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EVALUATION OF URBAN EXPANSION AND VEGETAL COVER LOSS IN IKORODU, NIGERIA

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ABSTRACT

There is no city anywhere in the world that is static as far as urban expansion is concerned. This explains why lkorodu which was one of the fringes of Lagos in 1987 is now completely integrated into Lagos as a mega city in 2017. One of the effects of this expansion is vegetation loss and its attendant ecosystem disequilibrium. The aim of this paper is to analyze urban expansion and loss of vegetation cover in Ikorodu, Lagos state. This study used techniques of Remote Sensing and GIS to identify the rate of urban expansion and the degree of vegetal loss using the Landsat imageries of 1987, 1997, 2007 and 2017. The maximum likelihood classification algorithm in Idrisi Selva software was used to extract three major land cover classes (i.e. Built up, Vegetation and Water body). The average rates of change were elicited for each of the land cover types. Vegetation had diminished from 341.6 km^2 (92.91%) in 1987 to 191.6 km^2 (52.09%) in 2017. Conversely, built-up areas had increased from 16.90 km^2 (4.60%) in 1987 to 171.0 km^2 (46.51%) in 2017. Water body reduced from 9.163km^2 (2.49%) in 1987 to 5.12 km^2 (1.39%) in 2017.The correlation analysis showed that city expansion is majorly dependent on road network distribution pattern. Judging from the rate at which vegetation is depleting in the study area, the city may rapidly deplete almost all her vegetation cover if control measures are not put in place. It is recommended therefore, that urban planning institutions should be strengthened to properly plan and monitor urban expansion of the study area. Secondly, the State Department of Environments and other relevant agencies should as a matter of urgency, start working in concert with planners to establish urban greenery as mitigating measure against vegetation loss in the area.

Keywords: Urban; expansion; cities; vegetation; environment; greenery

Introduction

The multi-directional growth of a city and its fringes toward non-built-up areas can be termed urban expansion. Urbanization is the process that refers to the growth both in size and numbers of urban centres (Dahal *et al.*, 2017). This accelerated growth has been monumental from the beginning of the 20th century (Ifatimehin and Musa, 2006), especially in developing countries such as Nigeria. It is imperative to deduce that urban sprawl is predicated on anthropogenic activities amongst other factors. Increase in population over time, results in sprawling development that consequently manifest in form of socio- economic, health and environmental challenges that are very prevalent in all emerging urban centres (Bayan *et al.*, 2011; Zhao *et al.*, 2016). These drawbacks also reflect in the poor physical planning of Ikorodu as an integral part of a megacity. The negligence of urban planners to properly situate peri-urbanization landscape during land use planning decisions at various levels, can accentuate future unsustainable land use changes (Grimm *et al.*, 2008, Araya and Cabral, 2010). The environmental implications of rapidly growing urban areas are unquantifiable, they partly manifest by consistent displacement of agricultural land and vegetal loss in the peripheral areas of cities by residential and manufacturing layouts (Ujoh *et al*., 2011, Martellozo *et al*., 2014). Looking at urban expansion from global perspectives, Angel (2005) revealed that in the year 2000, urban built-up area in the world consumed about 400,000 square kilometers, which amounted to about 0.3% of the total land area of the world. He projected that by 2030, about 1,100,000 square kilometers (about 0.85%) shall be urbanized if the same growth rate is maintained (Angel, 2005 and Ajayi, 2018).

Theoretically, this work study is premised on Hoyt Homer's Sector Model based on the assumption that common low-income households are usually found near railroad lines, and commercial establishments. In 1939, Hoyt modified the concentric zone model to account for major transportation routes. He postulated that most major cities evolved around the nexus of several important transport facilities such as roads, railroads, sea ports, and trolley lines that emanated from the city's center. Hoyt theorized that cities would tend to grow in wedge-shaped patterns, or sectors, emanating from the Central Business District (CBD) and centered on major transportation routes (Hoyt, 1939).

Deforestation rate or loss of vegetation in Nigeria is about 3.5 percent which implies a loss of 350,000– 400,000 hectares per annum. Between 1990 and 2005 alone, Nigeria lost 21% of her forests (Ladipo, 2010). The depletion of vegetal cover adversely affects various ecosystems by way of biodiversity loss, wildlife habitat, food supply, medicinal herbs, pollution, erosion and drought. Urban vegetation is an integral part of a whole gamut of sustainable development, environmental conservation and urban planning process of a city (Rahman, 2009). The destruction of urban vegetation such as botanical gardens, public schools, homestead gardens, public parks, vegetation around government offices, cemeteries and playgrounds is traceable to infrastructural development (Rahman, 2009).The importance of vegetation in the environment cannot be underestimated when considered against the backdrop of the role it plays as a major carbon sink, microclimate moderation and for aesthetic (Ige, *et.al*,.2017).Urban vegetation also absorbs heat and makes the day cooler, as well as provides shades to pedestrians. A tree can remove 26 pounds of carbon dioxide from the atmosphere per year which is equals to 6,835km of car emissions (Van Boummel *et al*., 2006; Relf, 2009).

In recent times, geospatial technologies (Remote Sensing and Geographic Information System) have proven to be the most cost effective and time-saving tools for monitoring land use/cover change at large spatial and temporal (Kwarteng and Small, 2010; Agbor *et al*, 2012; Hui and Yonghong, 2012; Gamba, 2014 and Shao *et al*., 2017). Remote Sensing and GIS have brought synergistic relationships amongst numerous disciplines as it relates to both spatial and statistical data analysis. Remote Sensing helps in acquiring multi spectral spatial and temporal data through space borne remote sensors while image processing technique helps in analyzing the dynamic changes associated with the earth resources such as land and water using remote sensing data (Mohd *et al*., 2011).

Therefore, this study attempted to map the status of land use land cover change (LULCC) of Ikorodu, Lagos State over a 30-year period (1987-2017) to estimate the rate of vegetal cover loss because of urban expansion. The study would also attempt to investigate some key driver variables of expansion apart from the increase in population of the study area.

Materials and Methods

The Study Area

Ikorodu is one of the Local Government Areas on the outskirts of Lagos Metropolis

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(Fig 1). It is between longitude 3°.43' and 3°.70' W and latitude 6.53' and 6.68'N of the equator. It is bordered in the east by Epe and west by Kosofe Local Government Areas, in the south by the Lagos lagoon, and towards the north by Ogun State. It spans across an area of about 396.5km^2. Ikorodu was created in 1968 as one of the administrative divisions of Lagos State. Upon creation, farming, fishing and trading were the mainstay of the early inhabitants of the area. In sequel, several hectares of land were set aside for farming activities. The population grew from 184,674 in 1991 to a projected (annual growth rate of 8.84%/year) population of 910,466 in 2017 (Lagos State Bureau of Statistics, 2017). Ikorodu has a tropical climate with an average temperature of about 26.9°C and an annual rainfall of about 1670mm. Geologically, Ikorodu is directly underlain by the Benin Formation which consists largely of sands/ sandstones with lenses of shales and clays (Obiora, 2005)

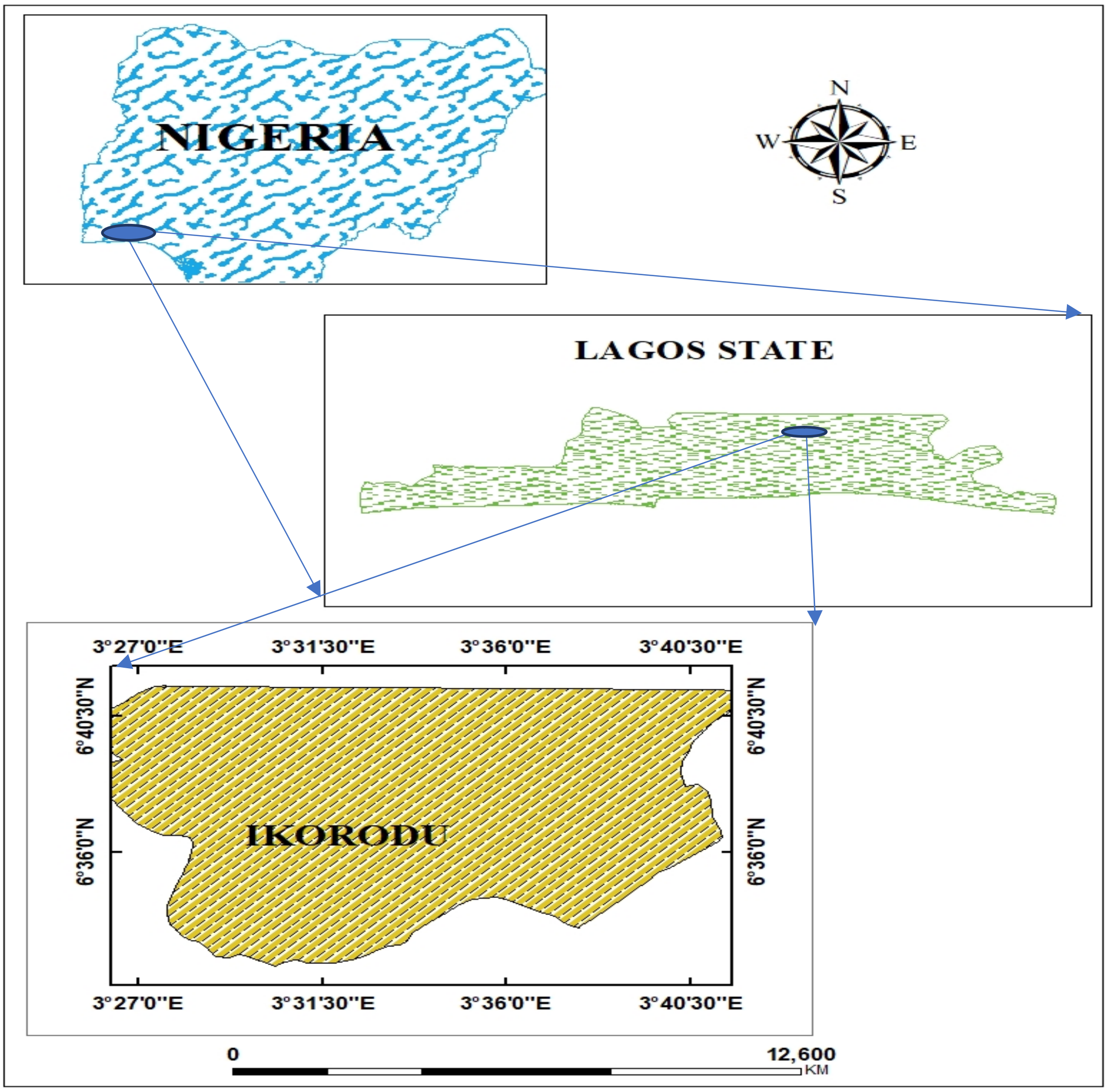

Figure 1: Map of the study area.

Materials

Data used and source

Landsat satellite images of the study area for 1987, 1997, 2007, 2017 and Shuttle Radar Topography Mission (SRTM) image were obtained from USGS Earth Explorer official website. Another important data used is the road network of the study area (Extracted from Google Map).

Table 1: Data and their sources

S/N	Data Type	Source	Path/Row	Resolution	Date of Captured
1	Landsat (TM) 1987	http://earthexplorer.usgs.gov/.	191/55	30m	02/01/1987
2	Landsat (TM)1997	http://earthexplorer.usgs.gov/.	191/55	30m	17/02/1997
3	Landsat (TM+)2000	http://earthexplorer.usgs.gov/.	191/55	30m	04/12/2007
4	Landsat (OLI)2017	http://earthexplorer.usgs.gov/.	191/55	30m	03/03/2017
5	SRTM	http://earthexplorer.usgs.gov/.		30m	05/07/2015
6	Road network of Lagos	Extracted from Google Map by the Author	-	-	05/05/2017

Software used

(i) ArcGIS 10.5 software (ESRI) was used to generate various thematic layers.
(ii) Idrisi Selva (Clark Lab) was used do all raster related image analysis.
(iii) Microsoft Office package came very handy for the correlation analysis and the presentation of the work.

Image processing

Geometric rectification is critical for producing spatially corrected maps of land use/cover changes through time. The Landsat TM, ETM+ and OLI images were in UTM projection (Zone 31N) on WGS84. Therefore, the images of the study area were geometrically corrected. The color composites for the four images were generated from Landsat TM, ETM+ and OLI bands 2, 3, 4, 5 and 7. These color composites were selected to assist in the selection of training sites for classification purposes. Supervised classification has been widely used in remote sensing applications (Ojigi, 2006; Kwabe, 2010; Omo-Irabor, 2016). The images were classified using supervised classification i.e. maximum likelihood classifier algorithm. This is because it provides a consistent approach to parameter estimation problem. It can be applied in reliability analysis to censored data. From the classified images, the land use/land cover (LULC) maps were extracted and the requisite statistics generated thereafter. The classification scheme utilized only three land use classes representing built-up area, vegetation and water body. The post interpretation phase included preparation of land use maps and detection of their changes. A greater part of the analysis was predicated on the post-classification comparison approach. It was employed for analyzing land use/cover changes, by comparing independently produced classified land use/cover maps. The main advantage of this method is that it has capability to provide descriptive information on the nature of changes that occurs (Mundia and Aniya, 2005; Alboody *et al.*, 2008). The stepwise processing scheme used in this study is as shown in Figure 2.

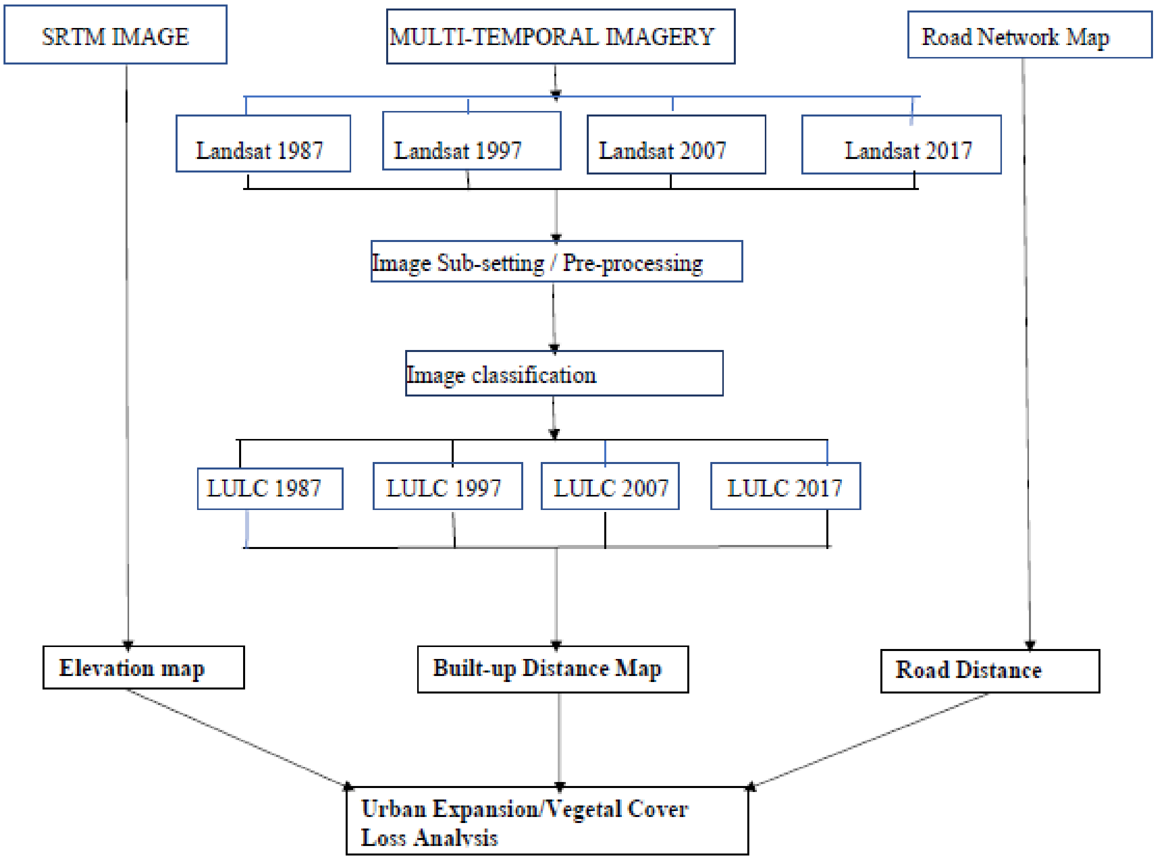

Figure 2: Flowchart of urban expansion/vegetal cover loss analysis.

Average Rate of Change

The average rate of change describes the rate at which one quantity is changing with respect to something else changing. In other words, it calculates the amount of change in one item divided by the corresponding amount of change in another item (Adams, 1995).

Average rate of change (ARC) $= \frac{f(x)-f(a)}{(x-a)}$

Where:

f(x) – f(a) = the change in the function “f” as the input changes from “a” to “x”

x – a = the change in the input of the f function.

Correlation Analysis

Most of the changes in land use land cover depend on certain factors like roads, commerce, topography, population etc. (Xiangmei et al 2016). This study considered the contributions of roads and elevation to expansion rate of Ikorodu over the years. Variables used in the model include: slope, distance from built up areas, distance from forest areas, and distance from road. Distance maps of these drivers including that of built area were produced using existing road map, the DEM image and LULC maps. Euclidean distance algorithm was used to calculate the distance maps. Distance from built up areas was considered dependent variable while all other variables were considered independent variables. (IDRISI Selva Manual, 2012) correlation analysis was carried out to assess the degree of relationship among the variables.

Results and Discussions

Analysis of Land Use Changes and Dynamics of Urban Expansion

The urban change analysis is based on the statistical data extracted from the three-different land use and land cover maps of the classified images (Figures 2, 3, 4, 5). As at 1987, vegetation accounted for the largest land cover type in Ikorodu which is 341.6 km^2, representing 92.91% of the total land cover of the study area while built-up area was 16.9 km^2 (4.6%) of the total land cover. By 2017, the land cover had changed tremendously consequent upon accumulated anthropogenic activities. Vegetation had diminished from 341.6 km^2 (92.91) in 1987 to 191.6 km^2 (52.09%) in 2017. Conversely, built-up areas had increased from 16.90 km^2 (4.60%) in 1987 to 171.0 km^2 (46.51%) in 2017. Water body reduced from 9.163km^2 (2.49%) in 1987 to 5.12 km^2 (1.39%) in 2017

.Table 2: LULC Distribution of Ikorodu in 1987, 1997, 2007 and 2017

LULC	1987		1997		2007		2017	
	AREA	%	AREA	%	AREA	%	AREA	%
VEGETATION	341.6	92.91	326.1	88.69	311.0	84.59	191.6	52.09
BUILT_UP	16.90	4.597	32.37	8.803	48.92	13.31	171.0	46.51
WATER	9.163	2.492	9.195	2.500	7.745	2.107	5.121	1.393
TOTAL	367.7	100	367.7	100	367.7	100	367.7	100

Using the average rate of change from 1987 – 2017 it was observed (Table 3) that vegetation as a land cover reduced at an average rate of 7.5 km^2 (1.36%) per year in a 30-year period. It also explains the average rate of increase of the built-up area which was increased at an average rate of 5.14 km^2 (1.40%) per year. This connotes a very high rate of urban expansion in Ikorodu (Agbor and Makinde 2017)

Table 3: Comparison of area and rates of change of LULC between year 1987 - year 2017.

LULC	1987		1997		2007		2017		AVERAGE RATE OF CHANGE (1987-2017)	
	AREA	%	AREA	%	AREA	%	AREA	%	Km^2/yr	%/yr
VEGETATION	341.6	92.91	326.1	88.69	311.0	84.59	191.6	52.09	-7.5	-1.36
BUILT_UP	16.90	4.597	32.37	8.803	48.92	13.31	171.0	46.51	5.14	1.40
WATER	9.163	2.492	9.195	2.500	7.745	2.107	5.121	1.393	-0.13	-0.04
TOTAL	367.7	100	367.7	100	367.7	100	367.7	100		

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Table 4: Differences in LULC: Area/Percentage gained (+) or lost (-) between year 1987 - year 2017.

LULC	DIFF (1987-1997) (+ gain, – loss)		DIFF (1997-2007) (+ gain, – loss)		DIFF (2007-2017) (+ gain, – loss)	
	AREA	%	AREA	%	AREA	%
VEGETATION	341.6-326.1 (-15.50)	92.91-88.69 (-4.22)	326.1-311.0 (-15.10)	88.69-84.59 (-4.1)	311.0-191.6 (-119.40)	84.59-52.09 (-32.5)
BUILT_UP	16.9-32.37 (+15.47)	4.60-8.80 (+4.21)	32.37-48.92 (+16.6)	8.80-13.31 (+4.51)	48.92-171.0 (+122.08)	13.31-46.51 (+33.2)
WATER	9.16-9.20 (0.032)	2.5-2.5 (0)	9.20-7.75 (-9.55)	2.50-2.11 (0.39)	7.75-5.12 (2.624)	2.11-1.39 (0.71)

The vegetation loss (Table 4) was 4.22% between 1987 and 1997 and rose to 32.5 % between 2007 and 2017. This is traceable to a rapid urban expansion. About 4.21% of other land cover types transitioned to Built-up areas between 1987 and 1997 and further increased to 33.2% between 2007 and 2017.

The total difference of loss in vegetal cover between 1987 and 2017 is about 28.28 % while the total gained by built up area between 1987 and 2017 (30year period) is 28.99%. This further validates the fact that what was lost in vegetation was gained by built-up.

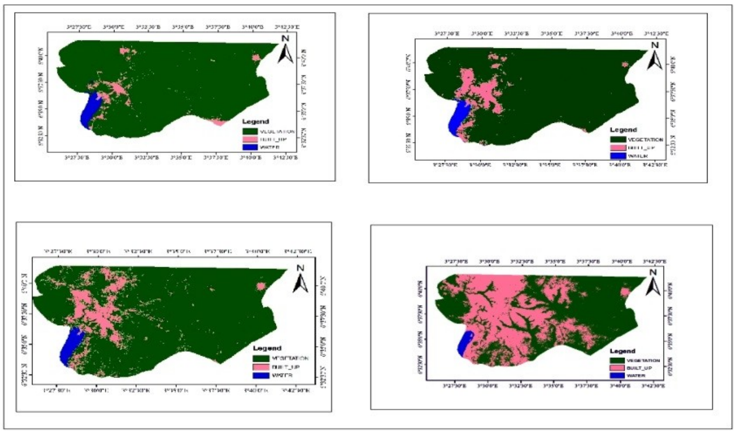

Figure 3: LULCC map between 1987 and 2017

Land Use Land Cover Change variables

The variables considered responsible for observed changes in land use pattern between 1987and 2017are represented in figure 3. The degree of association between the dependent variable and the independent variables is given in table 5. The correlation matrix shows the relationship between roads and built-up is very strong (R = 0.78) and that of elevation is (R = 0.73). This indicates that accessibility to urban facilities and services and the topography generally favoured construction and other activities that must have led to Ikorodu expansion rate. Road with a higher value could be considered as a more influencing factor. It is pertinent to state the urban renewal agenda of both Governors Ahmed Tinubu and Babatunde Fashola between 1999 and 2015 precipitated the massive construction of roads in both urban and peri-urban areas of Lagos State. These roads in no small measure have accelerated the rate of urban sub-urban expansion

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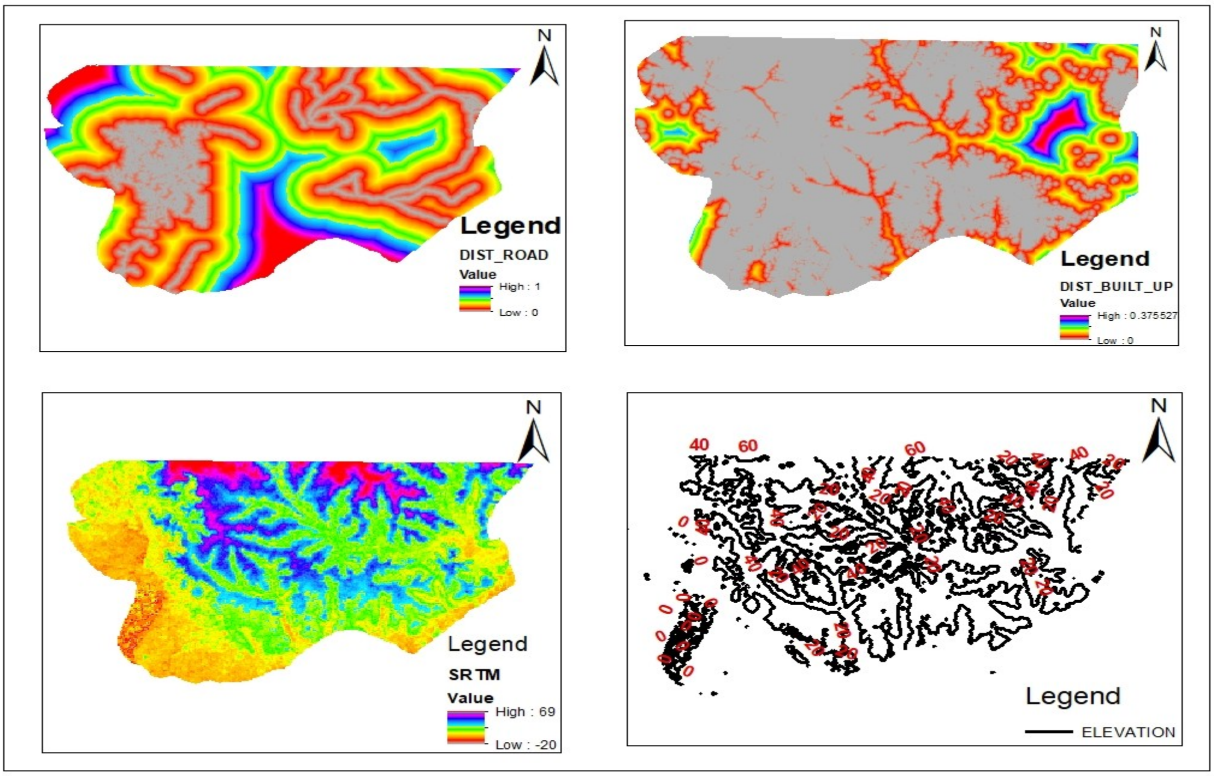

Figure 4: The variables considered responsible for observed changes in LULCC

Table 5: Correlation matrix

	Built-up	SRTM	Road
Built-up	1		
SRTM	0.72736	1	
Road	0.78088	0.236005	1

Conclusion and recommendation

The analysis above reveals that urban expansion has been very intense in Ikorodu, at the expense of vegetal cover. Road density and elevation showed positive relationships with urban expansion. Between 1987 – 2017 vegetation cover reduced at an average rate of 7.5 km^2 per year in a 30-year period. Conversely, the built-up area increased at an average rate of 5.14 km^2 per year during the period under consideration. Planners and policy-makers should put more premiums on the increase in land consumption rate and pattern when looking at urban morphology. They can achieve this by critically evaluating the spaces for future urban expansion, encouraging the construction of high-rise buildings, and the opening of the peri-urban through the construction of access roads. Looking at the instrumentalities of geospatial technologies in this study, I would strongly recommend that Government Agencies and Departments should encourage capacity building and technological advancement in the field of Remote Sensing and GIS.

REFERENCES

Adams, Robert A. (1995). Calculus: A Complete Course (3rd edition). Addison-Wesley Publishers Ltd. Page 129.

Agbor, C.F., Aigbokhan, O. J., Osudiala, C.S., and Malizu, L. (2012). LAND USE LAND COVER CHANGE PREDICTION OF IBADAN METROPOLIS. Journal of Forestry Research and Management. Vol.9, 1-13; 2012. ISSN: 0189-8418

Agbor Chukwuka Friday and Makinde Esther Oluwafunmilayo (2017). Land Surface Temperature Mapping Using Geoinformation Techniques Geoinformatics FCE CTU 17(1), 2018, doi:10.14311/gi.17.1.

Ajayi V. O (2018). Urban Land Use Land Cover Changes and Their Effects on Urban Thermal Pattern. Case study of Nigeria's Federal Capital City. Journal of Environment and Earth Science. Vo 8. No5

Alboody A., Sedes F.and Inglada J. (2008). Post-classification and spatial reasoning: new approach to change detection for updating GIS database. In 3rd International Conference on Information and Communication Technologies. From Theory to Applications (ICTTA), 1–7.

Angel S, (2005). The dynamics of global urban expansion. Transport and urban development department. The World Bank Washington D.C.

Araya H. Y., and Cabral, 2010. Analysis and Modeling of Urban Land Cover Change in Setiubal and Sesimbra, Portugal. Remote Sensing, (2):1549-1563

Bayan Alsaaideh, Almad Al-Hanbali and Ryutaro Tateishi (2011): Assessment of Land use/cover Change and Urban Expansion of the Central Part of Jordan, Using Remote Sensing and GIS. Asian Journal of Geoinformatics, Vol 11, No 3.

Dahal, K. R., Benner, S., & Lindquist, E. (2017). Analyzing spatiotemporal patterns of urbanization in Treasure Valley, Idaho, USA. Applied Spatial Analysis and Policy, 1-22.

Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., Bai, X., et al. (2008), Global Change and the Ecology of Cities, Science, 319(716).

Gamba, P. 2014. Image and Data Fusion in Remote Sensing of Urban Areas: Status issues and research trends. International Journal of Image and Data Fusion. 5(1):2-12.

Hoyt H, (1939). The Structure and Growth of Residential Neighbourhood in American CitiesWashington, Federal Housing Administration.

Hui, Y., and Yonghong, J. (2012). A new approach for vegetation change detection in urban areas. Geo-spatial Information Science, Volume 9 2006- Issue 4: pp 298-305

Ige, S. O., Ajayi, V. O., Adeyeri, O. E., Oyekan, K. S. A., (2017), "Assessing Remotely Sensed Temperature Humidity Index as Human Comfort Indicator Relative to Landuse Landcover Change in Abuja, Nigeria", Spatial Information Research. DOI: 10.1007/s41324-017-0118-2.

Ifatimehin O.O, Ufuah ME (2006). "An Analysis of Urban Expansion and Loss of Vegetation Cover in Lokoja, Using GIS Techniques". Zaria Geogr. 17(1): 28-36. Kwabe D.I (2010). "An Estimation of Urban Sprawl in the Federal Capital City, Abuja Using Satellite Images and GIS Tools". M.Sc Dissertation, Department of Geography and Environmental Management, University of Abuja, Nigeria.

Kwarteng,A.,and C.Small (2010). Remote sensing of urban environmental conditions. In Remote sensing of urban and suburban areas, ed. T. Rashed and C. Jurgens, 267–87. Berlin: Springer.

Ladipo D. The State of Nigeria's Forests Research for Development Review; 2010: 4.

Lagos State Government (2013): Digest of Statistics 2013, Lagos Bureau of Statistics Lagos

Lagos State Government (2017): Digest of Statistics 2017, Lagos Bureau of Statistics Lagos.

Martellozo, F. Ramankutty, N. Hall, R. J. Price, D. Purdy, B. Fried, M. (2014): Urbanization and the Loss of Prime Farmland: A Case Study in the Calgary-Edmonton Corridor of Alberta Regional Environmental Change 15 (5):881– 893.

Mohd Noor, N. Alias A., Mazlan, H and. Zainora (2012) M. A Managing Urban Land in Developing Countries Using GIS and Remote Sensing: Towards Resilient Cities. Department of Urban and Regional Planning, IIUM, Gombak, Malaysia.

Mohd Noor, N., Abdullah, A and Mazlan, H (2011). Classification of Satellite fused data for land use mapping in Development Plan Purposes, Journal of Malaysian Institute of Planners, Vol.9.pg.97-106, ISSN 1675-6215

Mundia, C. N., Aniya, M. (2005). Analysis of land use/cover changes and urban expansion of Nairobi city using remote sensing and GIS. International Journal of Remote Sensing, 26(13), 2831-2849.

National Population Commission (2007). Legal Notice on Publication of the Details of the Breakdown of the National and State Provisional Totals 2006 Census. Federal Republic of Nigeria Official Gazette, Vol. 94, No. 24, Government Notice 2. May 15.

Obiora D.N and Owuka S. O (2005): Groundwater Exploration in Ikorodu, Lagos-Nigeria: A Surface Geophysical Survey Contribution. The Pacific Journal of Science and Technology. Volume 6, Number 1.

Ojigi, L.M. (2006) Analysis of Spatial Variations of Abuja Land Use and Cover from Image Classification Algorithms. In: Kerie, N. and Skidmore, A.K., Eds., Proceedings of the Mid-Term International Symposium Photogrammetry and Remote Symposium, WGVII/4, 162-168.

Omo-Irabor O. O. (2016). A Comparative Study of Image Classification Algorithms for Landscape Assessment of the Niger Delta Region. Journal of Geographic Information System, 2016, 8, 163-170

Rahman, M (2009), preserving green spaces in Dhaka City. The Daily Star.

Relf, D. (2009). The Value of Landscaping. Virginia Cooperative Extension.

Shao, Z., Deng, J., Wang, L., Fan, Y., Sumari, N., and Cheng, Q. (2017). Remote Sensing Fuzzy Auto-Encode Based Cloud Detection for Remote Sensing Imagery. Remote Sensing, 9(4)

Ujoh F, Kwabe ID, Ifatimehin OO (2011). Urban expansion and vegetal cover loss in and around Nigeria's Federal Capital City. Journal of Ecology and the Natural Environment.;3(1):1-10.

VanBommel, F., Heitkonig, I., Epema, G., Ringrose, S., Bonyongo, C., &Veenendaal, E. (2006). Remotely Sensed Habitat Indicators for Predicting Distribution of Impala (Aepyceros melampus) in the Okavango Delta, Botswana.Journal of Tropical Ecology, 22, pg. 101- 110.

Xiangmei Li, Ying Wang, Jiangfeng Li and Bin Lei (2016). Physical and Socioeconomic Driving Forces of Land-

Use and Land-Cover Changes: A Case Study of Wahan City, China. Discrete Dynamics in Nature and Society. Volume 2016, Article 108061069, 11 pages.

Zhao, M., Xu, G., & Li, Y. (2016). Evaluating urban public facilities of Shenzhen by application of open source data. Geospatial Information Science, Vol. 19, no. 2, 129-139