ANALYSIS OF CHANGES IN LANDUSE AND LANDCOVER IN THE SUBURBAN AREAS OF IBADAN, NIGERIA

BY

Olayiwola, A.M.* and Fakayode, O.

Department of Geography, Obafemi Awolowo University,
Ile-Ife, Nigeria
Corresponding Author's Email: olaadewale1@gmail.com

ABSTRACT

This study analysed the spatial changes in landuse and landcover in the suburban areas of Ibadan, Nigeria between 1986 and 2017. Data were sourced from the National Population Commission (NPC) and Landsat imageries (Landsat 5 MSS/TM, 1986; Landsat 7 ETM+, 2002; and Landsat 8 OLI/TIRS, 2017). Administrative maps of the area were scanned, georeferenced and digitized in ArcGIS environment. Following Anderson's modified version of supervised classification scheme, the imageries were classified into four landuse/landcover classes: built-up, vegetation, exposed surfaces and water bodies. The changes in landuse/landcover for the area were determined by pixel labelling. The period of change analysis was divided into two epochs; 1986-2002 and 2002-2017. Furthermore, a transition probability matrix of landuse change was developed and utilized for assessing the probabilities of other landuses changing to built-up in Markov chain detection method with Cellular Automata. Results of accuracy assessment indicate good image classification (1986, 99.98%; 2002, 99.62%; 2017, 99.21%). Also, results indicate that in the first epoch of study the greatest loss was from vegetation, while very little portions of water bodies and exposed surfaces were converted to other uses. In the second epoch, much of the exposed surface and vegetation were transformed into built-up, while there was no significant transition in the water bodies. Results indicate a future probability of exposed surface and water bodies changing to built-up as higher than that of vegetation. The study concluded that heterogeneous and haphazard land development in the study area was borne out of uncontrolled urban growth. Thus, the study recommends the need for the town planning authorities to be proactive in their duties in order to forestall imminent dangers of shortage of food supply as well as slum and sprawl formation.

Key words: Landuse/cover changes, Markov chain, Physical expansion, Suburban, Transition probability, Trend analysis.

INTRODUCTION

Urban growth combined with urban sprawl, inadequate infrastructure and land use planning are serious challenges in most developing countries. Nonetheless, the importance of human settlements and sustainability of the inhabitants with regards to environmental conditions and orderly use of the urban land cannot be overlooked. The United Nations (2001) corroborated by Herold et al. (2003) revealed that urban areas cover only 3% of the earth's land surface but over half of the world's population now resides in cities. In recent times, it is observed that most of urban development impulses are located at the urban hinterland widely referred to as suburban, peri-urban, suburbs, urban fringe, city edge or metropolitan shadow (United States Census Bureau, 2010; Aguda and Adegboyega, 2013). Suburban area is where urban and rural uses of the land are mixed to form a transition zone between city and countryside. It is an area of transition between well recognized urban land uses and the rural area. The process of suburban development is complex; it involves many concerns such as change in landownership pattern, land transfer process, types of development, regulatory measures and their enforcement (Adell, 1999; Aguda and Adegboyega, 2013; Adedire, 2018).

Human concentration in the urban centres has encouraged continuing studies on urban dynamisms (Gude et al., 2006; Ahmed and Ahmed, 2012; Lin et al., 2012). However, settlements change spatio-temporally with varying patterns and diverse drivers (Wilson et al., 2003; Sevenant and Antrop, 2007; Aguilera et al., 2011; Olayiwola et al., 2014). The temporal and spatial dilemmas created by urban dynamics are unending concerns, and so the study of urbanisation is a living issue that requires constant updating (Ahsan and Islam, 1999). Therefore, literature abounds on urbanisation and expansion of human settlements. The existing literature explored the extent of development, historical antecedents, spatial distribution and organisation, the causal factors and urbanisation problems (Onokerhoraye and Omuta, 1994; Herold, et al., 2003; Adegboyega and Aguda, 2010).

It has also been noted that certain differences do occur in the factors influencing the growth and development of human settlements (Liu et al., 2010). Furthermore, various scholars have identified different patterns of settlement growth (Mabogunje, 1968; Johnson, 1994; Liu et al., 2010). Also, there are abundant studies on changes in settlements' landscape for alternative human settlement patterns. In this regard, the contributions of digital representation to advancement in spatial representational research have been greatly emphasized (Deng et al., 2009; Dewan and Yamaguchi, 2009; Wang et al., 2011; Yin et al., 2011). Akin to the analysis of settlements' spatial patterns is the location of settlements which is determined by a wide range of factors (Oyeleye, 2001; Abolade, 2007; Luck, 2007; Robinson et al., 2012).

The pattern of settlement growth is a unique characteristic of spatial changes that take place in the settlement's built-up areas (Aguilera et al., 2011). Thus, analysis of urban landuse/cover changes; especially the spatiotemporal pattern of urban growth, becomes crucial. Analysing the growth pattern of settlements at different time-scales can be used for effective planning of landuse for maximum utilisation of the land resources (Bhatta, 2010; Liu et al., 2010). In addition, investigating landuse/landcover changes is required in formulating sound viable urban development policies that can lessen the adversative impacts of urbanization and ensure sustainable human settlement development. Also, it enables the understanding of the size and speed of landuse change across various time intervals (Arsanjani et al., 2012; Hettiarachchi et al., 2014). However, inadequate data on spatial growth can limit the process of urban and regional planning and development management (Cheng, 2003; Omwenga, 2010; Estoque and Murayama, 2015; Katyambo et al., 2017).

Several methods and techniques have been developed and applied to quantify and characterize settlement growth processes and patterns, for example visual interpretations of high-resolution aerial photographs. In addition, the advent of land-change science , particularly advances in GIS and remote sensing such as Markov chain analysis, trend analysis and transition probability, have provided platforms to scrutinise landscape transformations across space and time (John and

Xiuping, 2006; Lillesand and Kiefer, 2008; Arsanjani et al., 2013; Estoque and Murayama, 2015). These processes are dynamic simulation-based and statistical-estimation models used to capture the spatio-temporal pattern of urban change through the incorporation of spatial interaction effect in to the analysis of modelling landuse and landcover change (Hu and Lo, 2007). Advancement in and availability of high resolution remote sensing imagery have not only stimulated accurate mapping of urban environments but have also enthused periodic monitoring of urban growth (Mark, 2007; Guindon and Zhang, 2009; Bagan and Yamagata, 2014; Shyamantha et al., 2016).

Ibadan suburb is a contiguous area consisting of many settlements of various sizes which are arranged into six Local Government Areas (LGAs). While some studies have been conducted in the suburban area of Ibadan (Fabiyi, 2006; Agbor et al., 2012; Adebola et al. 2015), less attention is paid to the details of the dynamics of settlements growth to understand their growth pattern. In addition, though there are several studies on each of the LGAs or individual settlements in Ibadan suburb but there is no known published study that incorporates all or, at least, a combination of few of these LGAs or settlements. Furthermore, most of the previous studies relied on just simple change detection techniques which yielded a single estimate of spatial growth between two dates. This does not help much in understanding how and why the growth might have taken place. In addition, this study combined spatio-temporal analysis of landuse/landcover with Markov change detection and Cellular Automata (CA) to examine the variations in the pattern and magnitude of growth in the study area. Therefore, the study analysed the spatial changes in landuse and landcover in the suburban areas of Ibadan between 1986 and 2017 with the view to assessing the growth pattern of the selected section in the suburban areas of Ibadan, Nigeria.

THE STUDY AREA

The study was conducted in selected suburban areas of Ibadan, Nigeria. Ibadan, the capital city of Oyo State, is located in the South-eastern part of Oyo State, Nigeria (Mabogunje, 1968; Fabiyi, 2006). It consists of eleven Local Government Areas (LGAs); five of which constitute the municipal and the remaining six LGAs form the suburb. Based on their proximity of location, three of the six suburban LGAs were selected for this study, these are: Akinyele, Lagelu and Egbeda LGAs (Figure 1). The study area is located between Latitudes 7º 18'N to 7º 42'N; and Longitudes 3º 45'E to 4º 12'E. The National Population Commission of Nigeria (NPC, 2006) revealed that the study area contained 643,587 people spread over a total land area of about 969.08km² (Table 1). The study area consists of Yorubas and other tribes from different parts of the country (Fabiyi, 2006).

The study area falls within the tropical climate characterised by wet season (March to October) and dry season (November to February). While the mean annual rainfall is about 1,260mm, the mean annual temperature is 26.6ºC (Oguntoyinbo, 1994; Oyadiran, 2010). Much of the area is covered by pre-Cambrian igneous and sedimentary rocks. The major soil type is the ferruginous tropical soils (Agboola, 1979; Bankole and Bakare, 2011). In effect of these attributes coupled with intense human activities, the natural vegetation is derived forest (Toyobo et al., 2011). Major economic activities in the study area include farming, trading, public service employment and transport. Though, there are very few modern manufacturing industries in the area, but there are many local craft industries using local materials to produce highly sophisticated items such as farming tools, pottery, woodcarving and blacksmithing. Also, there are sporadic occurrence of calabash carving, textile weaving, dyeing, glass and brass works in the area (Fabiyi, 2006; Bankole and Bakare, 2011; Adelekan et al., 2014).

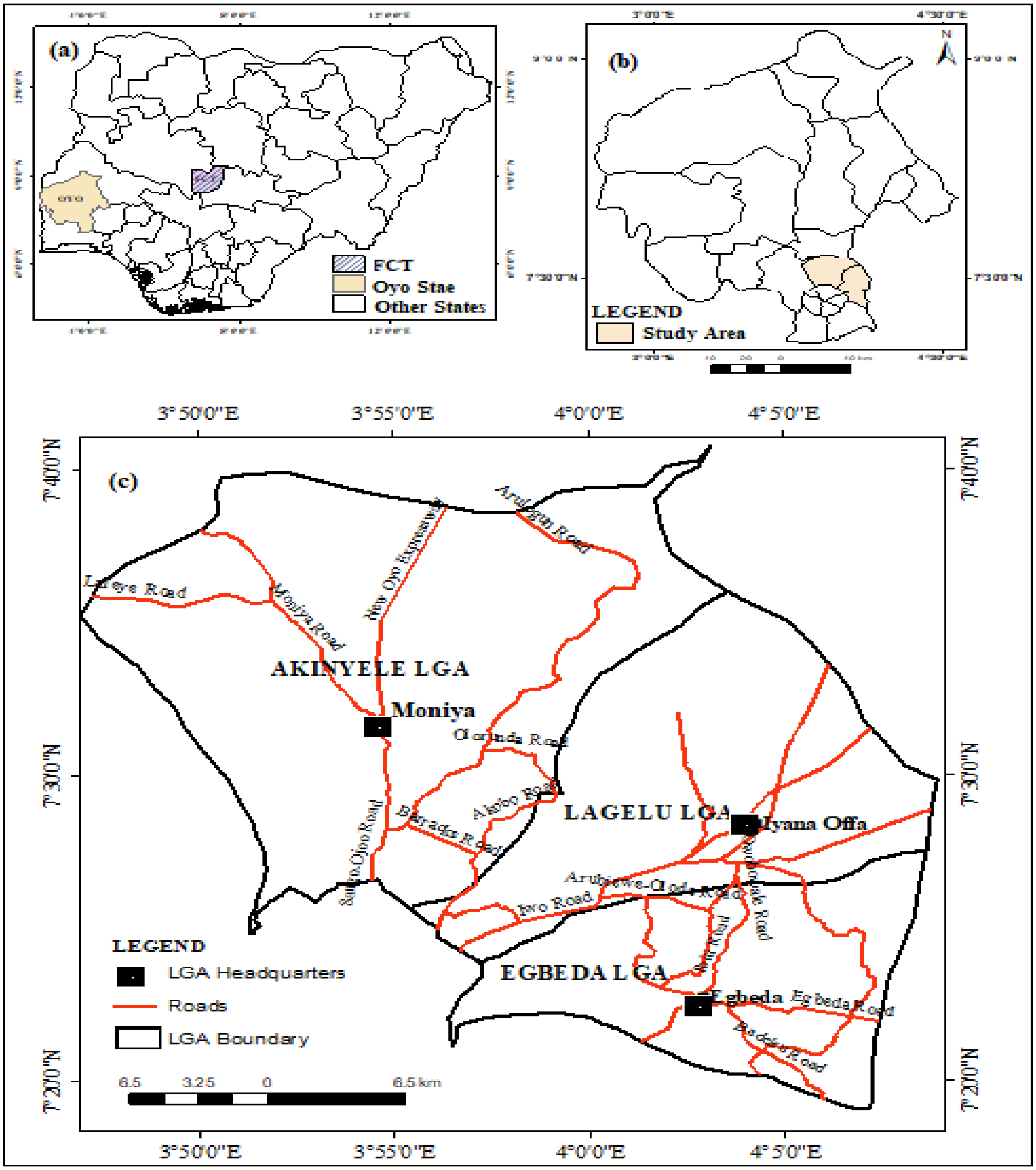

Figure 1: The Study Area: (a) Nigeria (b) Oyo State (c) Study Area
Source: Oyo State Ministry of Lands

Table 1: Size of the Study Area

S/N	L G A	Headquarters	Land Area* (km²)	Population		
				1991**	2006**	2017***
1.	Akinyele	Moniya	514.05	140,118	211,811	294,622
2.	Egbeda	Egbeda	188.33	129,461	283,643	394,538
3.	Lagelu	Iyana-Offa	266.70	68,901	148,133	206,048
		Total	**969.08**	**338,480**	**643,587**	**895,208**

Sources: * Town Planning Departments of Akinyele, Egbeda and Lagelu LGAs
** National population Commission of Nigeria (NPC, 1991; 2006)
*** Projection at 3% annual growth rate (NPC, 2017)

MATERIALS AND METHODS

Population data were used to calculate the consumption rate and landuse coefficients of the study area; and Landsat imageries were used to analyse the spatial extent and rate of urban growth. In addition, Global Positioning System (GPS) receiver was used to obtain geographic coordinates of relevant landmarks for ground validations (Table 2).

Table 2: Types and Sources of Data

Data	Spatial Resolution	Acquisition Years	Path	Row	Source
Administrative Maps	NA	2014	NA	NA	Oyo State Ministry of Lands
Landsat 5 MSS/TM	30m	1986	191	55	http://glcf.umiacs.umd.edu
Landsat 7 ETM+	28.5m	2002	191	55	http://glcf.umiacs.umd.edu
Landsat 8 OLI/TIRS	28.5m	2017	191	55	GLOVIS
Population Data	NA	1991; 2006	NA	NA	National Population Commission, Ibadan

Hardcopies of the administrative maps of the selected LGAs were scanned, georeferenced and digitized to make them available for further analysis within GIS software environment. However, all the imageries used were already geo-referenced and geometrically corrected, thus, they were just projected. The portion covered by the study area was extracted using clip tool in ArcGIS 10.5. Also, visual interpretability of the imagery was improved through imagery enhancement, contrast stretching and false colour composites. Furthermore, the imageries were classified into landuse/landcover classes following Anderson (1971) modified version of supervised classification scheme. Moreover, accuracy assessment was conducted to ensure the level of accuracy and quality of the classification exercise (Foody, 2002; Herold et al., 2003; Hai and Yamaguchi, 2008; Lillesand and Kiefer, 2008). Accuracy of the classification was assessed using 100 randomly sampled ground truth points.

The changes in landuse/landcover for the area were determined by pixel labelling of Landsat imageries. Therefore, the Landsat imageries were classified into four feature classes, namely: built-up area, vegetation, exposed surfaces and water bodies using maximum likelihood classification algorithm supervised classification technique (Table 3). The built-up area class which characterizes the settlement areas were carved out from the classified imageries and mapped to display the nature of changes in 1986, 2002 and 2017 (Herold et al., 2003; Hai & Yamaguchi, 2008).

Table 3: Classification of Landuse/cover in the Suburban Area of Ibadan

S/N	Classes	Land use/cover
1.	Built-up Area	Residential, commercial and services, transportation, communications, utilities, industrial and commercial areas
2.	Vegetation	Farmland, plantation, natural vegetation and all other green spaces
3.	Exposed surface	Sandy areas, bare/exposed rock, earth surfaced roads, transitional areas and all non-green open spaces.
4.	Water Bodies	Rivers, streams, lakes, and reservoirs.

Source: Adapted after Anderson (1971)

Due to data availability, the period of change analysis was divided into two epochs; first and second epochs. While the first epoch spanned over sixteen years (1986-2002), the second epoch covered a period of fifteen years (2002-2017). Nonetheless, the difference of one year between the spanning periods of the two epochs is not expected to have significant effect on the results of the study. The resulting landcover maps were compared and areas that were not classified as the same at different times were regarded as changed areas (Veldkamp and Lambin, 2001; Yang and Lo, 2002; Allen and Lu, 2003; Hu and Lo, 2007; Alphan et al., 2009). Furthermore, a transition probability matrix of landuse change was developed and utilized in a Markov chain detection method. However, Agbor et al. (2012) corroborated by Bayes (2013) noted that the transition probability may be accurate on a per category basis, but may be inadequate in analysing spatial distribution of occurrences within each landuse category. Therefore, to overcome this lapse, the present study complemented the analysis with Cellular Automata (CA).

RESULTS AND DISCUSSION

Image Classification and Accuracy Assessment

The overall accuracies of the classification for 1986, 2002 and 2017 are 99.98%, 99.62% and 99.21%, respectively (Table 4). These values indicate that there were high significant agreements between reference points and the extracted classes. Herold et al. (2005) considered accuracy assessment level of, or above 85% as a good result for remote sensing image based analysis. Thus, accuracy assessment values of the imageries used in this study indicate good image classification.

Table 4: Image Classification Accuracy Assessment

Class Name	1986 Pa; $\mathcal{U}a$	2002 Pa; $\mathcal{U}a$	2017 Pa; $\mathcal{U}a$
Built-up	100.00; 100.00	100.00; 95.36	99.80; 99.49
Vegetation	100.00; 100.00	99.71; 99.96	98.93; 100.00
Exposed Surfaces	99.30; 98.87	97.35; 94.99	100.00; 48.96
Water bodies	96.58; 97.50	94.01; 100.00	100.00; 100.00
Kappa Statistics ($\mathcal{K}$)	0.9972	0.9748	0.9829
Overall Accuracy	99.98%	99.62%	99.21%

Sources: Landsat TM, 1986; ETM+, 2002 and OLI/TIRS, 2017 (Path 191 Row 55)

Physical Changes in the Suburban Areas of Ibadan

Table 5 shows the distribution pattern of landuse/landcover of the study area. Throughout the study period, vegetation occupied the highest portion of the area (78.89% in 1986; 74.84% in 2002; and 49.63% in 2017). Exposed surfaces recorded a dwindling coverage at 12.16% in 1986, 12.28% in 2002 and 24.87% in 2017. Also, the built-up area occupied 8.82% of the area in 1986, 12.71% in 2002 and 25.30% in 2017. The total built-up area in 1986, 2002 and 2017 were 85.484km², 123.173km² and 245.099km², respectively (Table 5). Water bodies covered the least area of 0.13% in 1986, 0.17% in 2002 and 0.20% in 2017.

Table 5: Summary of Landuse/Landcover Statistics for 1986, 2002 and 2017

LULC	1986		2002		2017	
	Area (km²)	**%**	**Area (km²)**	**%**	**Area (km²)**	**%**
Built up	85.484	8.82	123.173	12.71	245.099	25.30
Vegetation	764.485	78.89	725.210	74.84	480.910	49.63
Exposed Surfaces	117.815	12.16	119.092	12.28	241.101	24.87
Water bodies	1.299	0.13	1.608	0.17	1.973	0.20
Total	**969.083**	**100**	**969.083**	**100**	**969.083**	**100**

Sources: Landsat TM, 1986; ETM+, 2002 and OLI/TIRS, 2017 (Path 191 Row 55)

These results confirmed certain assertions in the literature that suburban areas of large metropolis exhibit significant levels of land use change (Arsanjani et al., 2013; Adedire, 2018). A comparison of the results obtained from the computed output for the 31 years indicates an overall increase in the built-up areas (1986, 2002 and 2017 were 85.484km², 123.173km² and 245.099km²). However, it should be noted that urbanisation of the low density areas and along the urban-rural interface entails simultaneous processes of land conversion from natural landscape to human development, and increased population (Bhatta, 2010; Bankole and Bakare, 2011; Aguda and Adegboyega, 2013; Katyambo and Ngigi, 2017). Therefore, persistent increase in the built-up areas might be due to the increase in population within this period thereby leading to competition for space and huge encroachment into available lands for accommodation and economic activities. Over the years, the expansion increased outwardly from the metropolis to the hinterland taking over vegetation area and part of the exposed surfaces. On the whole, the expansion trends specify that the area is losing vegetation to development activities. These expansion trends could adversely affect the eco-environment of Ibadan suburban if not controlled.

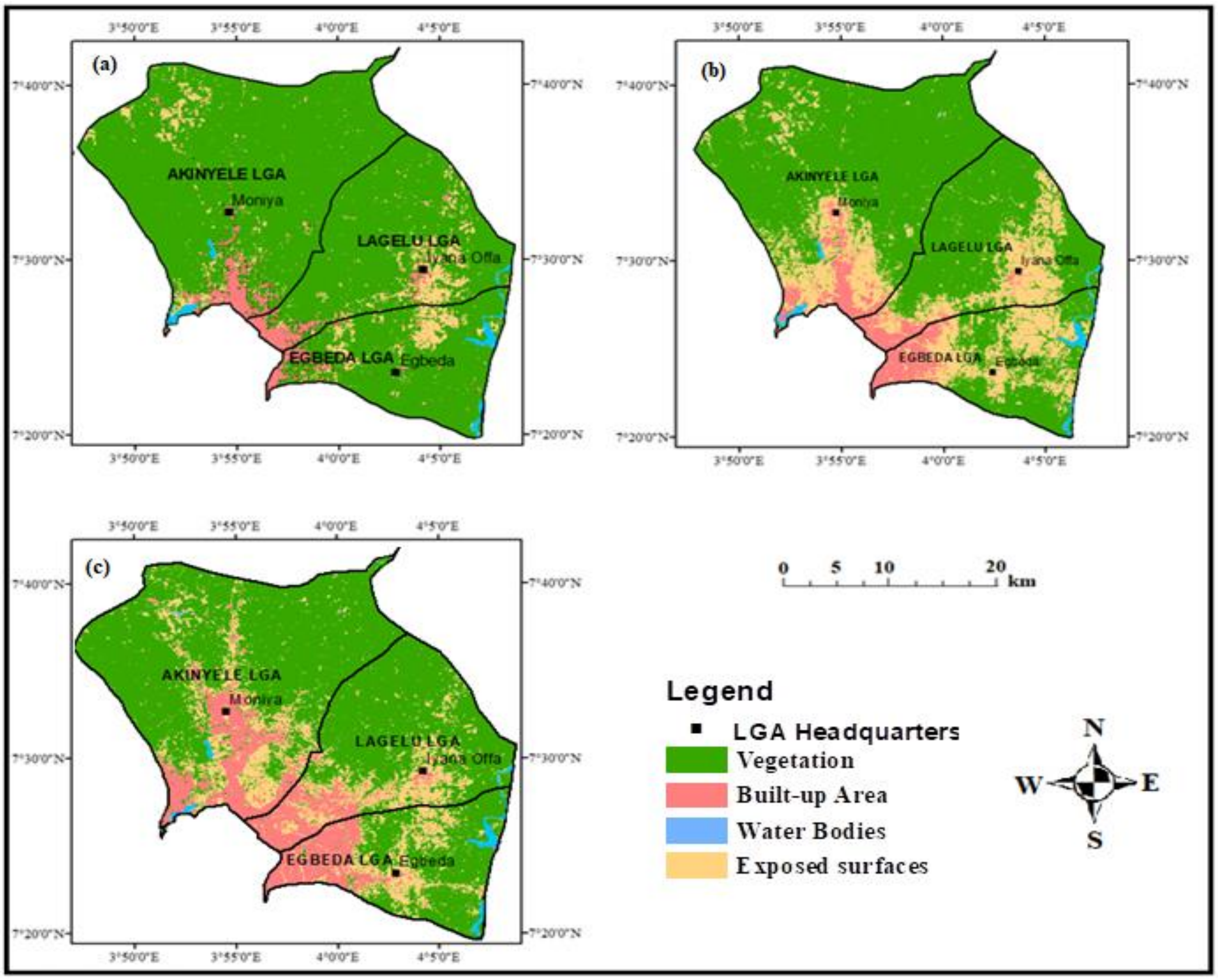

Figure 2: Landuse/landcover of the Study Area: (a) 1986 (b) 2002 (c) 2017
Sources**:** Landsat Imageries (Path 191 Row 55): TM 1986; ETM+ 2002; OLI/TRI 2017

In most of the previous studies relating to landuse and landcover changes, the general pattern has been that the conversion of natural landcover to other uses will continuously lead to losses in the extent of natural landscapes (Fabiyi, 2006; Abolade, 2007; Adegboyega and Aguda, 2010; Ahmed and Ahmed, 2012; Olayiwola et al., 2014; Estoque and Murayama, 2015). The present study indicated that intense human activities could alter the rate and magnitude of land uses. This study showed declines in vegetated area and dwindling changes in water bodies due to channelization of water ways and rehabilitation of dams within the study area. Also, there were small gains in exposed surfaces (12.16% in 1986, 12.28% in 2002 and 24.87% in 2017). This may not be unconnected with clearing of the natural vegetal covers to give room for farming.

Figure 2 shows that the expansion increased outwardly from the metropolis to the hinterland taking over vegetation area and part of the exposed surfaces. There is significant loss in the portions of vegetation to built-up areas and exposed surfaces (Figure 2).

Changes in Landuse/Landcover in the Study Area

Table 6 shows that the probabilities of changes in the landuse/landcover indicate that between 1986 and 2002, the probability of vegetation changing to built-up was 0.0748 (7.48%). Also, the probability of exposed surface changing to built-up between 1986 and 2002 was 0.2638 (26.38%). Table 6 shows further that between 2002 and 2017, the probabilities of other landuses changing to built-up area were: vegetation (0.1089; 10.89%); water (0.1250; 12.5%); and exposed surfaces (0.4425; 44.25%). At both epochs of analysis, exposed surfaces had the highest probability of changing to built-up.

Table 6: Transition Probability, 1986 to 2017

Class Name	Built-up		Vegetation		Water		Exposed Surface	
	1986 to 2002	2002 to 2017	1986 to 2002	2002 to 2017	1986 to 2002	2002 to 2017	1986 to 2002	2002 to 2017
Built-up	0.7149	0.9133	0.0718	0.0096	0.0006	0.0000	0.2127	0.0770
Vegetation	0.0748	0.1089	0.8423	0.6482	0.0003	0.0003	0.0827	0.2427
Water	0.1355	0.1250	0.0961	0.0000	0.6504	0.8750	0.1180	0.0000
Exposed Surface	0.2638	0.4425	0.3790	0.0505	0.0061	0.0017	0.3511	0.5052

Sources: Landsat TM, 1986; ETM+, 2002 and OLI/TIRS, 2017 (Path 191 Row 55)

Table 7 shows that whereas much of the exposed surface was later transformed into built-up in the second epoch of the study; there was no significant transition in the water bodies. Also, vegetation transitioned to built-up area by 30.65km² between 1986 and 2002 and 77.39km² between 2002 and 2017. On the whole, the spatial changes within the study area show significant landscape transitions during the study period.

Table 7: Landuse / Landcover Transition for Built-up Class (in km²)

S/N	1986-2002	2002-2017	Legend
1.	30.65	77.39	Vegetation to built-up
2.	22.35	52.30	Exposed surface to built-up
3.	0.10	0.16	Water bodies to built-up

Sources: Landsat TM, 1986; ETM+, 2002 and OLI/TIRS, 2017 (Path 191 Row 55)

Table 8 shows the percentage gains of the built-up class and losses for other landuses in the study area between 1986 and 2017. In the first epoch, the built-up area gained 38.33% in addition to the existing area covered before 1986; other landuses and landcover lost 11.11% within the period. This may not be unconnected with one of the major human occupation in the study area whereby the natural vegetal covers were cleared to give room for farming. Also, the gain was as a result of clearing the water ways and rehabilitation of dams within the study area. However, 50.57% of the total land area remained persistent in use (Figure 3). In the second epoch, the percentage gain of the built-up area was 51.33% as against 38.33% gained in the previous epoch. While the other landuse classes lost only 3.2% in this period, there was retrogression in the persistent land uses. Therefore, the incremental percentage change in the built-up area was gained from the losses of the persistent land uses.

Table 8: Percentage Gains and Losses of Landuses/Landcovers

Changes	1986 to 2002		2002 to 2017	
	km²	%	km²	%
Gains (by the built-up class)	53.1027	38.3	129.8664	51.3
Losses (of other landuses)	15.3882	11.1	8.0487	3.2
Persistence	70.0623	50.6	115.1109	45.5

Sources: Landsat TM, 1986; ETM+, 2002 and OLI/TIRS, 2017 (Path 191 Row 55)

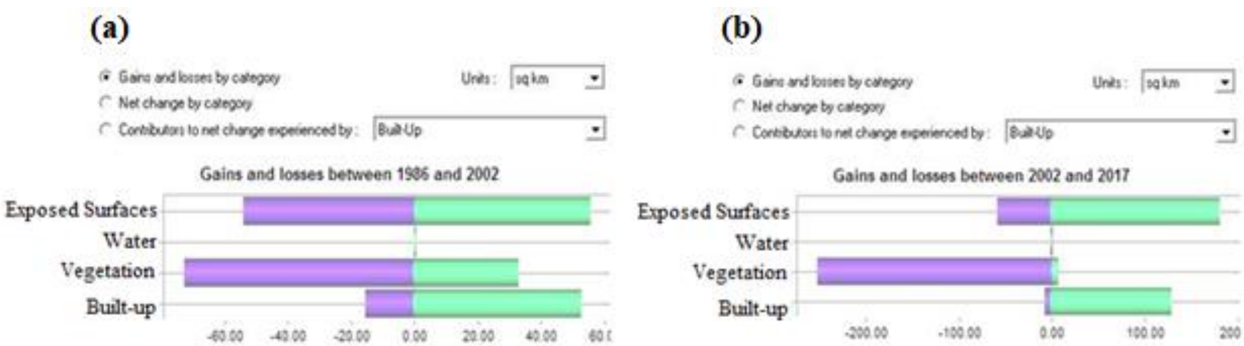

Figure 3: Gain and losses of LULC between: (a) 1986 and 2002 (b) 2002 and 2017
Sources: Landsat TM, 1986; ETM+, 2002 and OLI/TIRS, 2017 (Path 191 Row 55)

Most landuse change models do not create spatially explicit predictions of urban growth. However, such dynamic models as Markov change detection and Cellular Automata (CA) provide abilities to simulate possible urban growth under various planning and management situations. Therefore, whereas many of the previous studies used simple change detection method to estimate spatial growth between two dates, this study explored the usefulness of Markov change detection and Cellular Automata (CA) to examine the variations in the pattern and magnitude of growth in the study area. This produced probabilities of the transition patterns of land uses in the suburban area of Ibadan. Results indicate that probability of exposed surface changing to built-up is higher than probability of vegetation changing to built-up. Also, the probability of water body changing to built-up depicts that with time part of the water body might be converted to built-up class. In a similar case study in Ibadan Northwest Local Government Area of Oyo State, Nigeria, Adebola et al. (2015) found that maximum change occurred from wetland to bare surfaces and minimum change from thick vegetation to water body. Also, they observed that the built up area is the most consistent land cover type because it has the highest probability value. This contradiction could be as a result of differences in the study locations; the study of Adebola et al. (2015) was conducted in the core area of Ibadan with thicker population and more buildings than the present study area.

CONCLUSION

This study presented a remote sensing approach that allowed a separation of landuse categories and descriptions of its temporal changes. The spatiotemporal analyses of the growth pattern in the suburban area of Ibadan showed that the area is rapidly urbanising which could be as a result of ever increasing population. In effect, large proportions of vegetation and other landuses have been transformed to built-up areas at both epochs of the study. However, urban growth was rather uncontrolled resulting in heterogeneous and haphazard land development. This may pose serious threats to the inhabitants especially creating water shortages and development of squatters which may lead to the formation of slums and sprawls. In addition, the productive agricultural lands are being threatened, particularly around the fringes of the built-up areas.

From the foregoing, it is recommended that government should be sensitized to utilize the capabilities of Remote Sensing and Geographic Information Systems in policy and decision making relating to landuse and landcover changes. By so doing, the planning authority will be able to carry out regular urban audit on landuse changes which can be used to determine the trend and direction of development. In addition, the study recommends the need for the town planning authorities to be proactive in their duties in order to forestall imminent dangers of shortage of food supply as well as slum and sprawl formation. Also, the town planning authorities should be proactive and stop approving building plans without proper assessment of the areas intended to be developed. This will help in mitigating haphazard growth of the study area. Also, it will serve as a check to the complex implications of with urban growth problems like urban food crisis, poor accessibility, sprawl development at the fringe and other environmental problems that may be imminent.

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