

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

## 2 ABSTRACT

3 *An attempt is made in this study to examine the geospatial analysis of land cover/ land use*  
4 *changes between 2000- 2016 in the North Central region including the Federal Capital*  
5 *Territory Abuja. Multispectral satellite images of Landsat 7 ETM and 8 OLI/TIRS of 2000,*  
6 *2008 and 2016 with three land-use types were identified and analysed using Geographic*  
7 *Information System ArcGIS 10.5 software. The land-use types are Urban representing the*  
8 *built-up area, Vegetation and water bodies. The area of each land use type per year was*  
9 *calculated and the result was used to compute land-use change and percentage change in*  
10 *square kilometres. The outcome of the analysis reveals that built-up area (Urban) land use*  
11 *increase from 10.64% in 2000 to 22.44% in 2008 and later 29.01% in 2016 while Vegetation*  
12 *reduced from 84.99% in 2000 to 73.24.% in 2008 and 62 .74% in 2016. In the same vein,*  
13 *water bodies which stood at 4.37% in 2000 reduced to 4.32% in 2008 before declining again*  
14 *in 2016 to 4.27% respectively. The results have therefore highlighted the nexus between*  
15 *climate change and resource depletion and further provided valuable information for a*  
16 *robust assessment of the changes in vegetal resources of the study area over time. The study*  
17 *recommends sustainable forest resource management, vegetation monitoring and*  
18 *promulgation of vegetation control laws to improve the vegetation cover of the study area.*

19 **Keywords:** Land cover, Dynamics, Landsat Imageries, Climate change, Geospatial  
20 assessment

## 21 INTRODUCTION

22 Land use/land cover changes can occur naturally in the landscape as succession  
23 processes; however according to (Cappelaere *et al.*; 2009), landscapes are modified by human  
24 activities in response to a specific need of the population that depends on the land in  
25 question., in the Sahel for instance, agriculture and wood harvesting for cooking fuel are the  
26 major activities that cause modifications of the land cover (Tobar, 2008). Land cover change  
27 has also been described as the most significant regional anthropogenic disturbance to the  
28 environment (Roberts *et al.*, 1998). In essence, both land use and land cover changes are  
29 products of prevailing interacting natural and anthropogenic processes by human activities  
30 (the use to which land is being put). Land use and cover change and land degradation are  
31 therefore driven by the same sets of proximate and underlying factors elements. Land use and  
32 cover change is therefore central to environmental processes, environmental change and  
33 environmental management due to its influence on biodiversity, water budget, radiation  
34 budget, trace gas emissions, carbon cycling, livelihoods (Verburg *et al.*, 2002), and a wide

35 range of socio-economic and ecological processes (Desconnect *et al.*, 1997), which on the  
36 aggregate affects global environmental change and the biosphere. There are various forms of  
37 land use/land cover change. Land use can change from forest to agriculture with a huge  
38 impact on natural resources, biodiversity conservation, and water cycles. Although the land  
39 use/land cover classification process is rather subjective and it is difficult to identify a single  
40 ideal classification system (Anderson *et al.*, 1976), analysis of these changes is important in  
41 the adequate management of natural resources and the sustainable development of  
42 populations.

43 According to (Eludoyin *et al.*; 2011), most of the interest in land cover/ land use  
44 studies emanates from several processes associated with the earth's surface including land  
45 productivity, biodiversity, biochemical and the hydrological cycles. Therefore changes in the  
46 land cover analysis are important parameters that significantly impact on hydroclimatic  
47 processes particularly surface hydrology (Odunuga and Oyebande, 2007). It also forms the  
48 basis for understanding the interaction between human activities and the environment.

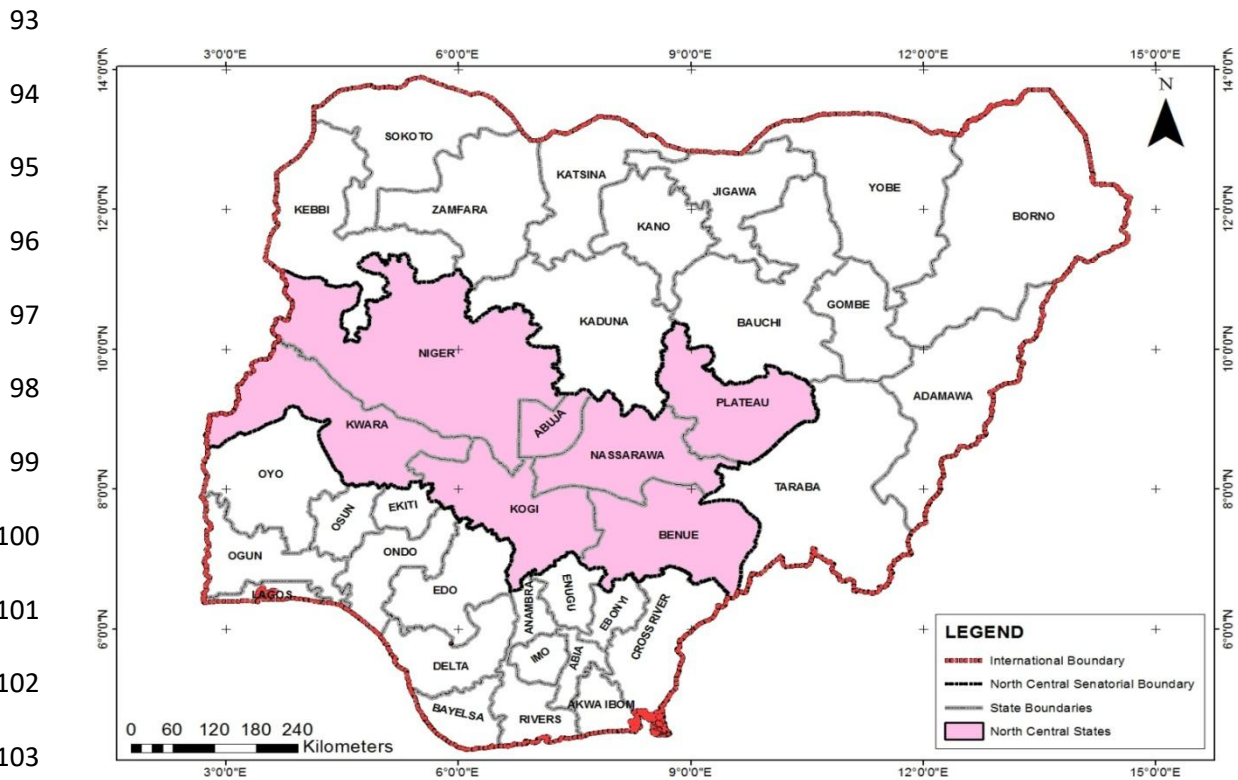
49 Land use/land cover changes can be analyzed by pre-classification and post-  
50 classification methods. Pre-classification methods apply image analysis algorithms to  
51 highlight change vs. no-change areas, whereas post-classification methods compare land  
52 use/land cover classes derived from images to indicate changes from one class to another  
53 between two different periods (Mubea, Mundia and Kuria, 2011). Tayyebi (2008) noted that  
54 “change studies recognize the biotic and abiotic components of multi-spectral and multi-  
55 temporal variations that are occurring within an ecosystem”. This will be domiciled on major  
56 two approaches: map-to-map and image-to-image comparisons. There are various forms of  
57 change detection applications that have been tested, and executed in different study areas; the  
58 result indicated no significant answer. We will employ the visual analysis based on the image  
59 to image comparison method for this study which commonly used for land change detection.

60 In Nigeria particularly in the central region, there is a dearth of empirical work on this subject  
61 matter. Abbas (2009) examined an overview of land cover changes in Nigeria between 1975-  
62 2005 where it was noticed that significant loss of arable land in Northern Nigeria occurred.  
63 It was established in the study that the savannah vegetation in the central states is fast  
64 transiting into the pure Sahel due to the influence of desertification and drought. Findings of  
65 the above research confirmed the recent security crises between herdsmen and farmers in the  
66 central states are manifestations of drought-induced land-use changes in the North. It is this  
67 attempt to bridge the existing gap in the literature that further necessitates this study.

## 68 **STUDY AREA**

69 Northcentral Nigeria lies approximately between 3<sup>0</sup> and 14<sup>0</sup>E and latitude 7<sup>0</sup> and 10<sup>0</sup>N. The  
70 region is made up of six states namely Benue, Kwara, Niger, Plateau, Nassarawa, Kogi and  
71 Abuja (the Federal Capital Territory) as shown in Figure 1. The relief of the lower Benue  
72 basin which this study falls comprises of two distinctive relief regions. The upper part is  
73 located in the northwest axis and is an extension of the steep scarp of the Jos Plateau. **The**  
74 **study area has an excellent drainage network from flows from the Benue River and River**  
75 **Niger.** At Lokoja, the River Niger and the Benue meet giving rise to Kogi as a confluence  
76 state. Most parts of the region are drained by the Benue River. The climate of the region is  
77 partly influenced by climates in the northern and southern region of Nigeria (Aper, 2006).  
78 **The tropical savannah climate characterized by wet and dry condition affects most parts of**  
79 **north-central Nigeria. The study area is within the Guinea savannah vegetation belt consisting**  
80 **of vegetation belt mainly of deciduous trees with grasses and shrubs (Idoko, 1998). Most of**  
81 **the grasses grow tall, coarse and scattered which are also of economic benefits.** The soils of  
82 North Central Nigeria are generally characterized by a sandy surface horizon overlying a  
83 weakly structured clay accumulation. **The Geology of the Lower Benue Basin is underlain by**  
84 **two principal geological formations namely the Precambrian Basement Complex and the**

85 Sedimentary Formations. While the basement complex consists of hard and crystalline  
 86 metamorphic rock, the sedimentary formation, on the other hand, comprise mostly  
 87 sandstones, shale, clay and limestone covering the entire southern part of the study area.  
 88 Nigeria's federal capital territory created in 1976 is the melting pot of all administrative and  
 89 political activities in the region. Agriculture forms the backbone of the economy of the lower  
 90 Benue basin with more than 70% of the working population engaged into farming, fishing,  
 91 livestock and poultry. This has made the zone often referred to as the food basket of the  
 92 Nation.



104 **Figure 1: Map of Study Area**

105 **MATERIALS AND METHODS**

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

109 **IMAGE GEO-PROCESSING FOR LAND USE CHANGE AND PERCENTAGE**  
110 **CHANGE**

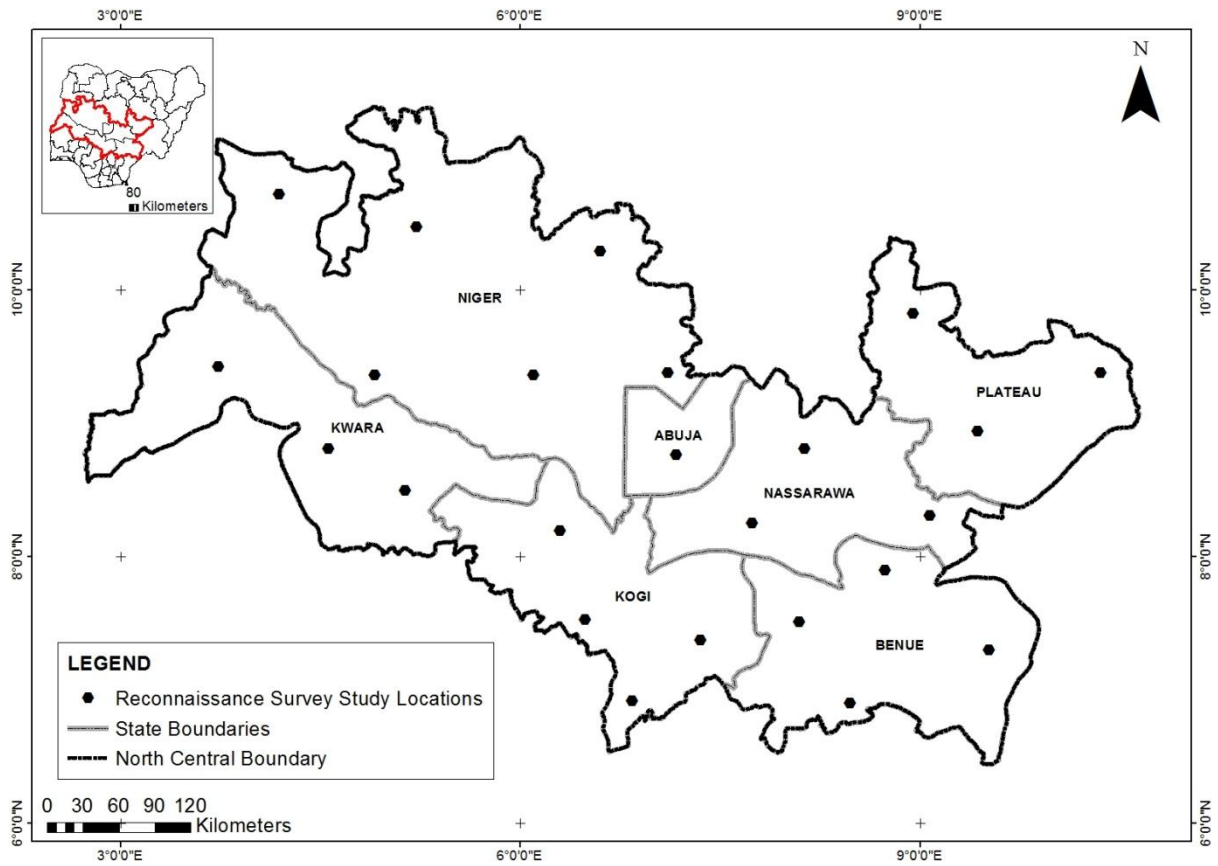
111 The study made use of multi-spectral satellite images of Landsat 7 ETM and 8 OLI/TIRS of  
112 2000, 2010 and 2017; all having the same characteristics. The images were enhanced by  
113 combining image bands from 1 to 5 only to ease mosaicing of each image scene in each year.  
114 A false colour composite band sequence 5, 4, 2, RGB was used for classifying the land cover.  
115 A combination of channel 5 (red), channel 4 (green) and channel 2 (blue) is effective in  
116 discriminating different vegetal cover types. Information from each land cover classes was  
117 collected from extensive field survey before the classification of satellite imageries. The field  
118 survey was performed throughout the study area with the use of a global positioning system  
119 (GPS) to track the coordinates of the sample points in each land use/land cover (Figure 2).  
120 The fieldwork was conducted between December 2015 and January 2016; to ground-truth the  
121 status of vegetation cover and development in each state. Sixteen scenes of the images of  
122 each year were mosaicked to represent one image for each year. Thereafter supervised  
123 classification using maximum likelihood algorithm classifiers was used to classify similar  
124 spectral signatures into various classes which included vegetation cover, water bodies and  
125 built-up area. Maximum likelihood classifier was chosen because it is the most widely  
126 adopted parametric classification algorithm. The area of each land-use class was computed in  
127 ArcGIS 10.5 which was used to compute the land-use change and percentage change in  
128 square kilometres. The percentage change was computed using this formula.

129 
$$\frac{\left(\frac{d}{t_1}\right) * 100}{y_2 - y_1}$$

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

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

133  $y_1$  and  $y_2$  are the base year and final year respectively.



135

136 **Figure 2. The North Central States showing Sampled Points**

137

138 **RESULTS AND DISCUSSION**

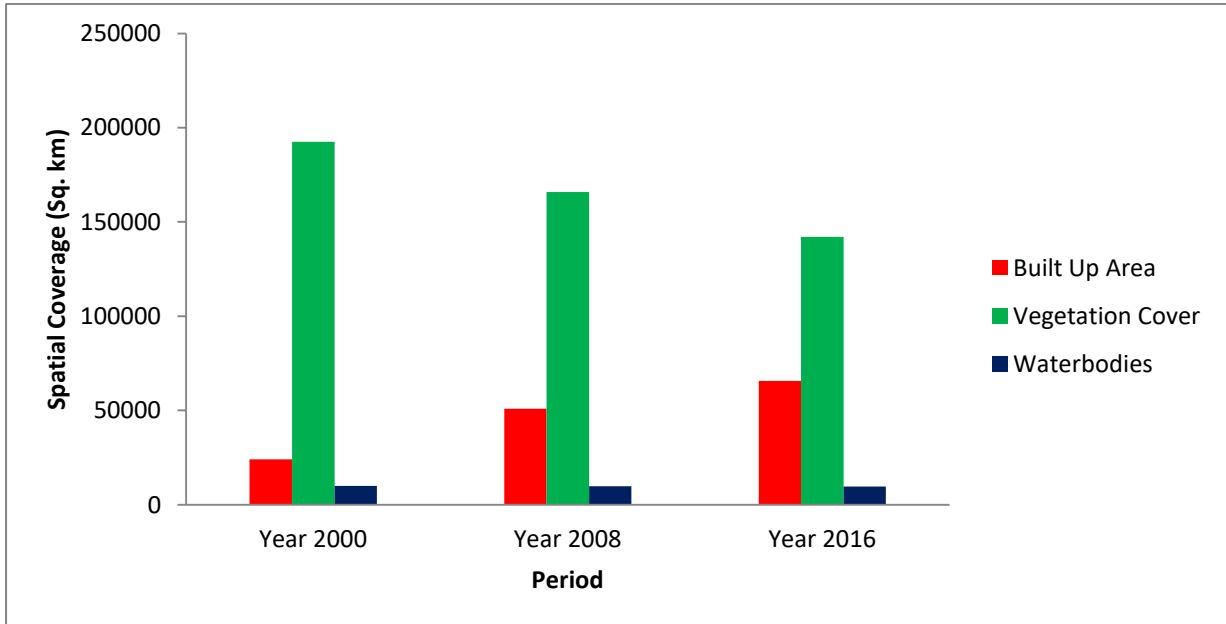
139 The results of the analysis are presented below:

140 Table 1: Summary of Land cover/land-use change at Different periods 2000-2016

Land cover	Extent	Percentage	Extent	Percentage	Extent	Percentage
	2000 (Sq. Km)	(%)	2008 (Sq. Km)	(%)	2016 (Sq. Km)	(%)
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

141



142

143 Figure 3. Spatial Extent of Landcover from 2000 to 2016

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149 Table 2: Rate of Change Analysis and Percentage Rate of Change of Landcover between  
150 2000 and 2016

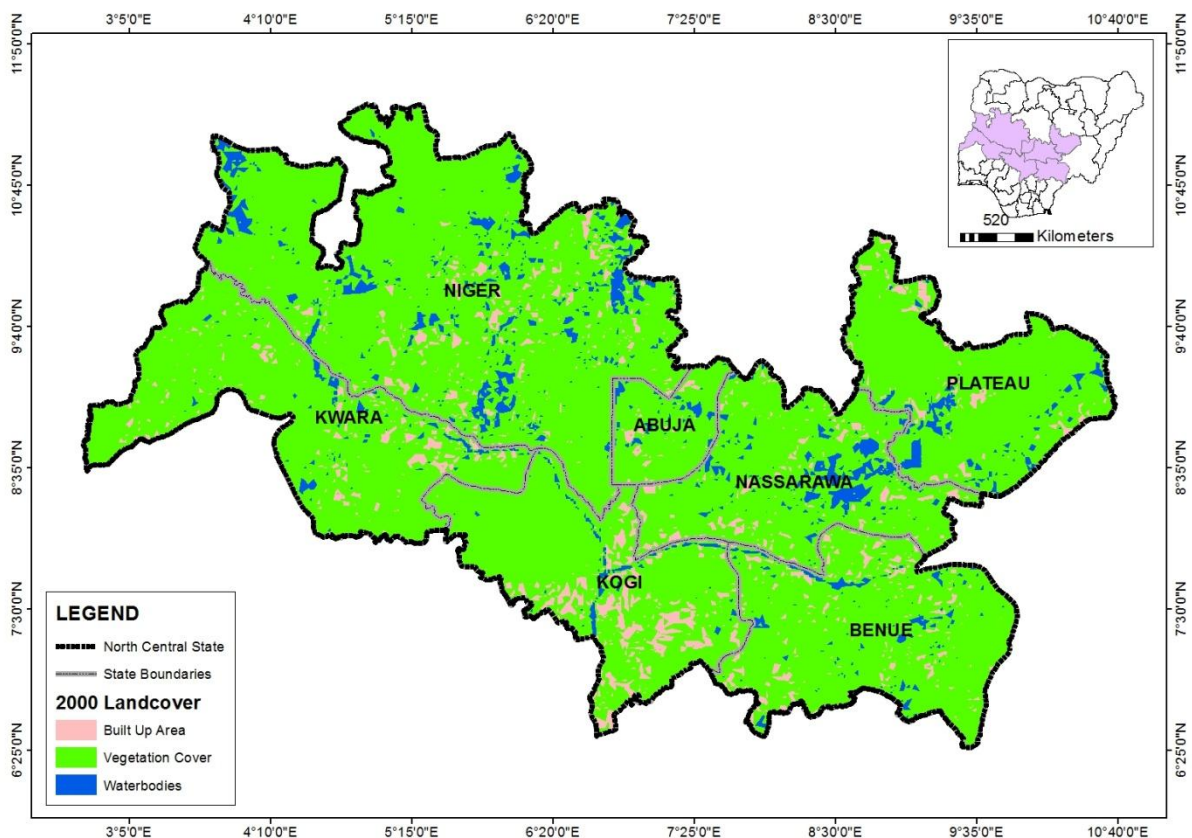
Land cover	2000-2008		2008-2016	
	Rate of Change (Sq Km)	Percentage (%)	Rate of Change	Percentage (%)
Built-Up Area	+26731.7	+111.00	+14871.75	+29.27
Vegetation Cover	-26620.67	-13.83	-23771.05	-14.33
Waterbodies	-110.98	-1.12	-105.75	-1.08

151

152 Tables 1 and 2 reveal the different land cover types, areal coverage, rate of change analysis  
153 and percentage rate of change in the three different periods of study respectively while Figure  
154 3 depicts the extent of the spatial coverage of each land cover from 2000 to 2016 in a bar  
155 chart for better illustration of the changes observed.

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

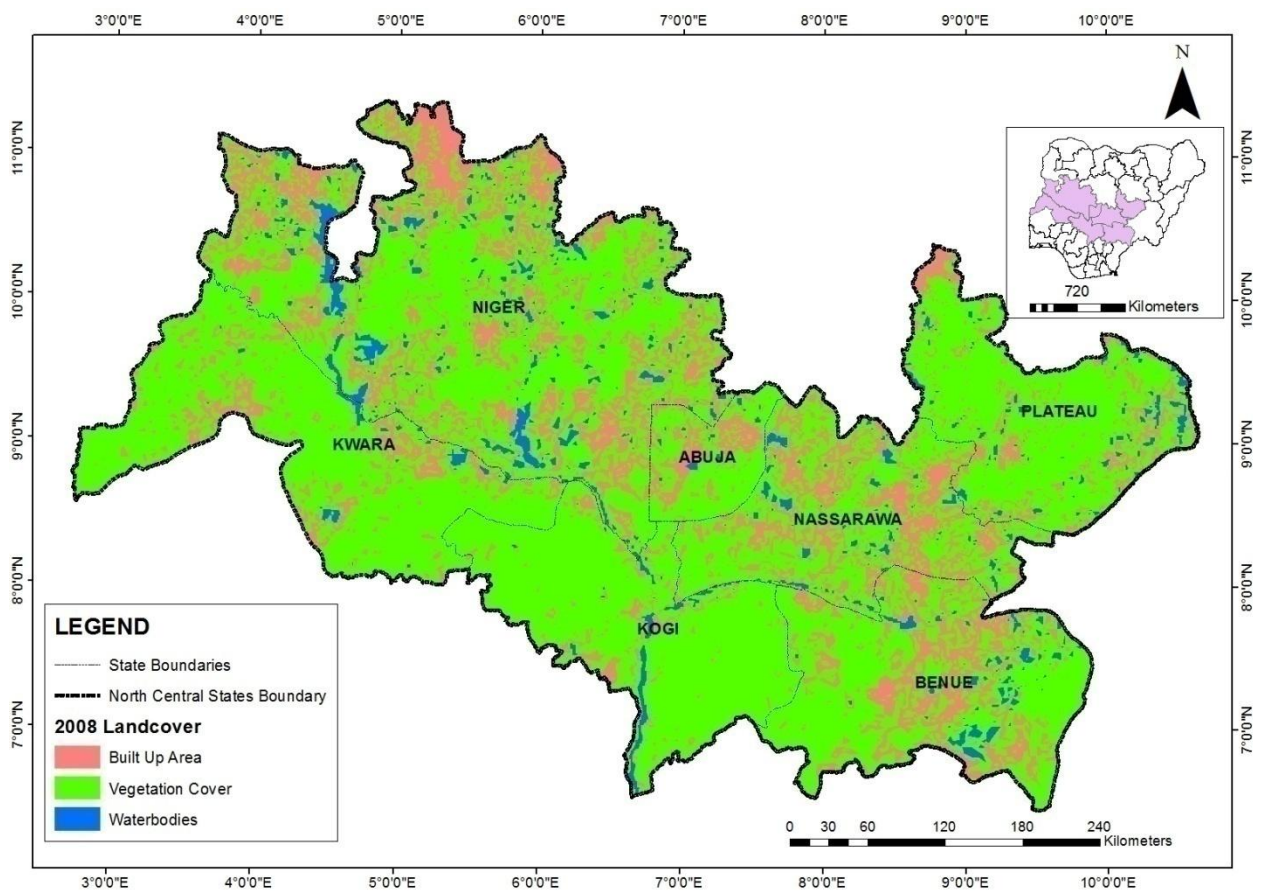
159 The results of the analysis further reveal that vegetation cover was the dominant land cover  
160 type while water bodies recorded the least during the period under investigation. This is  
161 illustrated below in the Landsat imagery obtained in 2000 (Figure 4).



162  
163 Figure 4: Land Cover of the Study Area For 2000

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

167 Secondly, encroachment on water bodies is expected as more human activities are extended  
 168 to the coastal and banks of the rivers with concomitant impact on the hydrology of the basin.  
 169 This is evident in vegetation reduction by 73.24% covering 165836.50 sq.km while water  
 170 bodies with 9784.15 sq km reduced by 4.32% and build up an area covering 50814.03 sq km  
 171 reduced by 22.44% as shown in table 2 and figure 5 respectively.  
 172



173  
 174 Figure 5: Land cover for 2008

175  
 176 The results of the analysis of land cover/ land use presented in Figure 6 reveal a progressive  
 177 decline in vegetation and water bodies from 2008 to 2016 with an increase in the built-up  
 178 area. In 2016, built-up area as land cover/ land use type increased by 29% with spatial  
 179 coverage 65685.78 sq km as reveal in table 2. Vegetation cover declined by 14.33% covering  
 180 only 62.74%. The causative factors are climatic shifts and an increase in urban growth.

181 Scholarly evidence reveals that rainfall in Northern Nigeria particularly the study area is  
 182 highly variable Ideki (2009). The variability of rainfall in terms of duration, amount and  
 183 intensity over the north-central region has resulted in dry spells and drought. Furthermore,  
 184 Olaniran (2002) asserts a progressive early retreat in rainfall in the north which could affect  
 185 crop production and food livelihood security. The observed decreasing trend in rainfall as  
 186 shown in Table 3 below indicate that markudi, Ilorin, Minna and Jos all experienced  
 187 declining rainfall trend all year round in 2016 as the MK values were all negative suggesting  
 188 decrease rainfall trend.

189 **Table 3: Mann Kendall and Sen’s Slope Statistics for SPI 12 Months Scale**

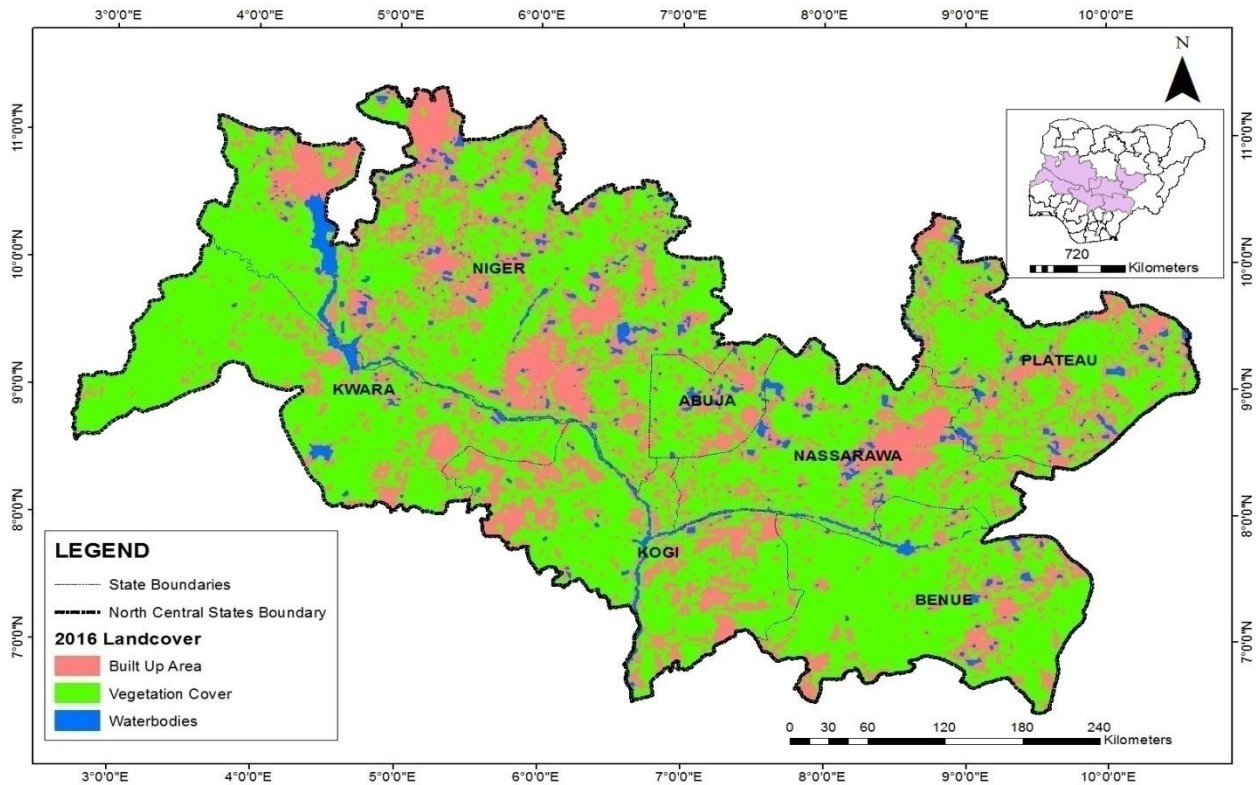
Station	Mann Kendall (Z) values	Sen slope estimate (Q) values
Makurdi	-1.01	-0.008
Ilorin	-0.22	-0.002
Lokoja	0.33	0.002
Minna	-0.01	0.000
Jos	-1.70+	-0.013
Abuja	2.08*	0.037
Lafia	2.75**	0.171

190 \*\*\* if trend at  $\alpha = 0.001$  level of significance  
 191 \*\* if trend at  $\alpha = 0.01$  level of significance  
 192 \* if the trend at  $\alpha = 0.05$  level of significance  
 193

194 Rainfall variability as shown in table 3 above, also manifest in delayed onset and early  
 195 cessation with enormous implication on land use/land cover pattern of the region. This is  
 196 because as rainfall amount reduces, people will be a constraint to a farm close to the existing  
 197 water bodies to improve soil moisture and boost crop yield. In addition to the above, erratic  
 198 rainfall in the extreme and Sahel regions of the country has pushed farmers and herders to the  
 199 north-central region for grazing and forestry products. Secondly, due to chronic poverty,  
 200 people depend heavily on fuel food for cooking resulting in massive deforestation of the  
 201 vegetation Abbas (2009).

202 Population and urbanization are other factors apart from the climate shift that also contributes  
 203 to the observed changes in the land use pattern of the study area. The North Central region is

204 the third most populous region in Nigeria with the Benue state ranked as the most populous  
 205 state (NPC, 2006). As population increase, urban growth also increases through the  
 206 construction of roads and other urban infrastructure with a concomitant effect on  
 207 deforestation, urban heat and changes in the land use and land cover Ideki, (2019).



208  
 209 Figure 6: Land cover for 2016

210  
 211 Similarly, rate of change analysis and percentage rate of change of land cover within the  
 212 period of investigation, reveal that between 2000-2008, built-up area rate of change was  
 213 26731.7 sq km at 111.00%, while vegetation cover changed at -26620.67 sq km with -13.83%  
 214 and water bodies has -110.98 its rate of change at -1.12%, this is shown in table 2 above.

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

219 The analysis performed here are consistent with previous research findings by Abass (2005),  
220 Olagunju (2008), Olajuyibe, Balogun and Adegboyega (2016) on monitoring drought and its  
221 effect on vegetation as well as similar research investigation by Fabeku and Okogbue (2014)  
222 on trends in vegetation response to drought, Omonijo and Okogbue (2014) and Fabeku and  
223 Faleyimu (2017).

## 224 **CONCLUSION**

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

233

## 234 **RECOMMENDATION**

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

- 237 • An improved understanding of the intricate relationship between human activities and  
238 the terrestrial environment. This is imperative considering the anthropogenic effect of  
239 climate change on the physical environment.
- 240 • The increase in the built-up area representing urban growth has an enormous  
241 implication on the hydrological balance of the study area. There is, therefore, the need  
242 to enact laws against forest encroachment and expansion to protect the ecosystem.

- 243 • There is a need for monitoring of the vegetation in states considered most vulnerable.
- 244 Furthermore, the study recommends sustainable forest resource management in the
- 245 region. There is a need to preserve the forest resource endowment of the study area.

246

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