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Geospatial Assessment of Land Cover Dynamics in the Guinea Savannah Ecological Zone

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

An attempt is made in this study to examine the geospatial analysis of land cover/ land use changes between 2000- 2016 in the North Central region including the Federal Capital Territory Abuja. Multispectral satellite images of Landsat 7 ETM and 8 OLI/TIRS of 2000, 2008 and 2016 with three land-use types were identified and analysed using Geographic Information System ArcGIS 10.5 software. The land-use types are Urban representing the built-up area, Vegetation and water bodies. The area of each land use type per year was calculated and the result was used to compute land-use change and percentage change in square kilometres. The outcome of the analysis reveals that built-up area (Urban) land use increase from 10.64% in 2000 to 22.44% in 2008 and later 29.01% in 2016 while Vegetation reduced from 84.99% in 2000 to 73.24.% in 2008 and 62 .74% in 2016. In the same vein, water bodies which stood at 4.37% in 2000 reduced to 4.32% in 2008 before declining again in 2016 to 4.27% respectively. The results have therefore highlighted the nexus between climate change and resource depletion and further provided valuable information for a robust assessment of the changes in vegetal resources of the study area over time. The study recommends sustainable forest resource management, vegetation monitoring and promulgation of vegetation control laws to improve the vegetation cover of the study area.

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1. INTRODUCTION

Land use/land cover changes can occur naturally in the landscape as succession processes; however according to [1], landscapes are modified by human activities in response to a specific need of the population that depends on the land in question., in the Sahel for instance, agriculture and wood harvesting for cooking fuel are the major activities that cause modifications of the land cover [2]. Land cover change has also been described as the most significant regional anthropogenic disturbance to the environment [3]. In essence, both land use and land cover changes are products of prevailing interacting natural and anthropogenic processes by human activities (the use to which land is being put). Land use and cover change and land degradation are therefore driven by the same sets of proximate and underlying factors elements. Land use and cover change is therefore central to environmental processes, environmental change and environmental management due to its influence on biodiversity, water budget, radiation budget, trace gas emissions, carbon cycling, livelihoods [4], and a wide range of socio-economic and ecological processes [5], which on the aggregate affects global environmental change and the biosphere There are various forms of land use/land cover change. Land use can change from forest to agriculture with a huge impact on natural resources, biodiversity conservation, and water cycles. Although the land use/land cover classification process is rather subjective and it is difficult to identify a single ideal classification system [6], analysis of these changes is important in the adequate management of natural resources and the sustainable development of populations.

According to [7], most of the interest in land cover/ land use studies emanates from several processes associated with the earth's surface including land productivity, biodiversity, biochemical and the hydrological cycles. Therefore changes in the land cover analysis are important parameters that significantly impact on hydroclimatic processes particularly surface hydrology [8]. It also forms the basis for understanding the interaction between human activities and the environment.

Land use/land cover changes can be analyzed by pre-classification and post-classification methods. Pre-classification methods apply image analysis algorithms to highlight change vs. no-change areas, whereas post-classification methods compare land use/land cover classes derived from images to indicate changes from one class to another between two different periods [9]. Tayyebi [10] noted that ‘‘change studies recognize the biotic and abiotic components of multi-spectral and multi-temporal variations that are occurring within an ecosystem’’. This will be domiciled on major two approaches: map-to-map and image-to-image comparisons. There are various forms of change detection applications that have been tested, and executed in different study areas; the result indicated no significant answer. We will employ the visual analysis based on the image to image comparison method for this study which commonly used for land change detection.

In Nigeria particularly in the central region, there is a dearth of empirical work on this subject matter. Abbas [11] examined an overview of land cover changes in Nigeria between 1975-2005 where it was noticed that significant loss of arable land in Northern Nigeria occurred.

It was established in the study that the savannah vegetation in the central states is fast transiting into the pure Sahel due to the influence of desertification and drought. Findings of the above research confirmed the recent security crises between herdsmen and farmers in the central states are manifestations of drought-induced land-use changes in the North. It is this attempt to bridge the existing gap in the literature that further necessitates this study.

1.1 Study Area

Northcentral Nigeria lies approximately between 3^0 and 14^0E and latitude 7^0 and 10^0N. The region is made up of six states namely Benue, Kwara, Niger, Plateau, Nassarawa, Kogi and Abuja (the Federal Capital Territory) as shown in Fig. 1. The relief of the lower Benue basin which this study falls comprises of two distinctive relief regions. The upper part is located in the northwest axis and is an extension of the steep scarp of the Jos Plateau. The study area has an excellent drainage network from flows from the Benue River and River Niger. At Lokoja, the River Niger and the Benue meet giving rise to Kogi as a confluence state. Most parts of the region are drained by the Benue River. The climate of the region is partly influenced by climates in the northern and southern region of Nigeria [12]. The tropical savannah climate characterized by wet and dry condition affects most parts of north-central Nigeria. The study area is within the Guinea savannah vegetation belt consisting of vegetation belt mainly of deciduous trees with grasses and shrubs [13]. Most of the grasses grow tall, coarse and scattered which are also of economic benefits. The soils of North Central Nigeria are generally characterized by a sandy surface horizon overlying a weakly structured clay accumulation. The Geology of the Lower Benue Basin is underlain by two principal geological formations namely the Precambrian Basement Complex and the Sedimentary Formations. While the basement complex consists of hard and crystalline metamorphic rock, the sedimentary formation, on the other hand, comprise mostly sandstones, shale, clay and limestone covering the entire southern part of the study area. Nigeria's federal capital territory created in 1976 is the melting pot of all administrative and political activities in the region. Agriculture forms the backbone of the economy of the lower Benue basin with more than 70% of the working population engaged into farming, fishing, livestock and poultry. This has made the zone often referred to as the food basket of the Nation.

2. MATERIALS AND METHODS

To assess land cover/land-use change and its implication on drought frequency in the study area, a change detection analysis was performed to determine the nature, extent and rate of change over time and space.

Fig. 1. Map of study area

2.1 Image Geo-processing for Land Use Change and Percentage Change

The study made use of multi-spectral satellite images of Landsat 7 ETM and 8 OLI/TIRS of 2000, 2010 and 2017; all having the same characteristics. The images were enhanced by combining image bands from 1 to 5 only to ease mosaicing of each image scene in each year. A false colour composite band sequence 5, 4, 2, RGB was used for classifying the land cover. A combination of channel 5 (red), channel 4 (green) and channel 2 (blue) is effective in discriminating different vegetal cover types. Information from each land cover classes was collected from extensive field survey before the classification of satellite imageries. The field survey was performed throughout the study area with the use of a global positioning system (GPS) to track the coordinates of the sample points in each land use/land cover (Fig. 2). The fieldwork was conducted between December 2015 and January 2016; to ground-truth the status of vegetation cover and development in each state. Sixteen scenes of the images of each year were mosaicked to represent one image for each year. Thereafter supervised classification using maximum likelihood algorithm classifiers was used to classify similar spectral signatures into various classes which included vegetation cover, water bodies and built-up area. Maximum likelihood classifier was chosen because it is the most widely adopted parametric classification algorithm. The area of each land-use class was computed in ArcGIS 10.5 which was used to compute the land-use change and percentage change in square kilometres. The percentage change was computed using this formula:

$$\frac{\left(\frac{d}{t1}\right) * 100}{y2 - y1}$$

Where,

d is the difference in the value of area covered by a land cover category at the initial time point and final time point

t_1 is the value of the area covered by a land cover category in the initial time point

y1 and y2 are the base year and final year respectively.

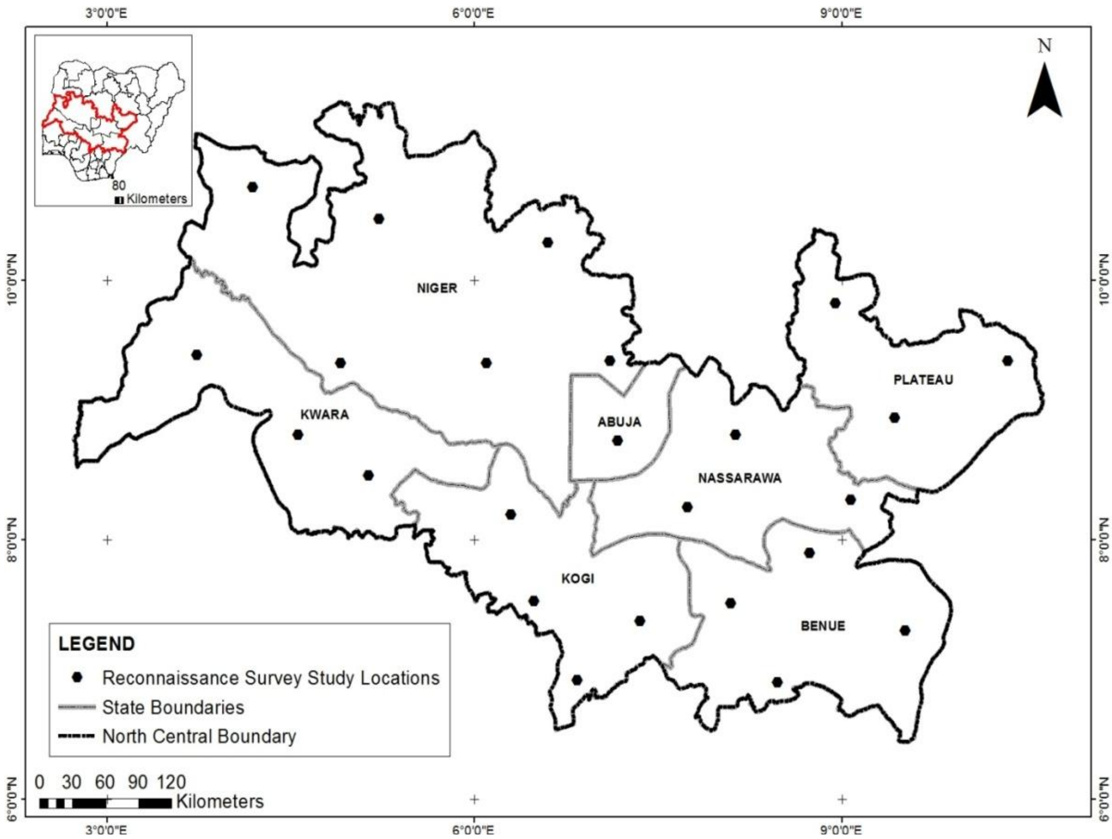

Fig. 2. The North Central states showing sampled points

3. RESULTS AND DISCUSSION

The results of the analysis are presented below:

Table 1. Summary of land cover/land-use change at different periods 2000-2016

Land cover	Extent 2000 (Sq. Km)	Percentage (%)	Extent 2008 (Sq. Km)	Percentage (%)	Extent 2016 (Sq. Km)	Percentage (%)
Built-Up Area	24082.33	10.64	50814.03	22.44	65685.78	29.01
Vegetation Cover	192457.17	84.99	165836.50	73.24	142065.45	62.74
Waterbodies	9895.13	4.37	9784.15	4.32	9678.40	4.27
Total	226434.63	100.00	226434.63	100.00	226434.63	100.00

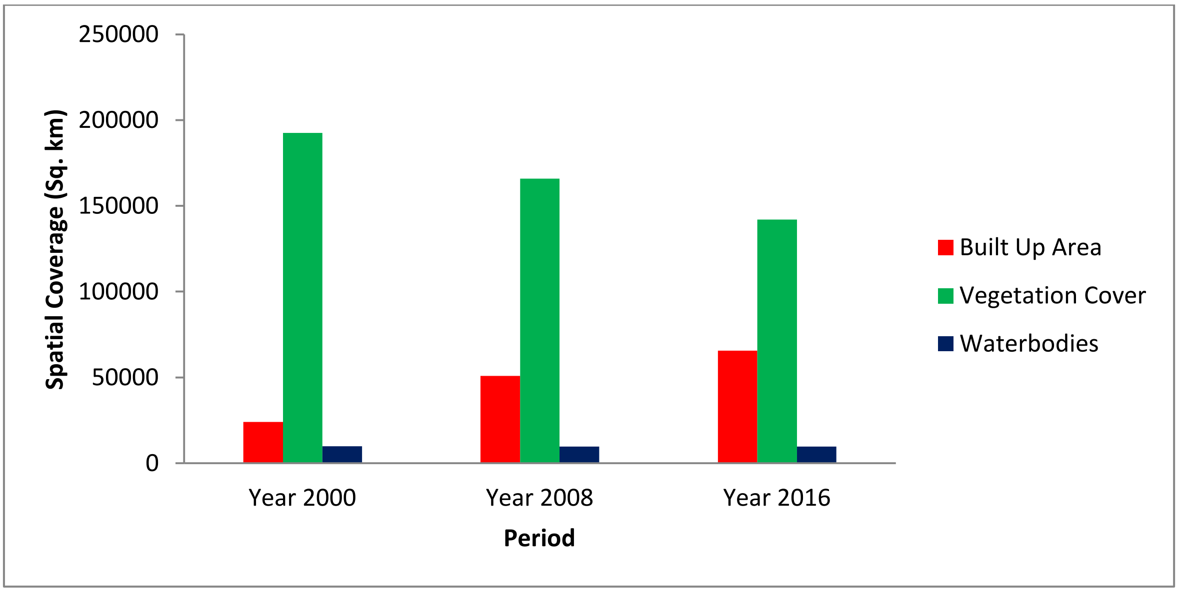

Fig. 3. Spatial Extent of Landcover from 2000 to 2016

Table 2. Rate of change analysis and percentage rate of change of Landcover between 2000 and 2016

Land cover	2000-2008		2008-2016	
	Rate of Change (Sq Km)	Percentage (%)	Rate of Change	Percentage (%)
Built-Up Area	+26731.7	+111.00	+14871.75	+29.27
Vegetation Cover	-26620.67	-13.83	-23771.05	-14.33
Waterbodies	-110.98	-1.12	-105.75	-1.08

Tables 1 and 2 reveal the different land cover types, areal coverage, rate of change analysis and percentage rate of change in the three different periods of study respectively while Fig. 3 depicts the extent of the spatial coverage of each land cover from 2000 to 2016 in a bar chart for better illustration of the changes observed.

An insight into Table 1 indicates that in 2000, water bodies has 4.37% of the land cover followed by built-up area 10.64% and finally vegetation cover with 84.99 % during the year under investigation.

The results of the analysis further reveal that vegetation cover was the dominant land cover type while water bodies recorded the least during the period under investigation. This is illustrated below in the Landsat imagery obtained in 2000 (Fig. 4).

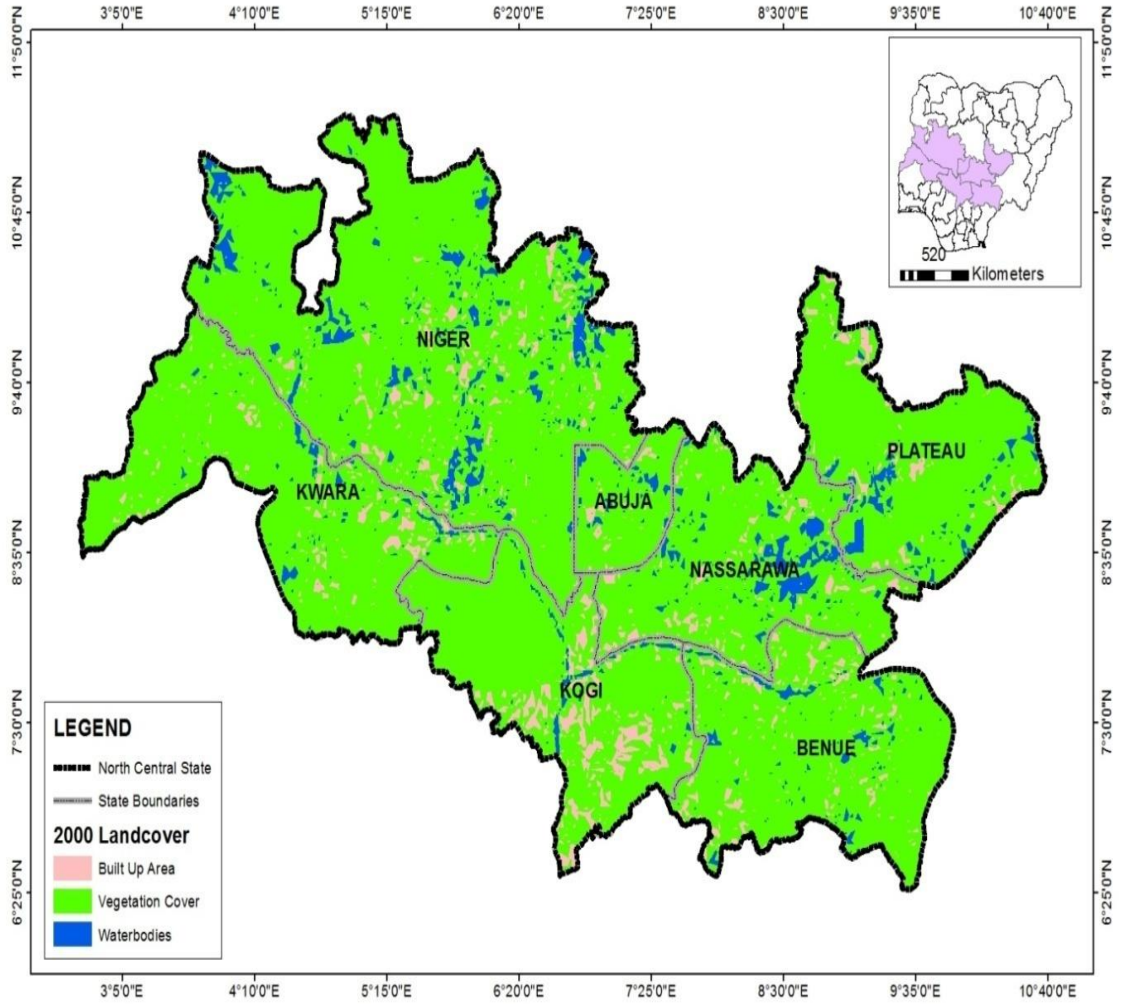

Fig. 4. Land cover of the study area for 2000

By 2008, the built-up area (Urban) has increased by 22.44%. This increase is bound to have implications on vegetation cover and water bodies. With increasing urban growth, the rich vegetation cover will be cleared for building and other construction activities.

Secondly, encroachment on water bodies is expected as more human activities are extended to the coastal and banks of the rivers with concomitant impact on the hydrology of the basin. This is evident in vegetation reduction by 73.24% covering 165836.50 sq.km while water bodies with 9784.15 sq km reduced by 4.32% and build up an area covering 50814.03 sq km reduced by 22.44% as shown in Table 2 and Fig. 5 respectively.

The results of the analysis of land cover/ land use presented in Fig. 6 reveal a progressive decline in vegetation and water bodies from 2008 to 2016 with an increase in the built-up area. In 2016, built-up area as land cover/ land use type increased by 29% with spatial coverage 65685.78 sq km as reveal in Table 2. Vegetation cover declined by 14.33% covering only 62.74%. The causative factors are climatic shifts and an increase in urban growth. Scholarly evidence reveals that rainfall in Northern Nigeria particularly the study area is highly variable [14]. The variability of rainfall in terms of duration, amount and intensity over the north-central region has resulted in dry spells and drought. Furthermore, [15] asserts a progressive early retreat in rainfall in the north which could affect crop production and food livelihood security. The observed decreasing trend in rainfall as shown in Table 3 below indicate that markudi, Ilorin, Minna and Jos all experienced declining rainfall trend all year round in 2016 as the MK values were all negative suggesting decrease rainfall trend.

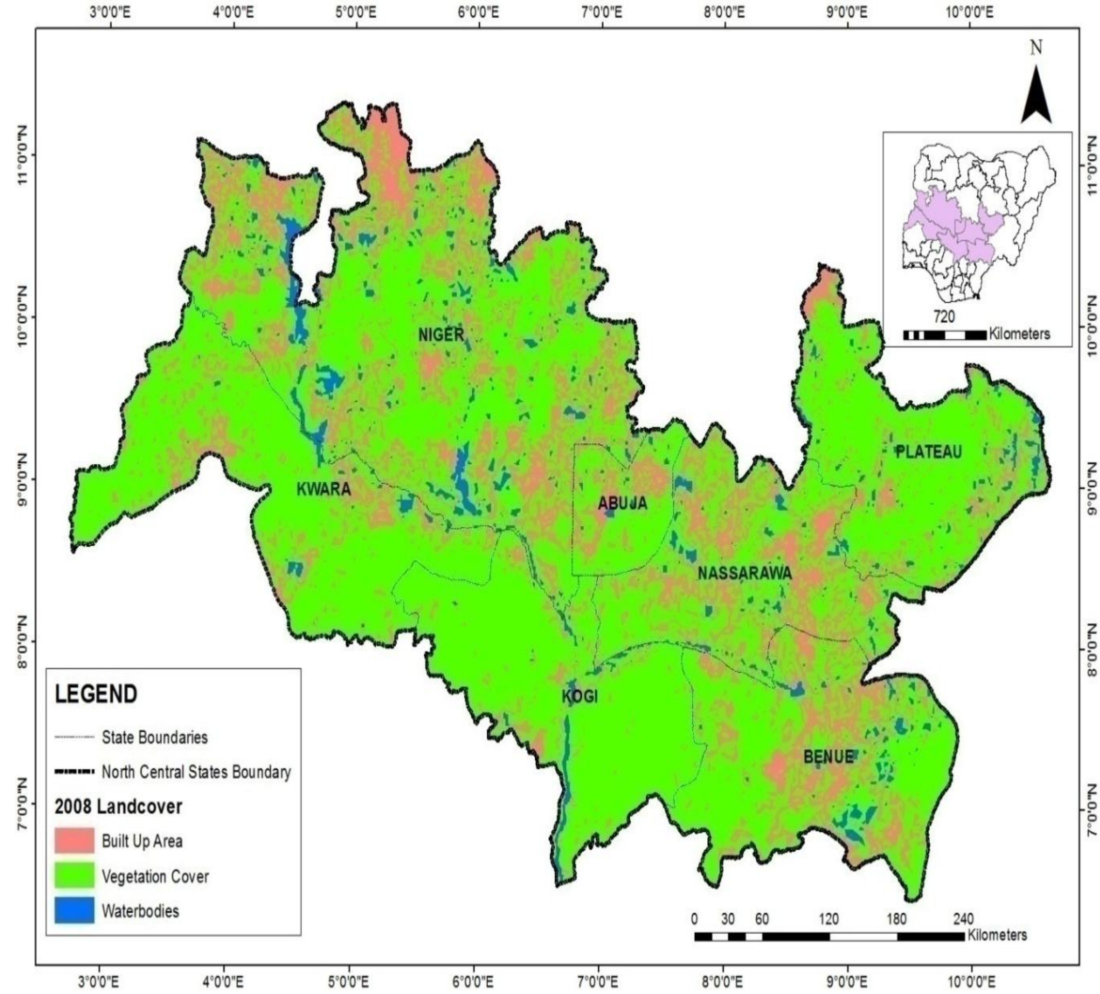

Fig. 5. Land cover for 2008

Table 3. Mann Kendall and Sen's slope statistics for SPI 12 months scale

Station	Mann Kendall (Z) values	Sen slope estimate (Q) values
Makurdi	-1.01	-0.008
Ilorin	-0.22	-0.002
Lokoja	0.33	0.002
Minna	-0.01	0.000
Jos	-1.70+	-0.013
Abuja	2.08*	0.037
Lafia	2.75**	0.171

**** if trend at α = 0.001 level of significance; ** if trend at α = 0.01 level of significance; * if the trend at α = 0.05 level of significance*

Rainfall variability as shown in Table 3 above, also manifest in delayed onset and early cessation with enormous implication on land use/land cover pattern of the region. This is because as rainfall amount reduces, people will be a constraint to a farm close to the existing water bodies to improve soil moisture and boost crop yield. In addition to the above, erratic rainfall in the extreme and Sahel regions of the country has pushed farmers and herders to the north-central region for grazing and forestry products. Secondly, due to chronic poverty, people depend heavily on fuel food for cooking resulting in massive deforestation of the vegetation [11].

Population and urbanization are other factors apart from the climate shift that also contributes to the observed changes in the land use pattern of the study area. The North Central region is the third most populous region in Nigeria with the Benue state ranked as the most populous state [16]. As population increase, urban growth also increases through the construction of roads and other urban infrastructure with a concomitant effect on deforestation, urban heat and changes in the land use and land cover Ideki, [14].

Similarly, rate of change analysis and percentage rate of change of land cover within the period of investigation, reveal that between 2000-2008, built-up area rate of change was 26731.7 sq km at 111.00%, while vegetation cover changed at -26620.67 sq km with -13.83% and water bodies has -110.98 its rate of change at -1.12%, this is shown in Table 2.

In the second period of the analysis (2008-2016), the rate of change for built-up area was rather on the downward trend with 14871.75 sq km and 29.27% as its percentage of change while vegetation cover change was -23771.05 at -14.33% followed by water bodies -105.75 sq km at -1.08% as its rate of change and percentage of change as highlighted in Table 2.

The analysis performed here are consistent with previous research findings by Abass [11], [17,18] on monitoring drought and its effect on vegetation as well as similar research investigation by[19] on trends in vegetation response to drought [20].

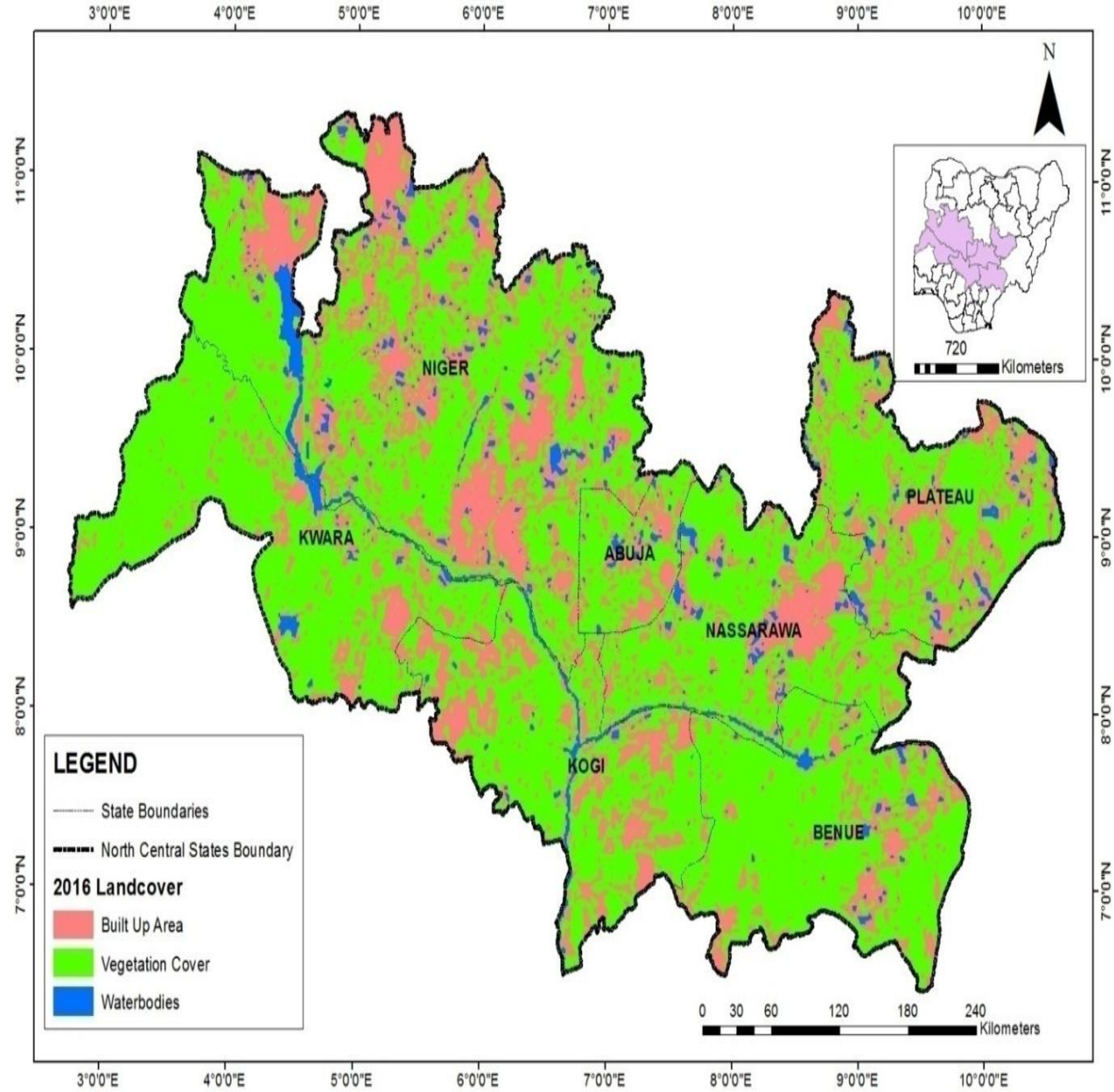

Fig. 6. Land cover for 2016

4. CONCLUSION

The study affirms that the land use and land cover of the study area have changed over the last few decades. While there was an increase in the rate of built-up area been the dominant land use/land cover type throughout the study (2000-20016), water bodies and vegetation witness reduced and downward trend during the aforementioned period. The changes in land cover highlighted in this study call for sustainable and proactive management of the biodiversity to mitigate the associated risk of global climate change. The study has, therefore, shed more light on the efficacy of remote sensing and GIS in the assessment of land cover dynamics.

5. RECOMMENDATION

The following recommendations have been put forward for adoption by policymakers to enhance their decision-making process:

- An improved understanding of the intricate relationship between human activities and the terrestrial environment. This is imperative considering the anthropogenic effect of climate change on the physical environment.
- The increase in the built-up area representing urban growth has an enormous implication on the hydrological balance of the study area. There is, therefore, the need to enact laws against forest encroachment and expansion to protect the ecosystem.
- There is a need for monitoring of the vegetation in states considered most vulnerable. Furthermore, the study recommends sustainable forest resource management in the region. There is a need to preserve the forest resource endowment of the study area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Cappelaere B, Descroix L, Lebel T, Guillaume Q. The AMM CATCH experiment in the cultivated Sahelian area of South- west Niger- investigating water cycle response to a fluctuating climate and changing environment. Journal of Hydrology; 2009.
2. Tobar IM. Geostatistical analysis of Land Use and land cover changes and population growth trends in the Komadugu – Yobe Basin, Nigeria. M.SC Thesis, University of Missouri-Kansas; 2008.
3. Roberts DA, Batista GT, Pereira LG, Walker EK, Nelson BW. Change identification using multitemporal spectral mixture Analysis; Application in Eastern Amazonia. In Remote sensing change detection. Environmental Methods and Applicarion, R.S Lunetta and Elvidge(eds) Chelsea, Michigan; An Arbor Press; 1998.
4. Verburge PH, Soepboer W, Veldkmp A, Limpiada R, Espaldon V, Mastura SS. Modelling the spatial dynamics of regional land use: The CLUE-S model. Journal of Environ Manage. 2002;(3).
5. Desconnect JC, Taupin JD, Lebel T, Leduc C. Hydrology of the HAPEX-Sahel central Super-Site: surface water drainage and aquifer recharge through the pool systems. Journal of Hydrology. 1997;188-189:155-178
6. Anderson JR, Hardy EE, Roach JT, Witmer RE. A land use and land cover classification system for use with remote sensor data." U.S. Geological Survey Professional Paper No. 964, USGS, Washington, D.C; 1976.
7. Eludoyin OS, Wokocha CC, Ayolagha G. GIS assessment of land use and land cover changes in Obio/Akpor L.G.A of Rivers State, Nigeria. Research journal of Environment and Earth Sciences. 2011; 3(4).
8. Odunuga S, Oyebande L. Change detection and hydrological implication in the Lower Ogun flood plain, SW Nigeria, IAHS Symposium on Remote Sensing for Environmental Monitoring and Change Detection, Perugia, ITALIE. 2007;316:91-99.
9. Mubea KW, Mundia CN, Kuria DN. The Use of Markov Chain Analysis in Predicting Land Use/Cover Change in Nyeri." Working paper, Department of Civil Engineering, Kimathi University College of Technology, Nyeri, Kenya; 2011.
10. Tayyebi A, Delavar MR, Saeedi S, Amini J, Alinia H. Monitoring land use change by multi-temporal LANDSAT remote sensing imagery." In Proceedings of the International Society for Photogrammetry and Remote Sensing, Commission VII, Beijing; 2008.

11. Abbas II. An overview of land cover changes in Nigeria, 1975-2005. Journal of Geography and Regional Planning. 2009;2. ISSN 2070-1845
12. Aper JA. Stream Discharge Characteristics in the Lower Benue Drainage Basin. Ph.D Thesis Submitted to the School Of Graduate Studies, University of Nigeria, Nsukka; 2006.
13. Idoko MO. Sectoral water demand and comsumption in Markurdi, Benue State. M.SC Thesis submitted to the School Of Graduate Studies, University Of Nigeria Nsukka; 1998.
14. Ideki O. Vulnerability and adaptation strategies to drought risk in north central Nigeria. PhD thesis submitted to school of Graduate studies, University of Port Hracourt; 2019.
15. Fabeku BB, Faleyimu OI. Drought Impact assessment on vegetation over the Sudano-Sahelian part of Nigeria; 2017.
16. Fabeku BB, Okogbue EC. Trends in vegetation response to drought in Sudano-Sahelian part of Northern Nigeria. Journal of Atmospheric and Climate Sciences. 2014;(4):569-588
17. National Population Commission (NPC). "Federal Republic of Nigeria: 2006 Population Census"; 2006.
    Available:www.nigerianstat.gov.ng/nbsapps/Connections/Pop2006.pdf.
18. Olagunju EC. Remote sensing for agricultural land use changes and sustainability monitoring in sudan. M.SC thesis department of computer and information science, Linkoping University, Sweden; 2008.
19. Olajuyibe AE, Adegboyega S, Balogun I. Monitoring drought and effects on vegetation in Sokoto, Nigeria using statistical and geospatial technologies. Ethiopian Journal of Evironmental studies and Management. 2016;(1).
20. Omonijo, Okogbue EC. Trends Analysis of Drought in the Guinea and Sudan – Sahelian Climatic Zones of Northern Nigeria (1901-2006). Atmospheric and climate Sciences. 2014;4.

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