN 2000 AND 2017 USING REMOTE SENSING AND GIS TECHNIQUES

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Abstract

The paper focuses on geospatial analysis of the land use and land cover pattern in Ilorin metropolis using Remote Sensing and Geographic Information System technique (GIS). Rapid land use change has taken place in many developing cities of Nigeria including Ilorin over the past decades. Information on the constant change in land use pattern for Ilorin metropolis is of importance because the city is experiencing rapid land use/cover changes and because land use/cover pattern information is indispensable for sustainable rural-urban land use planning and development. Landsat 7 and 8 images of Ilorin metropolis at three epochs of the years 2000, 2010 and 2017 were used. Environment for visualizing images (ENVI) and ArcGIS software were used for the image classification, image enhancement and further processing, analysis and land use map production. The Land consumption rate and land absorption coefficient pattern were analyzed. The results show that water body increased significantly from 0.474%, 0.474ha area in 2000 to 0.589% in 2010 and experienced even a greater increase in 2017 with 0.731% with an of 7.914ha of the total class. Built-up land increased massively from 26.901%, 420.534ha area occupied in 2000 to 511.770ha, 39.439% area in 2010 and showed a slight drop between 2010 and 2017 to 501.822ha representing 46.333% of the total class. In 2000, vegetation occupies 36.254%, 566.748ha but experienced an increase of 9.33ha area and occupied the highest class with 42.956% in 2010 but showed a massive decrease in 2017 to 358.761ha and 33.124% of the total class. Bare land showed a consistent decrease from 2000 with 568.593ha, 36.372% to 220.806ha, 17.016% in 2010 to 214.581ha, and 19.812% area of the total class in 2017. The study reveals increase in population of the metropolis, steady but increasing trend in built up land and reduction in vegetation. If adequate measures are not put in place, there may be a great measure of loss of naturally vegetated area in Ilorin metropolis, which is mainly because of urban growth and expansion, farming and gully erosion. This paper also confirms the convenience, accuracy and reliability of GIS and Remote Sensing techniques for geospatial analysis of landuse and land cover changes. It is recommended that the information from the results of this work should be use to optimally, effectively plan, and manage the study area.

Keywords: Land use/land cover, Landsat, Land use changes, ENVI, GIS

1.0 Introduction

The land use and land cover pattern of a region is an outcome of natural and socio - eco nomic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on land use and land cover and possibilities for their optimal use is essential for the selectio n, planning and implementation of land use schemes to meet the increasing demands fo r basic human needs and welfare. This information also assists in monitoring the dynam ics of land use resulting out of changing demands of increasing population. Land use an d land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. The advancement in the conce pt of vegetation mapping has greatly increased research on land use and land cover cha nge thus providing an accurate evaluation of the spread and health of the world's forest, grassland, and agricultural resources has become an important priority. Remote Sensing (RS) and Geographic Information System (GIS) are now providing new tools for advanc ed ecosystem management. The collection of remotely sensed data facilitates the synopt ic analyses of Earth - system function, patterning, and change at local, regional and glob al scales over time; such data also provide an important link between intensive, localize d ecological research and regional, national and international conservation and managem ent of biological diversity (Wilkie and Finn, 1996).

Therefore, an attempt is made in the study to carry out a geospatial analysis of status of l and use and land cover of Ilorin metropolis between 2000 and 2017 with a view to detec ting the land use changes and consumption rate that has taken place in the metropolis us ing both Remote Sensing and Geographic Information System techniques.

1.1 Aim and Objectives of the Study

This study is aimed at analysing the land use and land cover changes of Ilorin metropolis, Ilorin, Kwara State, Nigeria.

The following specific objectives were pursued in order to achieve the aim of the study.

1. Image classification and creation of land use and land cover maps for the epochs
2. Carry out change detection analysis vis-a-vis determination of the trend, nature and rate of land use and land cover change of the study area.
3. Determination of the land consumption rate and land absorption coefficient of the study area.

1.2 The Study Area

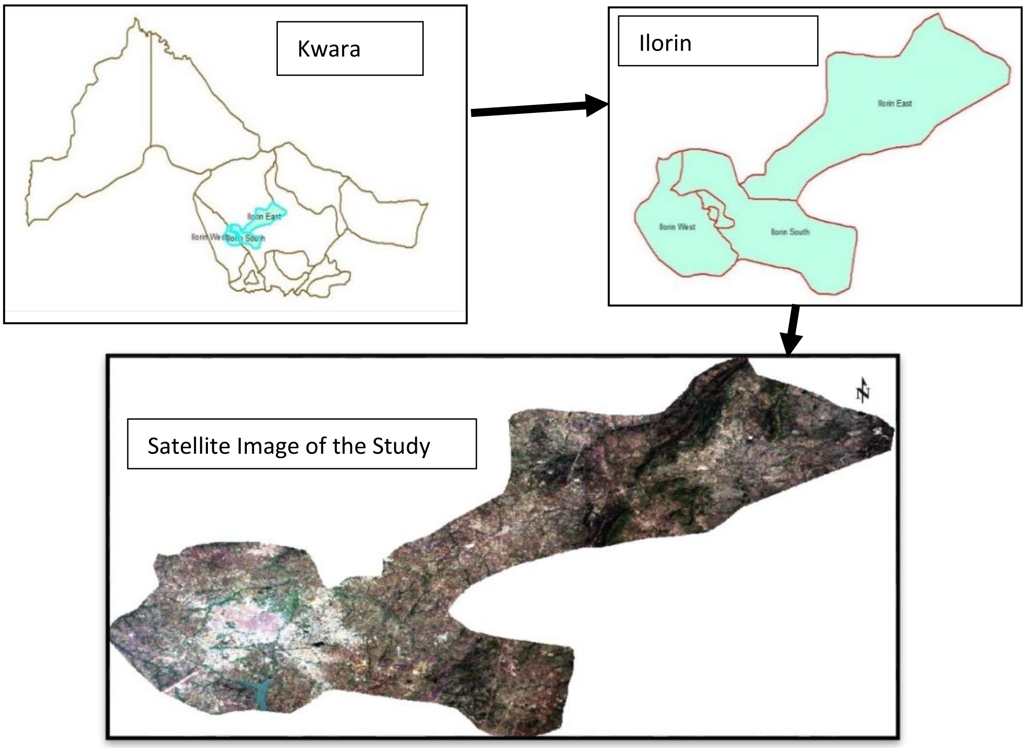

Figure 1.0: Map of the Study Area

Ilorin is the present-day capital of Kwara State. It is located on latitude 8^0 31 N and 4^0 35 E with an area of about 100km square (Kwara State Diary, 1997). It is one of the fastest growing urban centres in Nigeria with high rate of population growth. Ilorin city has grown in both population and area extent at a fast pace since 1967 (Oyegun, 1983). The landscape of the region (Ilorin) is relatively flat, this means it is located on a plain and is crested by two large rivers, the river Asa and Oyun which flows in North - South direction divides the plain into two; Western and Eastern part (Oyebanji, 1993).

2.0 Methodology

Figure 2.0 shows the flow chart of the methodology.

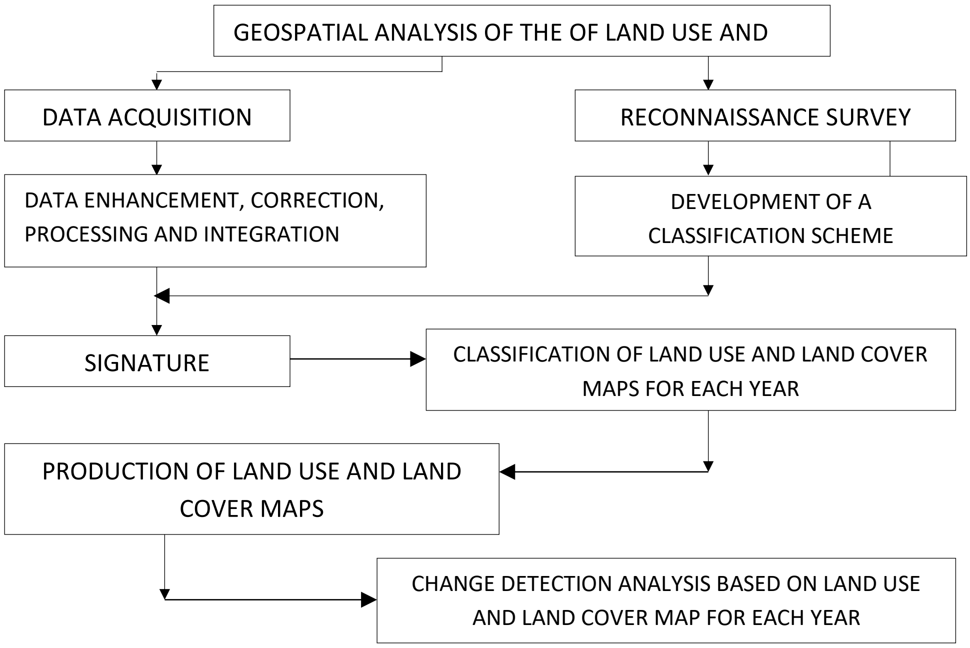

Figure 2.0: Flow chart of the methodology

2.1 Data Acquired and Source

Three epochs land satellite imageries of Ilorin metropolis were acquired for the study; 2000, 2010 and 2017 respectively. All the imageries were obtained from USGS Earth Explorer (www.usgs.earthexplorer.gov). Ilorin metropolis was clipped out using the local government boundary map and Kwara state administrative map and brought to Universal Transverse Mercator projection Zone 31, WGS1984.

Table 2.1: Data Type and Source

S/N	Data type	Date of production	Resolution	Spectral band	Source
1.	Landsat 7 imagery	13-11-2000	30m	Bands 1, 2, 3, 4	usgsearthexplorer.com
2.	Landsat 7 imagery	30-11-2010	30m	Bands 1, 2, 3, 4	usgsearthexplorer.com
3.	Landsat 8 imagery	30-12-2017	30m	Bands 1, 2, 3, 4	usgsearthexplorer.com
4.	Admin. and local Govt. Map of Kwara State				Office of Surveyor General, Kwara State

2.2 Software and Hardware Used

Three (3) software packages were used for this study:

(a) ArcGIS 10.2 - This was used for displaying and subsequent processing and enhancement of the image. It was also used for the carving out of Ilorin region from the whole imagery using both the admin and local government maps. This was also used to compliment the display and processing of the data

(b) ENVI 5.3 - This was used for the development of land use and land cover classes, classification and change detection statistical analysis of the study area.

(c) Microsoft Office - was used basically for the presentation of the research as well as the plotting of the graph and charts.

The hardware packages used include computer system and the Global Positioning System (GPS) for picking of data for ground truthing purpose.

2.3 Data Analysis Approach

- **Image Classification and Creation of Land Use and Land Cover Map**

Before classifying the image and creation of the land use and land cover maps, the classification scheme was developed which is based on Anderson et al (1967) as shown in Table 2.2.

Table 2.2: Land use and land cover classification scheme (Anderson's modification 1967)

Code	**Land use and Land Cover Categories**	**Description**
1.	WATER BODIES	River, permanent open water, lakes, ponds, canals and reservoirs
2	BUILT-UP L ANDS	All residential, commercial and industrial areas, village settlement and transportation infrastructure
3	VEGETATION COVERS	Trees, shrub land and semi nature vegetation, deciduous, coniferous and mixed forests, palms, orchids, herbs, gardens and grasslands
4	BARE LANDS	Fallow land, earth and sand land infillings, construction sites, excavation site, solid waste landfills, open space and exposed soil, rocky areas, dry grasses etc.

The maps of the study area was superimposed on the whole satellite imagery to clip out the area of interest in the ENVI software environment. Edges enhancement filter and radiometric corrections were made on the image as well as the removal of cloud cover and haze which made the image sharper and brighter. Lines on the image were removed from the surface of the imageries with the use of land-sat gap fill software. The presence of these lines was as a result of the scan line corrector that was put off in the scanner used in capturing the imageries. A region of interest (ROI) was created and supervised classification was then performed which was based on the researchers acquired knowledge of the study area and the surface cover types present on the image and the use of maximum likelihood classification. Maximum-likelihood was used because its

algorithm allows for the decision made at each pixel to minimize some error criterion throughout the classified areas, that is, over a large number of individual pixel classifications. During classification, class names were assigned to groups of pixels with similar spectral values that are supposed to represent a known feature on the ground. A region of interest thus stores locations of classified pixels and the assigned class names.
Further processing was done by importing the data into the ArcGIS environment for the production of the land use and land cover maps. The maps for the three epochs were done.

- **Change Detection Analysis**

The comparison of the land use and land cover statistics assisted in identifying the percentage change, trend and rate of change between 2000 and 2017. A table showing the area in hectares and the percentage change for each year (2000, 2010 and 2017) measured against each land use and land cover type was developed after which percentage change to determine the trend of change was calculated by dividing observed change by total sum of changes multiplied by 100 as shown in equation 1.

$$(Trend)\ percentage\ change\ = \frac{Observed\ change}{Total\ sum\ of\ change} \times\ 100 \qquad eqn.(1)$$

In obtaining annual rate of change, the percentage change is divided by 100 and multiplied by the number of study year 2000 - 2010 (10 years) and 2010 – 2017 (7 years).

- **Determination of the land consumption rate and land absorption coefficient.**

The Land consumption rate and absorption coefficient formula are given below;

$$Land\ consumption\ rate\ (LCR) = \frac{A}{P} \qquad eqn.(2)$$

A = area extent of the city in hectares, P = population

$$\text{Land absorption coefficient (LAC)} = \frac{A_2 - A_1}{P_2 - P_1} \qquad eqn.(3)$$

A_1 and A_2 are the area extents (in hectares) for the early and later years, and P_1 and P_2 are population figures for the early and later years respectively (Yeates and Garner, 1976).

LCR is equal to measure of progressive spatial urbanization of a study area and *LAC* is equal to measure of change of urban land by each unit increase in urban population (Olaleye et al., 2012). The 2000, 2010 and 2017 population figures of the study area were estimated from the 2006 census using the recommended National Population Commission (NPC) 2.6% growth rate as obtained from Nigeria population growth rate 2006 respectively. This is as represented in equations (4) and (5) respectively.

$$n = \frac{r}{100} \times\ Po \qquad eqn.(4)$$

$$Pn\ =\ Po\ +\ (n\ \times\ t) \qquad eqn.\ (5)$$

Pn = estimated population (2000, 2017) Po = base year population (2006 population figure)
r = growth rate (2.1%), n = annual population growth, t = number of years projecting for.

3.0 Results and Discussion

The results are as presented in form of statistical tables, figures, and charts.

3.1 The Classified Images and maps

Figures 3.1, 3.2 and 3.3 show the classified images of the epochs (2000, 2010, and 2017) and figures 3.4, 3.5 and 3.6 the land use/land cover maps for the years respectively. The water bodies are in blue color, built-up lands in red, vegetation in green and the bare lands in brown respectively.

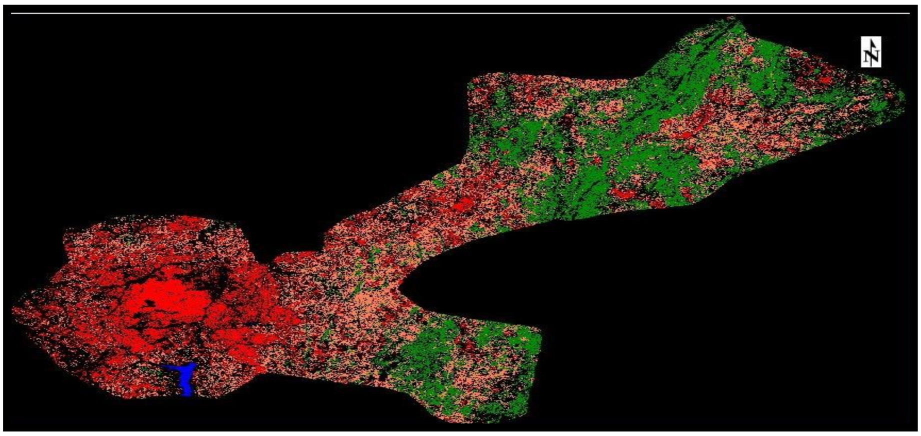

Figure 3.1: Classified Landsat image of Ilorin metropolis in 2000

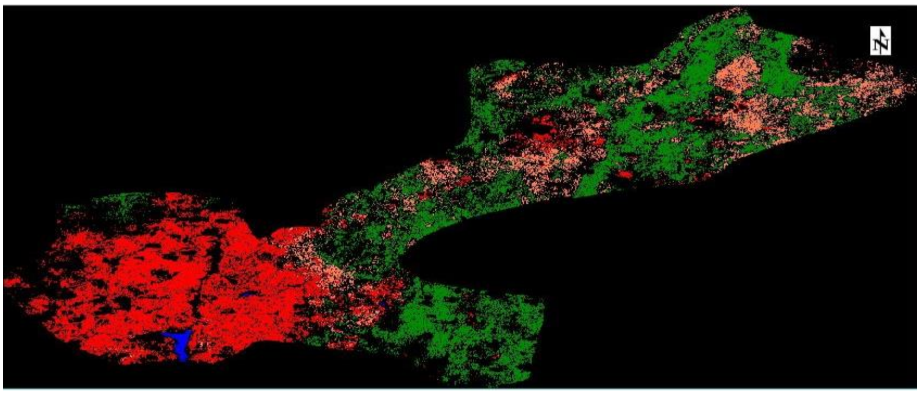

Figure 3.2: Classified Landsat image of Ilorin metropolis in 2010

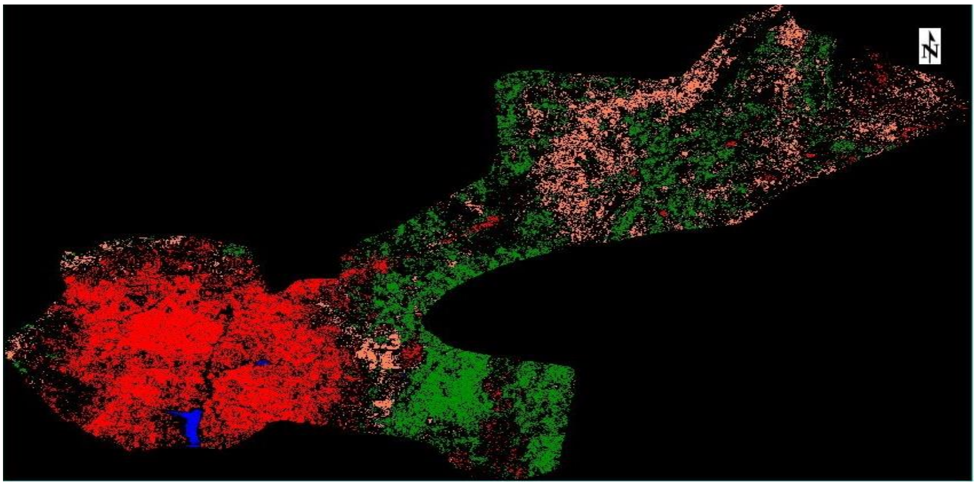

Figure 3.3: Classified Landsat image of Ilorin metropolis in 2017

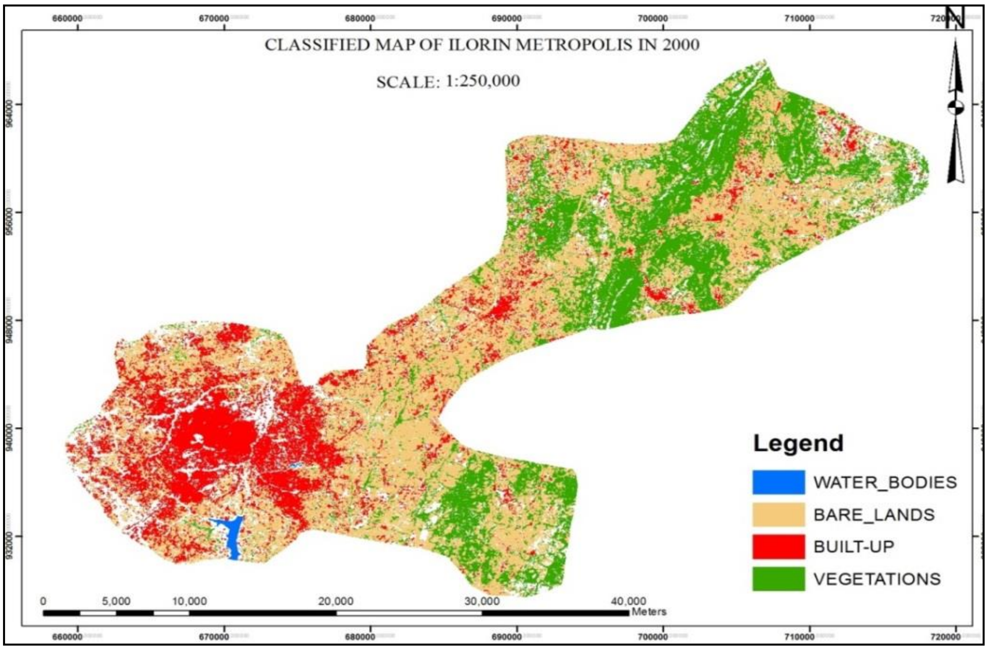

Figure 3.4: Land Use/Land Cover map of Ilorin in 2000

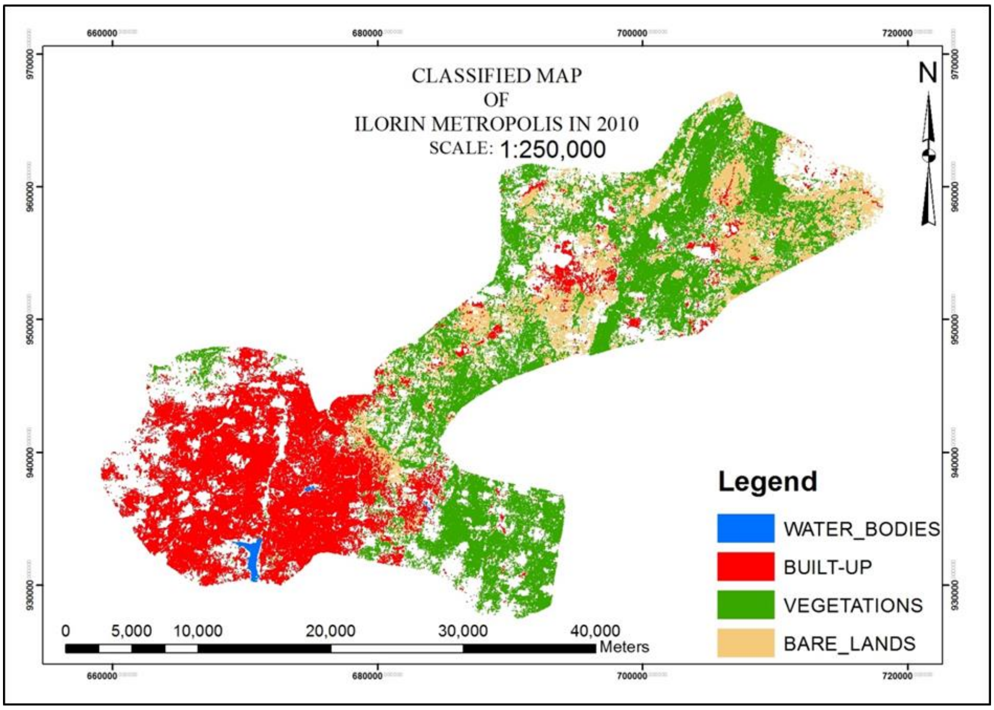

Figure 3.5: Land Use/Land Cover map of Ilorin in 2010

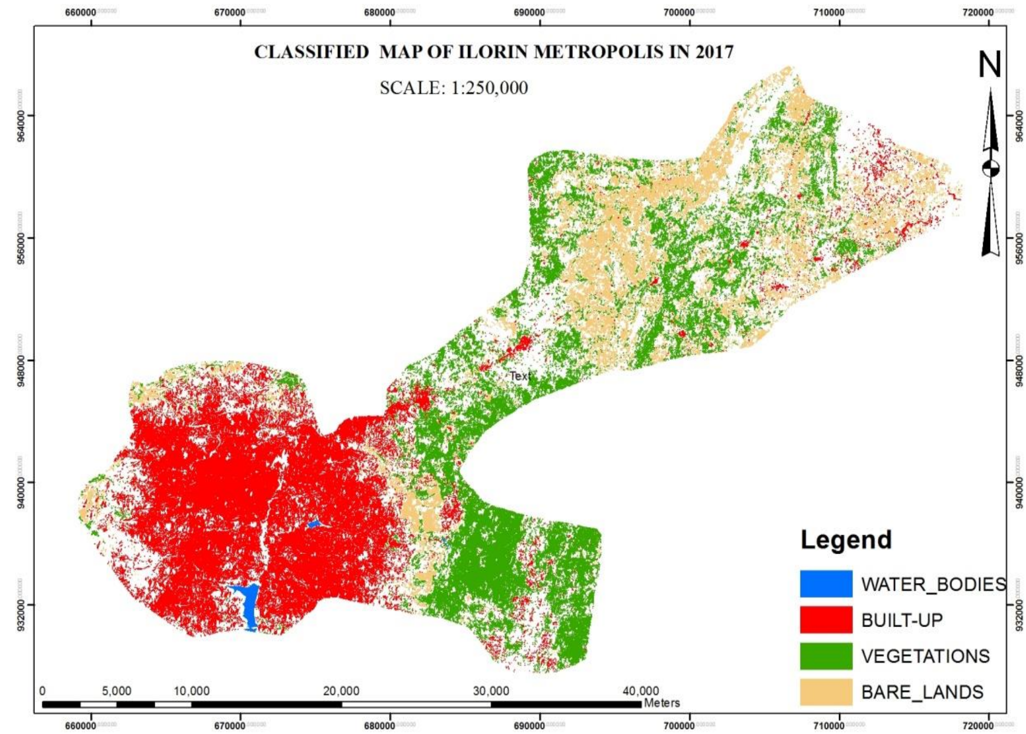

Figure 3.6: Land Use/Land Cover map of Ilorin in 2017

3.2 Land Use and Land Cover Change: Extent of Change, Trend, and Rate

- **Extent of change**

Table 3.1: Land use and land cover change of Ilorin metropolis: 2000, 2010 and 2017

S/n	Land Use/Land Cover Categories	2000 – 2010		2010 -2017		Annual rate Of change	
		Area (ha.)	Percentage Change (%)	Area (ha.)	Percentage Change (%)	2000/2010	2010/2017
1	Water Bodies	0.23	-0.087	0.27	-0.126	0.023	0.039
2	Built-up Land	91.236	-34.344	-9.948	4.636	9.124	-1.421
3	Vegetation Covers	-9.330	3.512	-198.657	92.588	-0.933	-28.380
4	Bare Lands	-347.787	130.919	-6.225	2.901	-34.779	-0.889

The percentages of change were calculated by dividing magnitude of change of each of Land use by its total area and multiply by 100 (M/A×100). The annual rate of change was calculated by dividing the magnitude of change of the land use by the reference year (M/10) for 2000-2010 and (M/7) for 2010-2017**.** From table 3.1 above, there seems to be a higher increment in vegetation between 2010 and 2017. This may be connected to the fact that the imagery was captured during wet season whereby some unoccupied bare lands changed back to vegetation and the policy formulated by the state government to conserve natural resources discouraged physical development of built-up land. Subsequently, built-up land only increased by 5% while both bare land increased by 130% between 2000 and 2010 but remained 2.901% between 2010 and 2017 due to aforementioned reasons.

Many projects were embarked on, in Ilorin, Kwara State and this attracted a lot of people to the area thus contributing to the physical expansion of the city as evident in the increased land consumption rate from 0.002 to 0.01 and land absorption coefficient by 0.02 between 2000 and 2010 which all encouraged migration into the city. The period between 2010 and 2017 witnessed a drop in the rate at which the physical expansion of the city was going as against 2000 and 2010. For instance, the built-up land only increased by 4%. Indeed, the subsidy removal policy and economic recession experienced during the present-day administration in the country during the period could be a major factor to what was witnessed. Furthermore, water body seems to remain at 1% though there are slight differences in the total area between this period. This was not so in 2000 because University of Ilorin Dam which was not yet constructed.

- **Nature and Location of Change in Land Use and Land Cover**

An important aspect of change detection is to determine what is actually changing to what i.e. which land use class is changing to the other. This information will reveal both the desirable and undesirable changes and classes that are "relatively" stable overtime. This information will also serve as a vital tool in management decisions. This process involves a pixel-to-pixel comparison.

In terms of location of change, the emphasis is on built-up land. From observation from figure 3.7, there seem to exist a growth away from the city center following the concentric theory of city growth postulated by Christaller (1933).

Although the pattern seems to be uniform, there exist more growth towards the south western part of the city comprising of the Asa dam area, Adewole Estate and Airport, GRA, Tanke, Sango, Kulende area etc. Between 2000 and 2010 as shown in the map, there exist drastic reductions in the spatial expansion of the city. The noticeable growths are on the edges of the developed areas of 2000 built-up land. From figure 3.3, the edges of built-up land seem to have been filled up with developments by 2017 leaving the only noticeable developments to areas around the city center. Thus, between 2000 and 2010, Built-up land has a loss of 34% but gained by 5% between 2010 and 2017. Bare land on the other hand gained by 130% between 2000 and 2010 but reduced to 3% between 2010 and 2017.

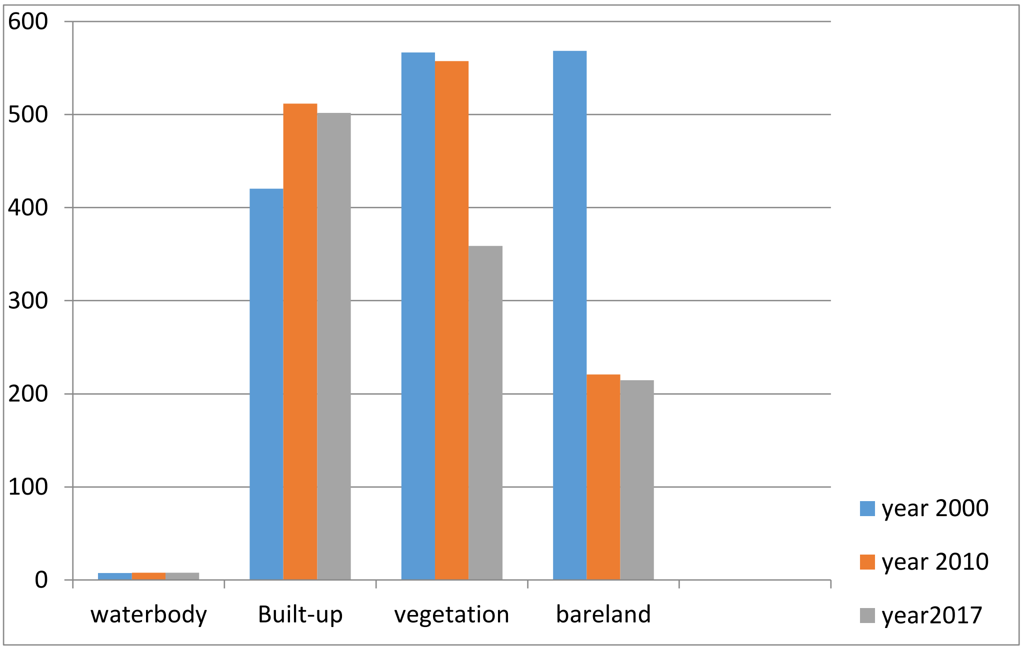

Figure 3.7: Chart Showing the Land Use and Land Cover of Ilorin in 2000, 2010 And 2017

3.2 Land Consumption Rate and Land Absorption Coefficient

The results of the area and percentage occupied by each land use type are as shown in table 3.2.

Table 3.2: Area of the Land Use/Land Cover Type in the study area (2000, 2010, 2017)

S/n	Land use/Land Cover Categories	2000		2010		2017	
		Area (Ha.)	Area (%)	Area (Ha.)	Area (%)	Area (Ha.)	Area (%)
1	WATER BODIES	7.416	0.474	7.641	0.589	7.914	0.731
2	BUILT-UP LANDS	420.534	26.901	511.770	39.439	501.822	46.333
3	VEGETATION COVERS	566.748	36.254	557.418	42.956	358.761	33.124
4	BARE LANDS	568.593	36.372	220.806	17.016	214.581	19.812

In 2000, Water bodies occupy the least class with just 0.474% of the total class, followed by built-up lands, which occupied only 26.901%. Vegetation covers occupied 36.2535% and slightly above it is bare lands occupying the highest class in the classification with a percentage of 36.372%.

In 2010, Water bodies still maintain and take up the least class but however, with a significant increase of 0.589%. This little increase could also be traced to notable construction of the University of Ilorin Dam, which was constructed between the years 2005/2006 season. Built up lands experienced a significant increase of 12.538ha occupying 39.439% of the total class. The vegetation covers occupied the highest percentage of 42.956% of the total class though it experienced a decrease of 9.33ha compared to the previous year under consideration taking up closely half of the total class. The higher percentage covered may be due to the season of the year probably the image was taken; either during the rainy or wet season during which the vegetation might have come up and taken up the bare lands. Bare lands however recorded 220.806ha and 17.016% area showing a significant decrease compared to the previous year.

In 2017, water bodies still occupied least class though significant increase was recorded occupying an area of 7.914ha and 0.731% of the total class. Built-up lands occupied 501.822ha area and 46.333% of the total class showing a steady increase. Vegetation covers have the highest percentage after built-up lands, occupied 33.124% and showed a great increase with a difference of 198.657ha compared to 2010. The bare lands still further decreased to 214.581ha though slowly, occupying 19.812% of the total class.

The estimated population of each study year as shown in table 3.3 were used in generating both the Land Consumption Rates and the Land Absorption Coefficients as given in table 3.4.

Table 3.3: Estimated population figures of Ilorin in 2000, 2010 and 2017

YEAR	POPULATION FIGURE	SOURCE
2000	675,216	RESEARCHER'S ESTIMATE Based on NPC, 2006
2010	842,991	
2017	901,586	

Table 3.4: Land consumption rate and absorption coefficient

YEAR	LAND CONSUMPTION RATE	YEAR	LAND ABSORPTION CO-EFFICIENT
2000	0.0023	2000/2010	0.002
2010	0.002	2010/2017	0.004
2017	0.001		

4.0 Conclusions

The result of the study reveals increase in population of the metropolis, steady but increasing trend in built up land and reduction in vegetation. This situation and the land use pattern if not well analyzed, will have negative implications in the area because of the associated problems of crowdedness and over-congestion like crimes and criminal acts, poverty, unemployment, competition in social amenities, environmental pollution and degradation and easy outbreak of epidemic diseases. It is therefore suggested that encouragement should be given to people to build towards the outskirts of the study area such as Ganmo, Amoyo, Idofian, Fufu, Eiyenkorin, etc through the provision of incentives and forces of attraction such as the basic social amenities like good motorable road, health facilities, good and regular electricity supply etc. that are available at the city center in these areas.

Expansion in the built-up land of the study area may not be stopped but the relevant stakeholders would need to initiate urban planning that will lead to a sustainable growth of the Ilorin metropolis

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