

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

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3

## ABSTRACT

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

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

## 22 INTRODUCTION

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

34 environmental management due to its influence on biodiversity, water budget, radiation  
35 budget, trace gas emissions, carbon cycling, livelihoods (Verburg *et al.*, 2002), and a wide  
36 range of socio-economic and ecological processes (Desconnect *et al.*, 1997), which on the  
37 aggregate affects global environmental change and the biosphere. There are various forms of  
38 land use/land cover change. Land use can change from forest to agriculture with a huge  
39 impact on natural resources, biodiversity conservation, and water cycles. Although the land  
40 use/land cover classification process is rather subjective and it is difficult to identify a single  
41 ideal classification system (Anderson *et al.*, 1976), analysis of these changes is important in  
42 the adequate management of natural resources and the sustainable development of  
43 populations.

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

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

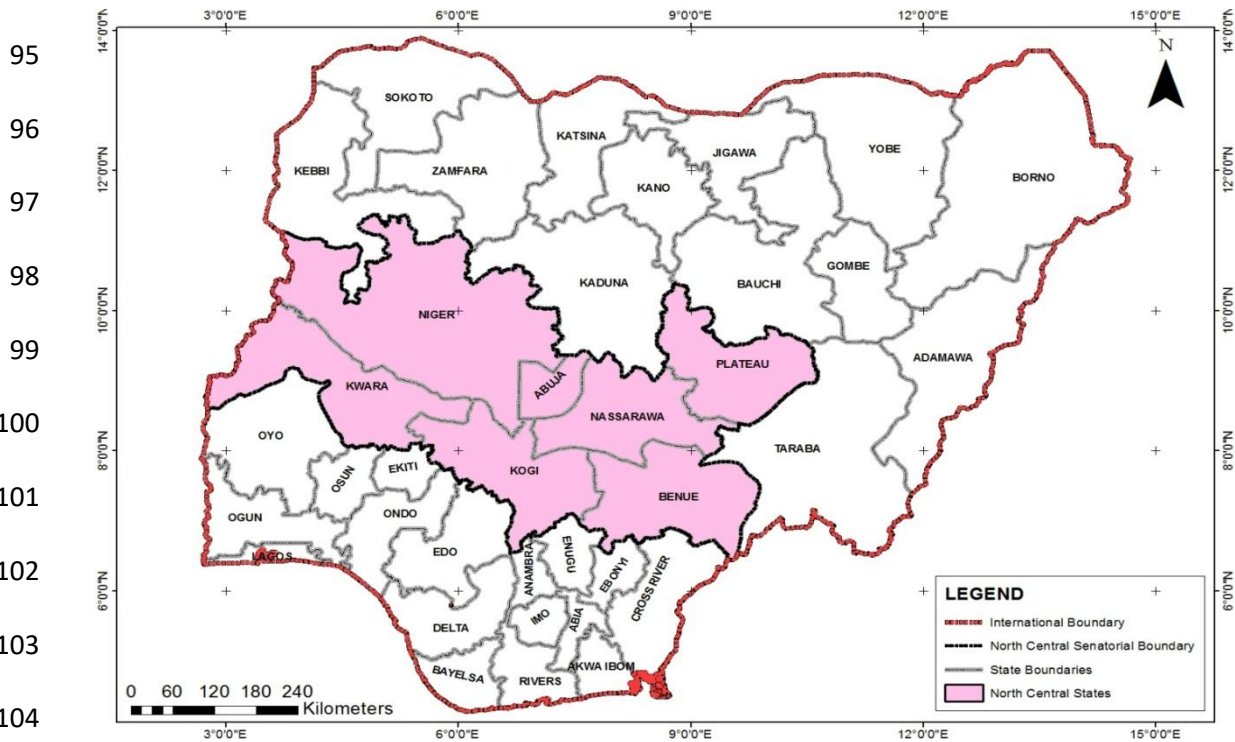
59 result indicated no significant answer. We will employ the visual analysis based on the image  
60 to image comparison method for this study which commonly used for land change detection.  
61 In Nigeria particularly in the central region, there is a dearth of empirical work on this subject  
62 matter. Abbas (2009) examined an overview of land cover changes in Nigeria between 1975-  
63 2005 where it was noticed that significant loss of arable land in Northern Nigeria occurred.  
64 It was established in the study that the savannah vegetation in the central states is fast  
65 transiting into the pure Sahel due to the influence of desertification and drought. Findings of  
66 the above research confirmed the recent security crises between herdsmen and farmers in the  
67 central states are manifestations of drought-induced land use changes in the North. It is this  
68 attempt to bridge the existing gap in the literature that further necessitates this study.

## 69 **STUDY AREA**

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

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

94



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

106 **MATERIALS AND METHODS**

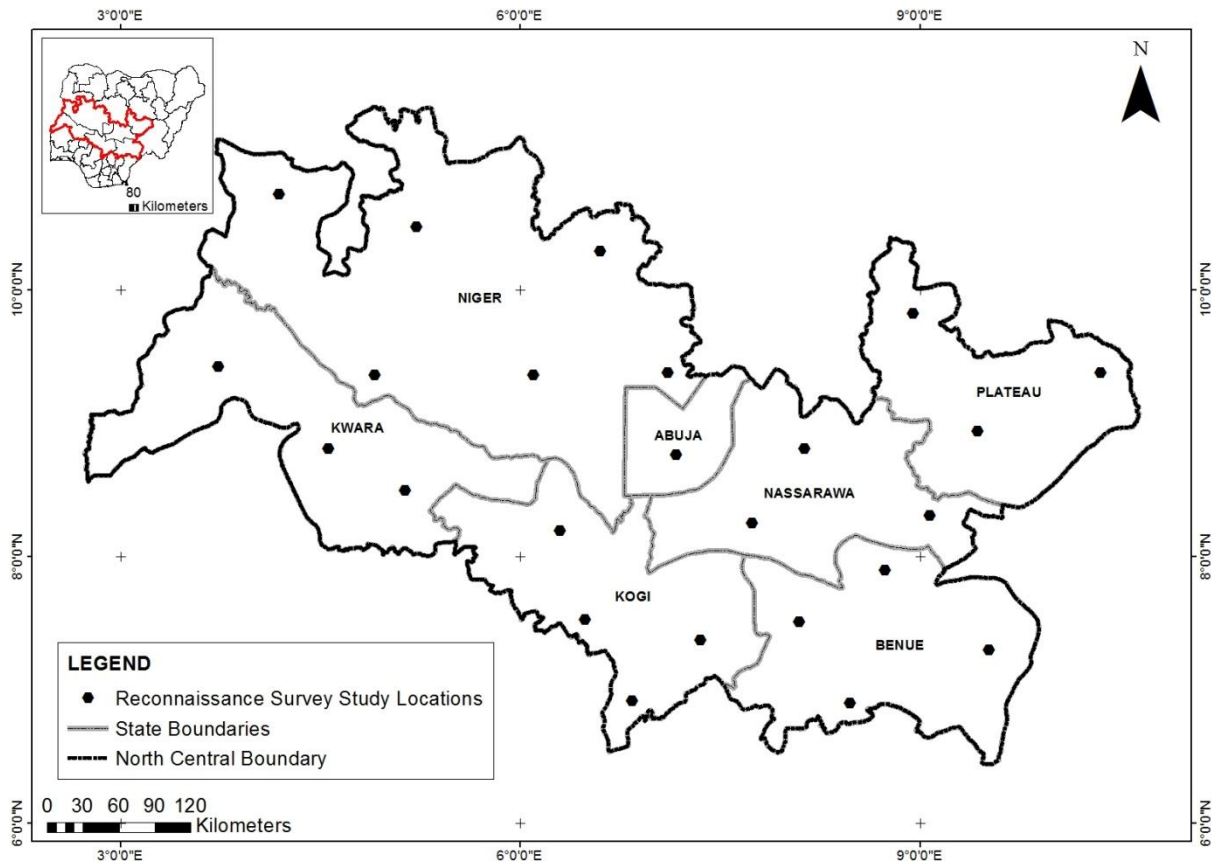
107 In order to assess land cover/land use change and its implication on drought frequency in the  
108 study area, a change detection analysis was performed to determine the nature, extent and rate  
109 of change over time and space.

## 110 **IMAGE GEO-PROCESSING FOR LANDUSE CHANGE AND PERCENTAGE** 111 **CHANGE**

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

130 
$$\frac{\left(\frac{d}{t1}\right) * 100}{y2-y1}$$

131 Where,  $d$  is the difference in the value of area covered by a land cover category at the initial  
 132 time point and final time point  
 133  $t_1$  is the value of the area covered by a land cover category in the initial time point  
 134  $y_1$  and  $y_2$  are the base year and final year respectively.  
 135



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

138  
 139 **RESULTS AND DISCUSSION**

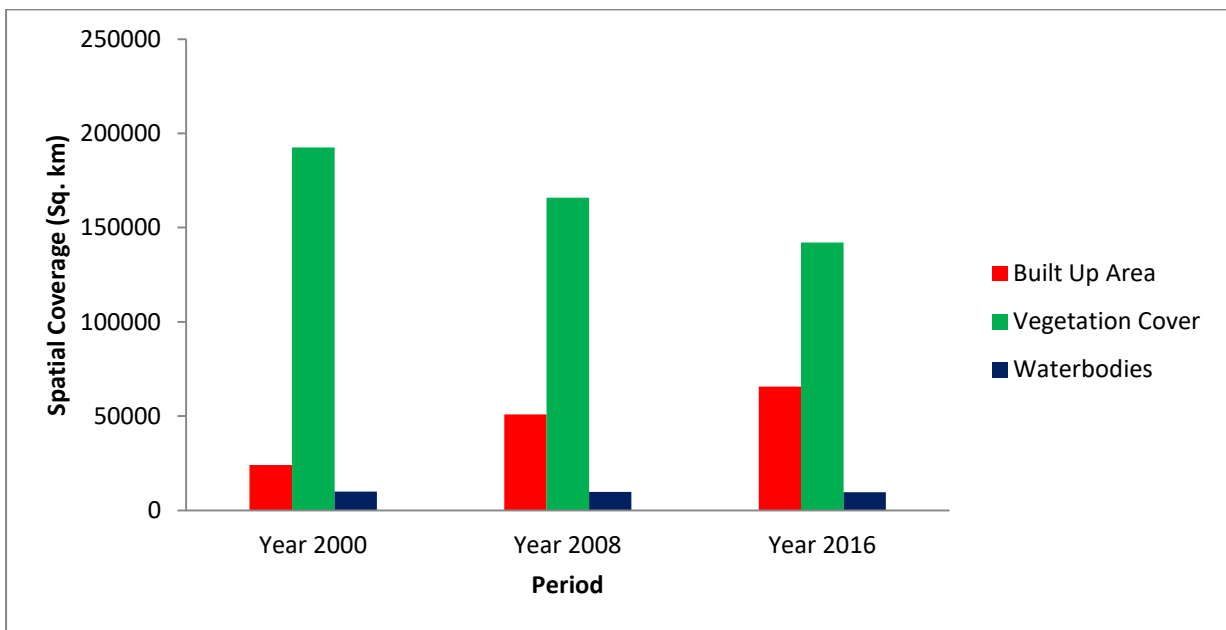
140 The results of the analysis are presented below:

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

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

	Km)		Km)		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

142



143

144 Figure 3. Spatial Extent of Land cover from 2000 to 2016

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150 Table 2: Rate of Change Analysis and Percentage Rate of Change of Landcover between  
151 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

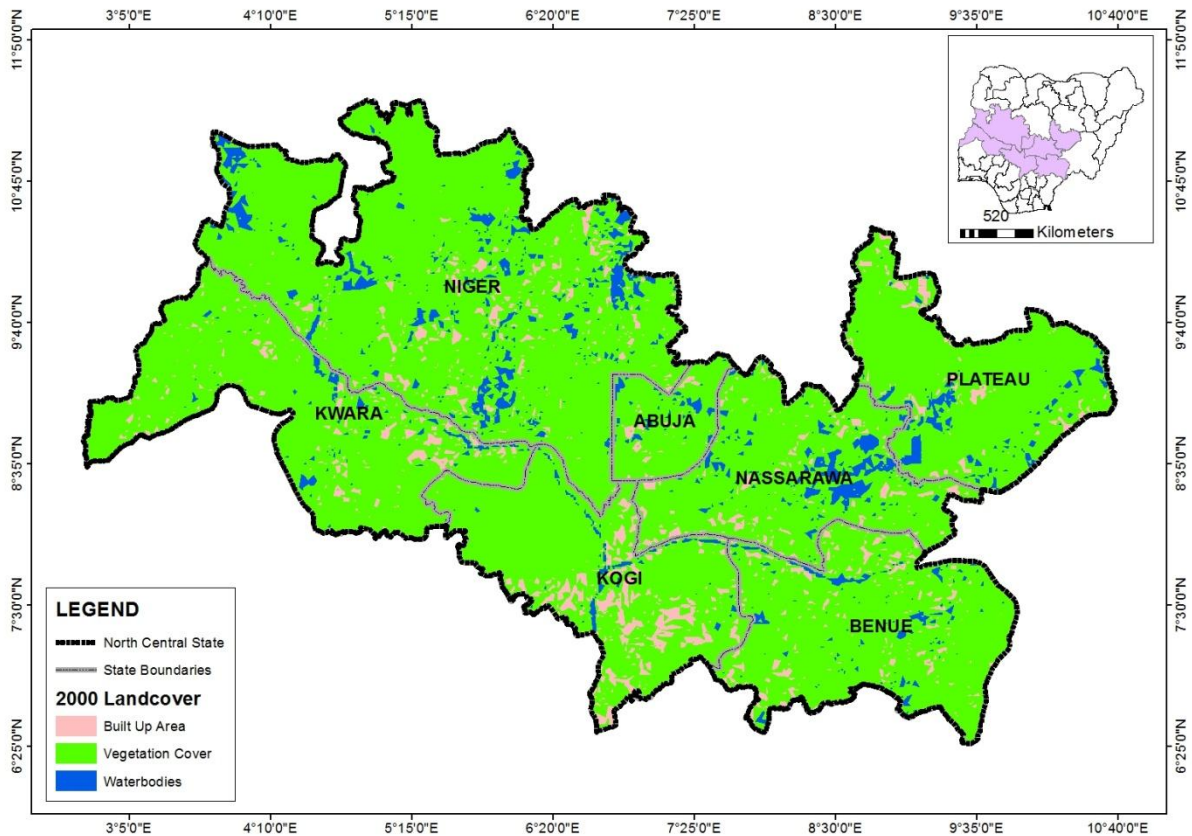
Vegetation Cover	-26620.67	-13.83	-23771.05	-14.33
Waterbodies	-110.98	-1.12	-105.75	-1.08

152

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

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

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



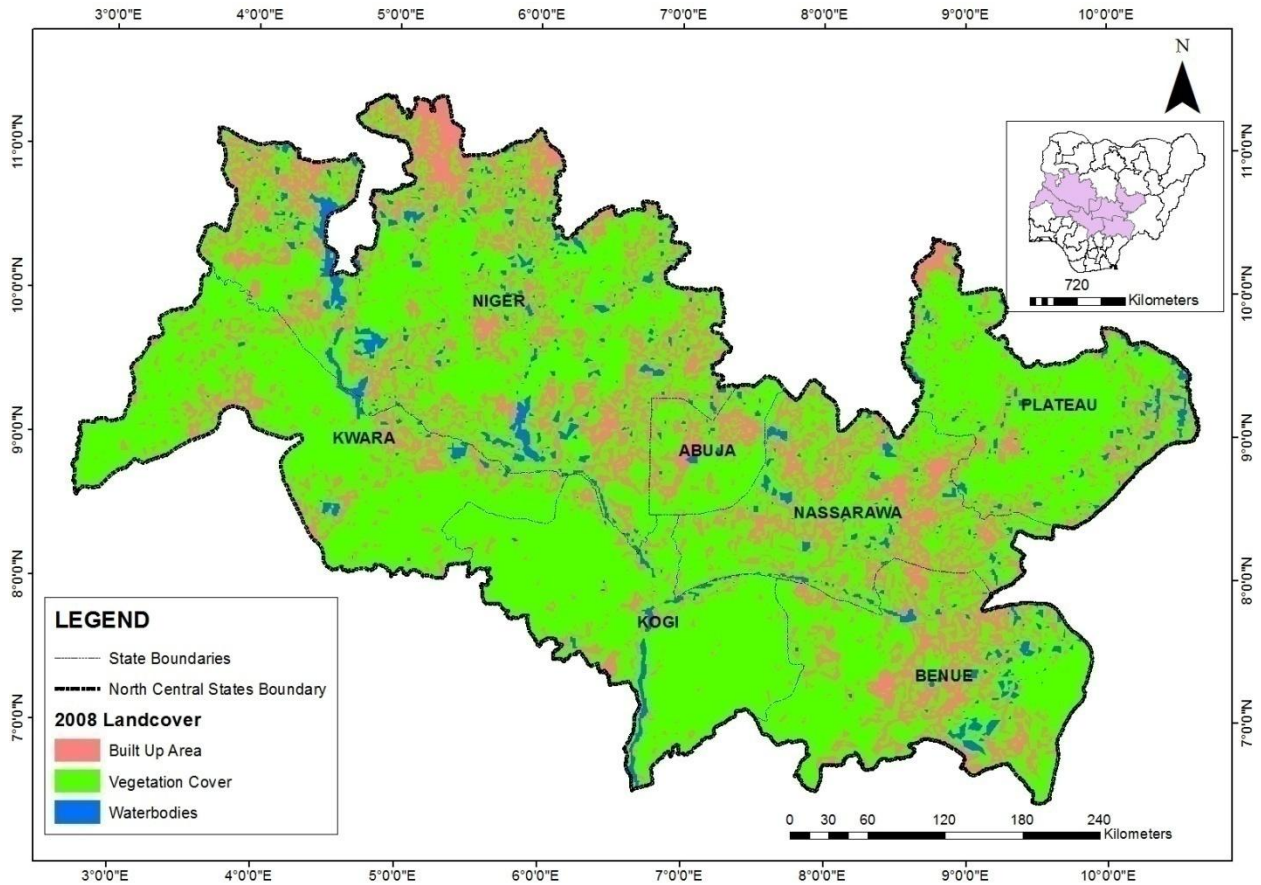
163  
164 Figure 4: Land Cover of the Study Area For 2000

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

168 Secondly, encroachment on water bodies is expected as more human activities are extended  
169 to the coastal and banks of the rivers with concomitant impact on the hydrology of the basin.

170 This is evident in vegetation reduction by 73.24% covering 165836.50 sq.km while water  
171 bodies with 9784.15 sq km reduced by 4.32% and build up an area covering 50814.03 sq km  
172 reduced by 22.44% as shown in table 2 and figure 5 respectively.

173



174

175 Figure 5: Land cover for 2008

176

177 The results of the analysis of land cover/ land use presented in Figure 6 reveal a progressive  
 178 decline in vegetation and water bodies from 2008 to 2016 with an increase in the built-up  
 179 area. In 2016, built up area as land cover/ land use type increased by 29% with spatial  
 180 coverage 65685.78 sq km as reveal in table 2. Vegetation cover declined by 14.33% covering  
 181 only 62.74%. The causative factors are climatic shifts and an increase in urban growth.  
 182 Scholarly evidence reveals that rainfall in Northern Nigeria particularly the study area is  
 183 highly variable Ideki (2009). The variability of rainfall in terms of duration, amount and  
 184 intensity over the north central region has resulted in dry spells and drought. Furthermore,  
 185 Olaniran (2002) asserts a progressive early retreat in rainfall in the north which could affect  
 186 crop production and food livelihood security. The observed decreasing trend in rainfall as  
 187 shown in Table 3 below indicate that markudi, Ilorin, Minna and Jos all experienced

188 declining rainfall trend all year round in 2016 as the MK values were all negative suggesting  
 189 decrease rainfall trend.

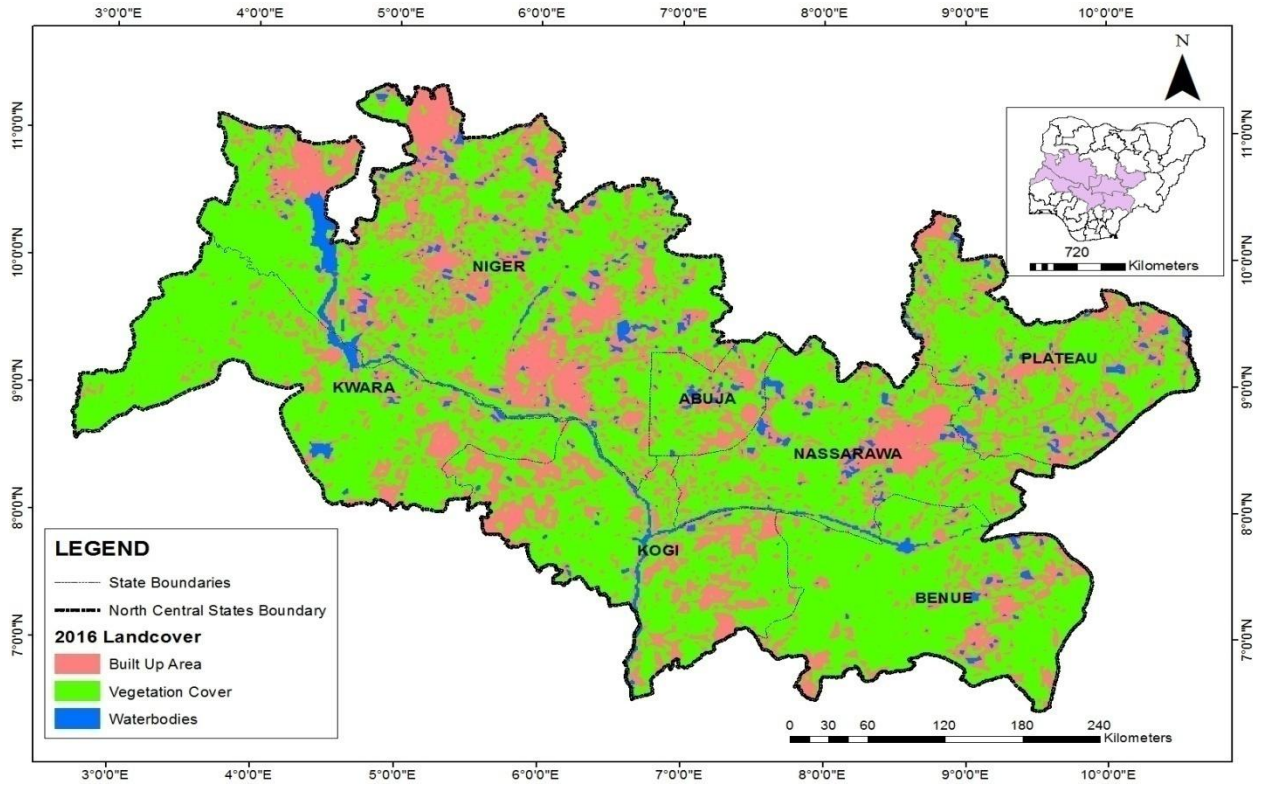
190 **Table 3: Mann Kendall and Sen’s Slope Statistics for SPI 12 Months Scale**

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

191 \*\*\* if trend at  $\alpha = 0.001$  level of significance  
 192 \*\* if trend at  $\alpha = 0.01$  level of significance  
 193 \* if the trend at  $\alpha = 0.05$  level of significance  
 194

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

203 Population and urbanization are other factors apart from the climate shift that also contributes  
 204 to the observed changes in the land use pattern of the study area. The North Central region is  
 205 the third most populous region in Nigeria with the Benue state ranked as the most populous  
 206 state (NPC, 2006). As population increase, urban growth also increases through the  
 207 construction of roads and other urban infrastructure with a concomitant effect on  
 208 deforestation, urban heat and changes in the land use and land cover Ideki, (2019).



209  
210 Figure 6: Land cover for 2016

211

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

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

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

225 **CONCLUSION**

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

234

235 **RECOMMENDATION**

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

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

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