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Land Use and Land Cover Change Detection Using Remote Geospatial Techniques: A Case Study of an Urban City in Southwestern, Nigeria

Abstract. Many cities in developing countries are experiencing ecosystem modification and change. Today, about 10 million hectares of the world's forest cover have been converted to other land uses. In Nigeria, there is an estimated increase of 8.75 million ha of cropland and decrease of about 1.71 million ha of forest cover between 1995 to 2020, indicating that Nigeria has been undergoing a wide range of land use and land cover changes. This paper analyses the changes in land use/cover in Ila Orangun, Southwestern, Nigeria from 1986 to 2018, with a view to providing adequate information on the pattern and trend of land use and land cover changes for proper monitoring and effective planning. The study utilized satellite images from Landsat 1986, 2002 and 2018. Remote sensing and Geographical Information System techniques as well as supervised image classification method were used to assess the magnitude of changes in the city over the study period. The results show that 26.36% of forest cover and 44.48% of waterbody were lost between the period of 1986 and 2018. There was a rapid increase in crop land by 365.7% and gradual increase in built-up areas by 103.85% at an annual rate of 3.25%. Forest was the only land cover type that recorded a constant reduction in areal extent. The study concluded that the changes in land use and land cover is a result of anthropogenic activities in the study area.

Key words: land use, land cover, change detection, landsat images, supervised classification, Nigeria

JEL Classification: R14

Introduction

Land use and land cover change detection plays an important role in effective monitoring and assessment of the level of human impact on ecosystems (Liping et al., 2018; Wang et al., 2020) through the use of remote sensing data. Thus, the use of remote sensing data for mapping urban ecosystems is vital to the understanding of the characteristics and structure of urban ecosystems (Fedrigo et al., 2019). Some of the major applications of remote sensing include acquisition, modelling, mapping and classification of spatial data of the earth's surface (Pettorelli et al., 2005; 2014). These spatial data are essentially useful for effective monitoring and management of various land cover features (waterbodies, vegetation, bare surface, soil and rocks) within an urban ecosystem (Pettorelli et al., 2014; Xue and Su, 2017; Fedrigo et al., 2019). Land cover refers to the physical features on the earth surface such as soil, vegetation, wetlands, water bodies, rocks, etc. Land use refers to the various ways by which humans use land, which may be for conservation, settlements, production, recreation or development.

Globally, there has been a continuous conversion of land cover to other land uses. According to the Food and Agriculture Organization (2020), about 10 million hectares (ha)

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of the world's forest, which was estimated to be one-third of the total world land cover, was converted mainly to agricultural land and other uses from 2015 to 2020. During this period, Africa had the highest annual rate of forest loss at 3.9 million ha (Food and Agriculture Organization, 2020). With the rapid increase in human population, particularly in many African nations, coupled with continuous land development and high demand for food, the situation is expected to continue. The report of the Forestry outlook Study in Africa (FOSA) on land use trends in Nigeria shows an estimated increase of cropland from 61.9 million ha in 1995 to 70.65 million ha in 2020, while forest cover decreased from 2.65 million ha in 1995 to 938,066.41 ha in 2020 (Aruofor, 2020). This report reveals that Nigeria has been undergoing a wide range of land use and land cover changes, which often lead to ecological imbalance.

Studies have attributed changes in land use and land cover to land development, population growth and urban expansion as a result of urbanization (Orimoogunje, 2014; Nath et al., 2020). Over the ages, particularly since organized human settlements started, human beings have been exploiting the biosphere resources through modification of various land cover to different types of land uses. Prior to the 1970s, ecologists focused mainly on the study of the relationships of organisms to each other and the components of the environment such as soil, light, and temperature, among others. Such studies as those by McIntosh (1974) dwelled on the relationships of flora and fauna in their environments. Many other studies focused on the adaptation and modification of plants and animals to a specific environment, and the distribution and abundance of biodiversity in specific environments, among others (Egerton et al., 2008; Bidlack and Jansky, 2011), with very little focus on land use and land cover changes. The United Nations estimates that about 55 % of the world's population are living in urban areas presently. This is expected to increase to 68 % by 2050 based on population projections (United Nations, 2019). With the rate at which urban populations are increasing in different parts of the world, ecological studies have been focusing on human activities in urban environments in relationship to land use and land cover change for monitoring and policy making (Grove, 1997; Ye et al., 2018; Chen et al., 2020).

Many cities in developing countries such as Nigeria, Liberia and Ghana are experiencing ecosystem modification and land use/cover change as a result of urbanization, population growth and economic development. Economic development often leads to land use and land cover changes which invariably alter the functioning of ecosystems that provide support for humans in all respects, including livelihood. Previous studies (such as Adesina, 2008; Ajala and Olayiwola, 2013; Butt et al., 2015; Ye et al., 2018; Chen et al., 2020) have shown that urban areas are experiencing rapid reduction in total area occupied by natural vegetation, forest and water bodies annually. These changes in land use patterns in different parts of the world have been resulting in ecological imbalance and environmental challenges such as flooding and biodiversity loss, as well as changes in local climate. The ecological imbalance and environmental challenges associated with continuous conversion of natural land cover to other man-made ecosystems, particularly in urban centres, justify the significance of this study. Thus, land use land and cover change detection plays an important role in effective monitoring and assessment of the level of human impacts on ecosystems and its resources. This paper therefore analyses the changes in land use/cover in Ila Orangun, Southwestern, Nigeria from 1986 to 2018. This is with a view to providing adequate information on the pattern and trend of land use/land cover changes over a period of thirty two years for proper monitoring and effective planning.

Materials and methods

Study area

Ila Orangun is situated in Osun state, Southwestern part of Nigeria. Ila Orangun is located approximately between latitudes 8° 2' 13" N and 7° 59' 30" N and longitudes 4° 52' 30" E and 4° 57' 30" E (Figure 1). It has an elevation of about 494 m above sea level. The community has one Local Government Area and eleven wards. According to the National Population Commission (2006), the town has a population of 62,049 but this has been estimated to increase annually by an official annual growth rate of 3.2 percent from 2006 to present (National Population Commission, 2020).

Ila Orangun experiences the Koppen AF humid tropical rainforest climate, which is characterized by high humidity and rainfall (Adejuwon and Jeje, 1976). The climate gives rise to high variety of biological diversity that supports agriculture. The area has two seasons: dry and wet. The wet season starts around March and ends around late October while the dry season is experienced from November to February (Iloeje, 1982; Climate Data, 2018). The average minimum and maximum temperatures in Ila Orangun are 25℃-28℃ and 31℃-32℃, respectively. The area is drained by several rivers which have their source from hills near the city (Ogunfolakan, 2009).

The original type of vegetation found in the Ila Orangun is that of tropical rainforest. However, the present vegetation can be referred to as secondary forest and derived savanna (Tijani and Onodera, 2009; Ogunleke and Oludele, 2013) as a result of land use/land cover changes over the years. The climate supports the growth of valuable cash crops like Cocoa (*Theobroma cacao*) and Kola nut (*Cola* spp.) as well as the production of timber from economic trees like Obeche (*Triplochiton scleroxylon*) and Iroko (*Milicia excelsa*) (Adejuwon and Jeje, 1976; Orimoogunje, 2014). It also favors the cultivation of food crops such as maize (*Zea mays*), yam (*Dioscorea alata*), okro (*Hibiscus esculentus*), cassava (*Manihot esculenta*) and vegetables (*Amaranthus* species) (Adejuwon and Jeje, 1976; Olaniran, 2013). The area has a land mass of approximately 332 square kilometres.

Table 1. Description of land use/land cover classes identified in the study area

Land Use/ /Land Cover Classes	Description
Forest	-Areas covered with matured trees and other green plants that closely grow together (which could be dense, secondary, disturbed or degraded forest).
Crop Land	-Areas of land use for cultivation of crops which include farmland or garden.
Built-up Area	-These are areas covered with buildings (completed or uncompleted) which include residential houses, offices, shops with road networks.
Water Body	-These are areas covered with rivers and reservoirs.
Rock	-Areas covered with exposed rocks

Source: Adapted from Adegboyega (2012).

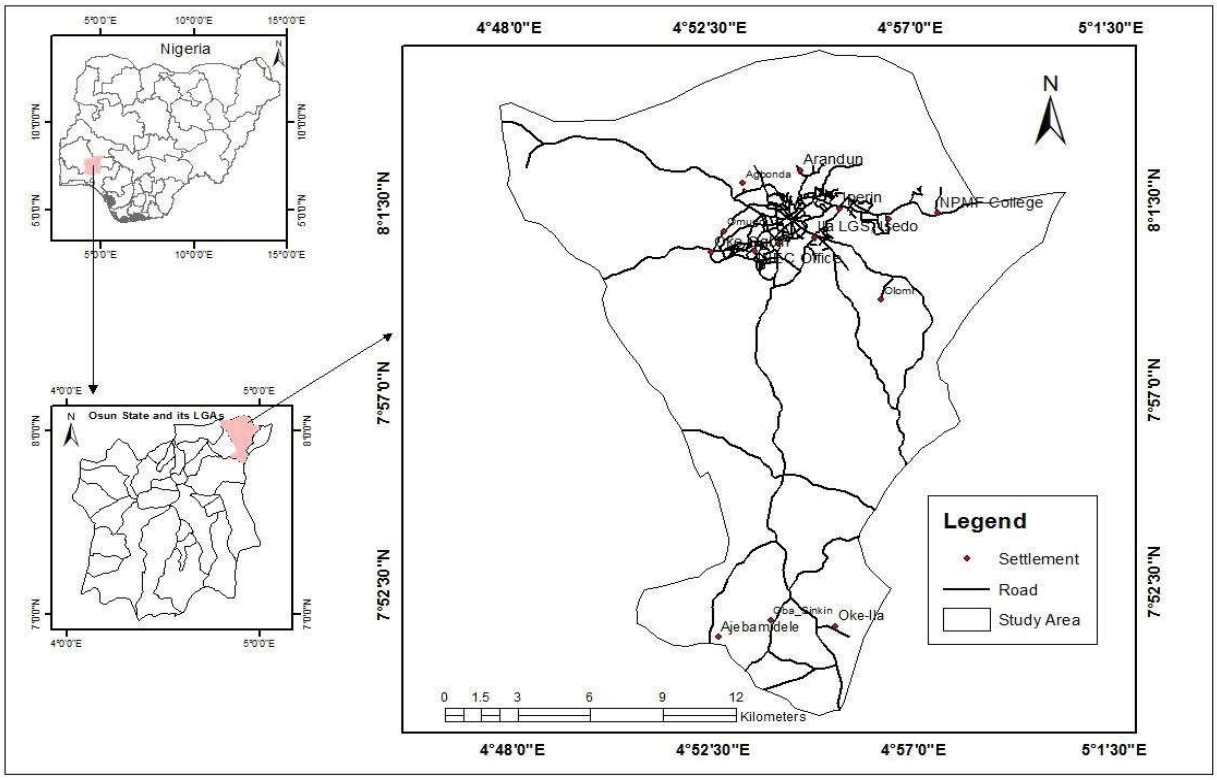

Fig. 1. The study area, Ila Orangun in southwestern, Nigeria

Source: Author's own elaboration.

Data collection

Data used for the study are Landsat images which were obtained freely from the United States Geological Survey (USGS) archive. Based on the available data, the study utilized satellite images from Landsat 1986, 2002 and 2018. Thus, Landsat Thematic Mapper (TM) 1986, Enhanced Thematic Mapper (ETM) 2002 and Landsat 8 OLI/TIRS located on Path 190 and Row 055 were utilized for this study (Table 1). This was with a view to obtaining useful information on the changes in land use patterns within the study area for adequate monitoring and planning. Landsat datasets were selected for this study, due to the fact that they are highly suitable for studies on land use/land cover change detection, give a time series of data on an area and also have good spatial resolution (Oyinloye et al., 2010; Boyle et al., 2014).

Image processing and classification

The Geographical Information System (GIS) software that was utilized for this study includes Earth Resources Data Analysis System (ERDAS) IMAGINE 9.2 and Aeronautical Reconnaissance Coverage Geographic Information System (ARCGIS) 10.2 versions. Subset images were created from the landsat images (1986, 2002 and 2018) using the administrative

boundary of the study area as a shapefile. This task was performed in order to select the pixels i.e. Area of Interest (AOI), that are within the geographic boundary of the study area. The areal extent and geographic co-ordinates of the subset images were described in order to aid the performance of various integrated analytical operations for change detection. The appropriate band combination from the multispectral satellite images were selected to create a colour composite that was specifically tailored to facilitate the identification of the features of interest in the GIS environment.

Table 2. Characteristics of the Dataset for the Ile-Ife and Ila Orangun

Data Type	Date of capture	Spatial Resolution	Landsat Scene	Location	
				on WRS	Source
Landsat Imagery	17 Dec., 1986	30 m	TM	P190R055	USGS
Landsat Imagery	01 Jan., 2002	30 m	ETM+	P190R055	USGS
Landsat Imagery	03 Jan., 2018	30 m	Landsat 8	P190R055	USGS

Source: USGS denotes United States Geological Survey.

A supervised classification method was employed because it aids the selection of pixels that represent land use features that are useful for the study (Oyinloye and Oloukoi, 2013; Boyle et al., 2014; Madaan and Sharma, 2012). Ground control points with coordinates of known locations were obtained using GPS to enhance the validity of the classified map during reconnaissance survey. The purpose of performing this task was to confirm the accuracy of the spatial information from remotely-sensed images (1986, 2002 and 2018) through a process known as ground truth (Ramzi, 2015). The same symbols were assigned to classes of similar group attribute data. The classification scheme which represents the tropical terrestrial biomes as described by Costanza et al. (1997) was chosen because it corresponds to the rainforest ecological zone of Nigeria. Based on this classification, five classes (forest, cropland, waterbody, built-up and rock) were identified from the multi-date satellite images (1986, 2002 and 2018).

Data Analysis

The thematic raster layers were quantified using ERDAS IMAGINE statistical tool. From the classified multi-date images acquired, land use/land cover (LULC) layers were digitized for change detection (such as trend, magnitude and rate of the change) using the formula which is expressed as:

$$\Delta LULC = LULC_2 - LULC_1 \quad (1)$$

Where:
$\Delta LULC$ is the land use/land cover change;
$LULC_2$ is the current area extent of a particular land use/land cover type;
$LULC_1$ is the previous area extent of a particular land use/land cover type.

In addition, Average Rate of change (*ARC*) of a particular land use/ land cover type was calculated using the formula which is expressed as:

$$ARC = \Delta LULC / T \quad (2)$$

Where:
ARC is the Average Rate of Change;
T is the total number of years.

Lastly, the annual rate of changes in various land cover types was determined using the formula:

$$LUDI = [(U_b - U_a) / U_b\ T] \times 100 \quad (3)$$

Where:
LUDI is the annual rate of change;
U_b and U_a represents the extent of urban expansion at time '*a*' and '*b*';
T is the length of time in years from time '*a*' to time '*b*'.

Results and discussion

Land use/cover change

The main land use in the study area included arable farming, residential and institutional. The land use/land cover areal extent of Ila Orangun for 1986, 2002 and 2018 is presented in Table 3. The study area covered an estimated area of 33,224.6 hectares. As presented in Figure 2 and Table 2, forest occupied (89.56%) represents the most extensive land use/cover type in 1986. The built-up area (5.2%) represents the second largest land use/cover type, followed by crop land (4.81%), rock (0.34%) and water body (0.09%) in 1986. However, by the year 2018, there were changes in the areal extent occupied by all the land use/cover types.

Table 3. Land Use/Land Cover Areal Extent of Ila Orangun between 1986 and 2018, in ha

Land use/Cover Classes	1986		2002		2018	
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)
Forest	29755.95	89.56	28357.20	85.35	21911.6	65.95
Crop Land	1598.10	4.81	2624.74	7.90	7442.3	22.40
Built-up Area	1727.68	5.20	2093.15	6.30	3521.8	10.60
Waterbody	29.90	0.09	13.29	0.04	16.6	0.050
bare surface	112.97	0.34	136.22	0.41	332.3	1.00
Total	33224.60	100.00	33224.60	100.00	33224.6	100.00

Source: Author's Computation, 2021.

The results of the trend/magnitude and rate of change for the classified land use/cover of Ila Orangun between 1986 and 2018 are presented in Table 4. The positive values of the magnitude of change and annual rate of change implies an increase in land use/cover from the previous year of study while the negative values of magnitude of change and annual rate of change implies a reduction in land use/land cover from the previous year of study. During the period between 2002 and 2018, forest was the only land cover type that recorded

a reduction in areal extent. The trend of land use/cover changes in Ila Orangun from 1986 to 2018 implies that part of forest area has been converted and lost to crop land, built-up area and rock annually (Figure 2 and Table 4). The results show that part of the areas that were formerly occupied by forest between 1986 and 2002 have been reduced more than three times the areal extent between 2002 and 2018.

Table 4. Analysis of the changes in Land Use/Land Cover in Ila Orangun between 1986 and 2018

Land use/ /Cover classes	Magnitude of change						Annual rate of change	
	1986-2002		2002-2018		1986-2018			
	area, in ha	%	area, in ha	%	area, in ha	%	ha/yr.	%
Forest	-1398.75	-4.7	-6445.6	-22.73	-7844.35	-26.36	-245.16	-0.82
Crop land	1026.64	64.24	4817.56	162	5844.2	365.7	182.63	11.43
Built-up area	365.47	21.2	1428.65	125.31	1794.12	103.85	56.07	3.25
Waterbody	-16.61	-55.55	3.31	24.3	-13.3	-44.48	-0.42	-1.39
Rock	23.25	20.58	196.08	143.94	219.33	194.15	6.85	6.07

Source: Author's Computation, 2021.

The results from the analysis of the land use/cover areal extent from 1986 to 2018 reveal that forest constitutes the most extensive type of land use/land cover by accounting for 65.95% of the total areal extent in 2018. However, the value in 2018 indicates a continuous and drastic decline in forest cover from 89.56% to 65.95% over a period of thirty-two years, mainly due to anthropogenic factors such as logging activities and urbanization, coupled with other urban development and continuous increase in crop land, built-up and rock areas as shown in Table 3. One of the possible reasons for continuous logging activities in Ila Orangun is as a result of the climatic condition which supports dense vegetation.

A comparison of the magnitude of change in the land use/cover indicates that while forest cover was decreasing continuously, cropland, built-up area and rock were increasing annually between 1986 and 2018 (Table 4). However, there were fluctuations (i.e. increase and decrease) in the trend and rate of change recorded in the areal extent occupied by water body during these periods (Tables 3 and 4). More specially, the results of the magnitude of change show that crop land, built-up area and rock increased by 365.7%, 103.85% and 194.15% at an annual rate of 11.43%, 3.25% and 6.07% per annum, respectively, between 1986 and 2018. The rate at which land use/land cover was converted to crop land was very rapid when compared to other land use/cover types over the study period. The study noted that the majority of the residents in Ila Orangun are predominantly subsistence farmers who engage in the cultivation of arable crops such as yam, maize, cassava and vegetables as a means for survival and livelihood. This is evident in the rapid trend by which crop land gained more areal extent than other land cover types in the study area from 1986 to 2018. The areal extent occupied by cropland by the year 2018 was more than double its initial size in 1986.

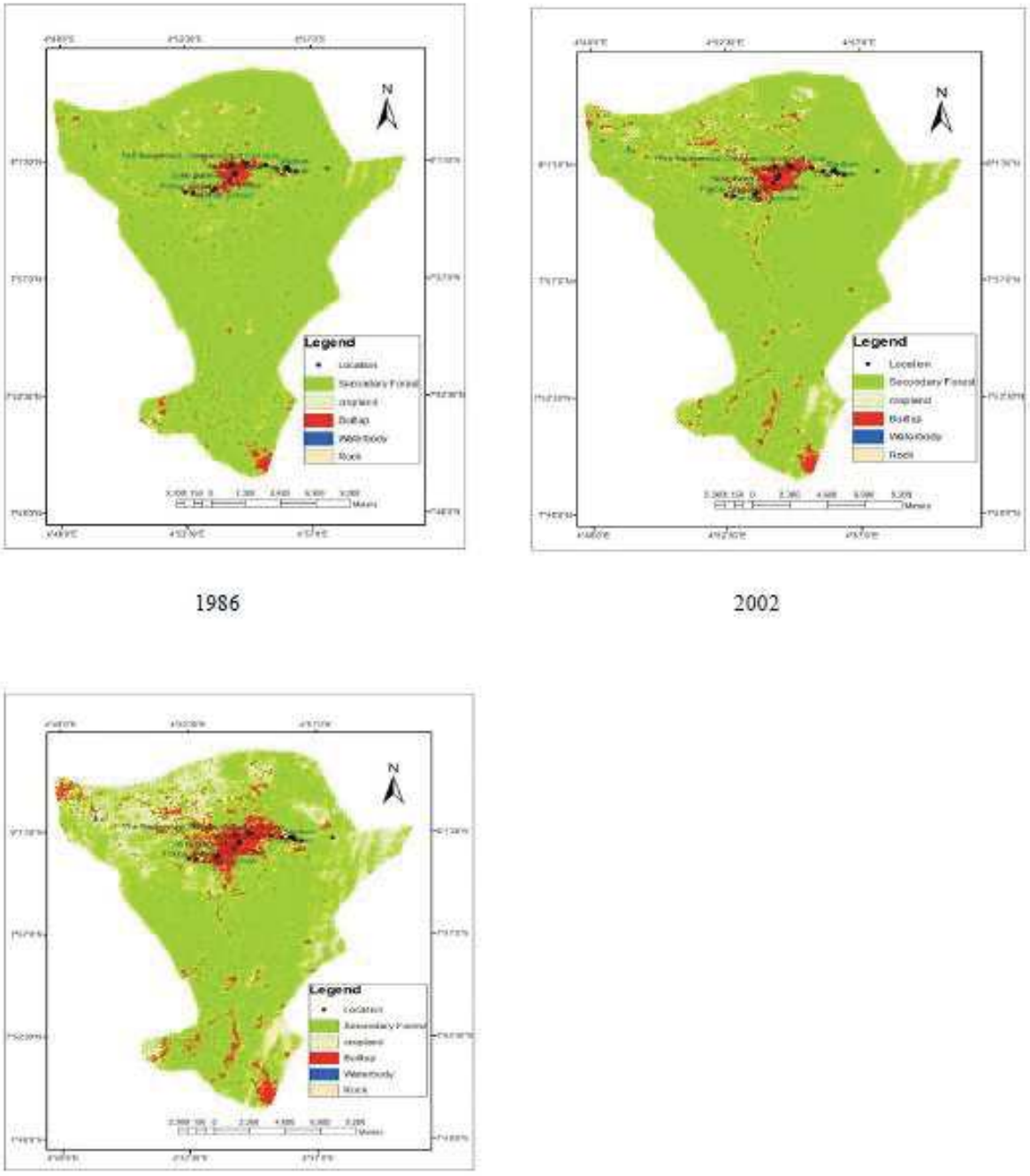

Fig. 2. Land Use/Land Cover Maps of Ila Orangun 1986, 2002 and 2018

Source: Author's own elaboration.

The changes can be attributed to urban development such as expansion of urban settlements, road expansion, population increase, urbanisation, transformation of natural areas to residential and commercial areas, as well as conversion of natural forest to farm land. These results are similar to the findings by Aguda et al. (2013), Ajala and Olayiwola (2014) and Oyinloye and Oloukoi (2013) on changes in land use/cover in urban areas of Nigeria as caused by urbanisation and conversion of vegetation areas to farmlands, roads and built-up areas over the years.

Implication of land use/cover change

Although, forest remained the most dominant of all the land use/cover types in Ila Orangun from 1986 to 2018, there had been a continuous decrease in the areal extent occupied by forest over the period of thirty-two years. A reduction in forest cover suggests the impacts of human activities such as farming, commercial logging and timber extraction, land development for buildings and road construction within the study area. Notably, the rate of deforestation between 1986 and 2002 was rapid, which is an indication that the flora and fauna as well as the ecosystem services supplied to the area has been greatly altered. The environmental effects of rapid forest decline in Ila Orangun include: forest degradation, loss of biodiversity, and reduction in forest carbon sequestration rates, which contributes to local and global climate change. The findings of this study support the observation of FAO (2020) that Nigeria's rainforest vegetation is declining rapidly with loss of genetic diversity of both flora and fauna species due to poor monitoring and management strategies.

The continuous increase in the trend by which land use/land cover classes are converted to built-up areas suggests a continuous demand for more buildings by the growing population within the study area. Likewise, Ajala and Olayiwola (2013) attributed increase in built-up area to increase in spatial extent as a result of population growth, physical growth and development. The results of the trend in cropland (1986-2018), suggest that farming is a predominant occupation in Ila Orangun. The results showed a higher rate of conversion of land cover to cropland than other classes of land cover. During the course of ground truthing activities and reconnaissance survey, it was revealed that many of the farmers are subsistence farmers who practice bush burning and shifting cultivation with the use of local farm tools. Such practices contribute to the alteration of ecosystems and cause ecological imbalance, which is regarded as unsustainable by the FAO (2020). Also, Boratyńska and Huseynov (2017) noted that such agricultural practices need to be improved through provision of modern technologies and improvement of agricultural infrastructure in order to improve food production and achieve sustainable development (Huseynov, 2020). The trend of the changes in the patterns of land use/cover in the Ila Orangun shows that there is need for the adoption of adequate monitoring policies and effective management strategies for ecological balance and sustainability.

Conclusions

Uncontrolled Land use activities are known to cause ecological instability and pose great threat to global food security. This study examined the changes in the pattern of land use and land cover in an urban city in southwestern, Nigeria from 1986 to 2018. It aimed at detecting the extent and rate of changes in land use pattern over a period of thirty two year for proper monitoring and effective planning.

Based on the results of this study, it can be concluded that the pattern of land use/cover in Ila Orangun has changed significantly over the past thirty-two years. The application of RS and GIS for change detection reflects a continuous and drastic decline in forest extent in the study area, which is an indication of disturbance of the ecosystem and depletion of its resources. The rapid expansion of cropland and built-up areas is a reflection of continuous uncontrolled anthropogenic activities due to population increases and urbanisation. With the results obtained from LULC analysis, it is evident that Ila Orangun lacks proper land use

planning and management since there is no official area designated for land development and farming. The practice of shifting cultivation and bush burning by subsistence farmers coupled with continuous rapid increase in cropland areal extent reveals that there is no proper monitoring or strict compliance with the utilization of land that is only designated for farming. The study concludes that the trend of LULC change in the area constitute a major threat to sustainable livelihood, food security and global climate protection.

From the findings of this research, the study recommends that there is need to create a database with regular updates on the changes of land use/land cover. This will provide a baseline for data retrieval which can help monitor the pattern, trend and changes of land use/land cover types for necessary actions. Since forest cover has been identified as a major land cover type that is vulnerable to anthropogenic activities, there is need to monitor land use activities for effective management. And since the majority of people living in Ila Orangun engaged in subsistence farming, there should be drastic measures to curb unsustainable farming practices in the study area. This will reduce ecosystem degradation, ecological resource depletion and ecosystem service deterioration while enhancing sustainable utilization of ecological resources.

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