



Land Use and Its Implication on Natural Environment of Donga LGA, Nigeria

Adelalu Tope Gabriel^{1*} and Zemba Ambrose Audu²

¹*Department of Geography, Taraba State University, Jalingo, Nigeria.*

²*Department of Geography, Modibbo Adama University of Technology, Yola, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Author ATG designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author ZAA managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/PSIJ/2017/37098

Editor(s):

(1) Yichi Zhang, Key Laboratory of Water Cycle & Related Land Surface Processes, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, China.

(2) Christian Brosseau, Distinguished Professor, Department of Physics, Université de Bretagne Occidentale, France.

Reviewers:

(1) Augrey H. Malambo, University of Zambia, Zambia.

(2) Joel Efiog, University of Calabar, Nigeria.

Complete Peer review History: <http://www.sciencedomain.org/review-history/22446>

Original Research Article

Received 30th September 2017

Accepted 30th November 2017

Published 26th December 2017

ABSTRACT

The study assessed land use and land cover changes and its effect on the communities in southern Taraba specifically in Donga. The paper identify and delineate different LULC categories, evaluates the rate of change that occurred and examine the implication on incessant flooding using multi-temporal satellite imageries of three different time periods, i.e Landsat Thematic Mapper (TM) of 2000, 2012 and 2016 acquired from USGS sites. Area calculations of the arc GIS 10.1 software were used to derive the trends, rates, and magnitude of changes while map overlay was employed for assessing the nature and location change. The images of the study area were categorized into five different classes namely water body, built up, vegetation, bare land and rock outcrop. The implication of LULC change on flooding incidence in the study area was analysed by an interaction with local communities through personal interaction with focus group and usage of questionnaire. The results reveal that barely two decades, built- up and bare land have been increased by 4% (137.7021 km²), and 12% (409.8324 km²) while vegetation, water body and rock outcrop have decreased by 16% (541.1142 km²), 0.08% (2.5924 km²) and 0.1% (3.8279 km²) respectively. Based on the interview conducted, 93% of the respondents are attestants to the fact that flooding is on the increase and 47% affirmed that increase in rainfall intensity is the major cause. Even though only

*Corresponding author: E-mail: adelalutopegabriel@yahoo.com;

8% of the respondents adduced flooding to change in land use and land cover, the analysed imageries show that between the spaces of 16 years, the present built up area is fifth times of the capture in the year 2000 and that 16% of the vegetation cover has disappeared for other use. The understanding of the intricacy of nature and the influence of land use and land cover change on the farming community is of necessity, more especially as the climate change and the government look inward to divert from mono economy. The dependency on land and land cover could increase in order to get out of this present recession as agricultural sector top the recovering agenda in the Nation.

Keywords: Land use/land cover; deforestation; encroachment; flooding; recession; Nigeria.

1. INTRODUCTION

Human beings have been modifying land for her succor to obtain food, fuel and shelter and other essentials of life for thousands of years. The modification manifest in indiscriminate clearing of forest areas; shifting agriculture; forest and bush burning; cultivation of hill slopes without any anti-soil erosion measures; reckless housing site development; faulty road construction methods and indiscriminate quarrying which have been associated to flooding [1]. [2] posited that, the vegetation of North-eastern Nigeria has been drastically reduced since the 1970s through the exploitation of natural forests for timber production or firewood and conversion to agricultural land. The observed pattern of change in land use has multifarious implications in these areas itself and the global environmental sustainability at large.

Understanding the complexity of Land Use and Land Cover (LULC) changes and their drivers at local level is essential to better understand the relationship between human and the environment [3]. The land covers are natural resources, natural biofilters, and erosion stabilizers protecting the land from direct punch of rainfall there by reducing the sedimentation load that would have find their course unto the river resulting to ache to aquatic animals consequently leading to flooding. There is need to understand the biophysical and human causes of land use and land cover change, because land use and land cover pattern and dynamics affect the structure and function of the earth ecosystem [4]. It could lead to a decreased availability of different products and services for human, livestock, agricultural production and damage to the environment. Such changes also determine, in part, the vulnerability of places and people to climatic, economic or socio-political perturbations [5]. Other effect includes road submergence preventing easy transportation of goods and services. Still in this axis it was submitted that

flooding as a result of Land use change could have link with Skirmish [6,7].

Irrespective of location, erosion losses as a result of flooding are usually very small from forestland or permanent pastureland and reverse is the case when it is denuded. According to [8], factors contributing to the frequency and severity of flooding in an area include: Rainfall intensity and duration; antecedent moisture condition; changes in landscape resulting from wild fires, the existence of attenuating features, like levees and flood control channel; velocity of flow; availability of sediment for transport, and the erodibility of the bed and banks of the water course; watershed conditions, such as steepness of terrain, soil types, amount of vegetation, and density of development.

In Nigeria, [9] have assessed the land use/land cover change in Lagos for the period of 20 year due to rapid development. [10] analysed the land use and land cover dynamics in Jalingo with a view to highlight the implications on the existing arable lands and food security. Only few researches have been done on the effect of the surrounding LULC change has on local and regional precipitation and consequent flood especially in Donga.

In Donga, flooding is now an annual occurring event especially after heavy rainstorm which is further worsened by the nature of the topography of the area [11]. This suggest, a need for a detailed and methodology- proven regional assessment of many areas especially the North-East and specifically Donga. This will exhibits the region's status to vulnerability to climate change (flooding) as this seems to have alliance with the Land use. The focus of this paper is to consider the configuration (shape and spatial arrangement) of land uses/land cover types, causes of the land use changes and its contribution to incessant flooding in Donga using geospatial technique.

2. STUDY AREA

Donga is a local Government Area in Taraba State, Nigeria. Its' headquarter is in the town of Donga on the Donga River at $7^{\circ} 48' 00''$ N $10^{\circ} 03' 00''$ E and 7.71667° 10.05000° E (Fig. 1). It has an area of about 3,420 km². It is a commercial centre which attracts people from many parts of neighbouring local government of the state like Takum, Wukari, Bali, Gassol. Not only that, it is also centre for administrative activities. Donga is well connected to the other part of the state with good transportation networks. These networks also give room for interstate trading in hide and skin especially fish business from River Donga.

The Donga River arises from the Mambilla Plateau in Eastern Nigeria, form part of the international border between Nigeria and

Cameroon, and flows northwest to eventually merge with the River Benue. The Donga watershed is about 20000 square kilometres in area. At its peak, near the Benue the river delivers 1800 cubic meters of water per second [12]. The watershed fall within the Guinea Savanna Zone with thick vegetation cover with tall grass and tree. The vegetation patterns show faithful reproduction of rainfall pattern. Like the rainfall, which is higher in the south and reduces as one progress toward the north, the vegetation is also so pattern [13] with annual rainfall of between 1000mm and 1200mm. According to [13], heavy rainfall promotes leaching and corrosion in the area. These two processes, he added that during the dry and wet season gives rise to lateritic soil. However, soil and hydrology of the place allow the cultivation of most staple foods and grazing lands for animals.

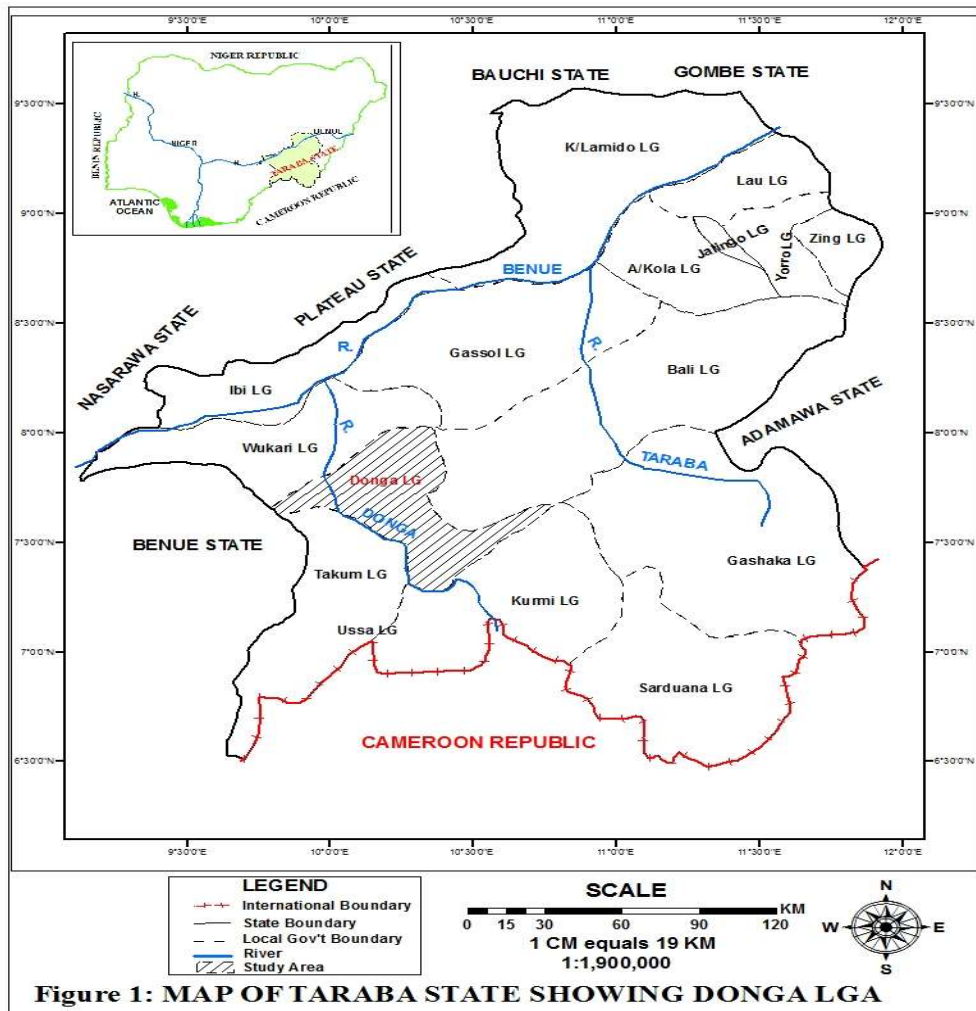


Figure 1: MAP OF TARABA STATE SHOWING DONGA LGA

From 1999 to 2006, population of this area rose from 84,626 and the total population on board was 134,111 at the 2006 census, with overall density of over 43 persons per square kilometers. [13] Submitted that soil fertility which is obtained through fallow period has been continuously shortened through increase in population and continuous cropping of the land. Increased population could generate increased pressure on the sustainability of land resources and environmental condition.

3. DATA SOURCES AND METHODOLOGY

3.1 Data Sources and Type

The main images that were acquired for the assessment of the land use and land cover change are that of 2008, 2012 and 2016 (Table 1). These were obtained from earth explorer site (<http://earthexplorer.usgs.gov/>). The three images were acquired between June and July, which is on-season and also fall within the period of wet season, hence the vegetation cover and land-use types appear the same on the images regardless of the year they were obtained [14] cited in [15]. It most need be pointed out that no specific reservation in mind for choosing these images. The idea was to capture the trend of the land use in the study area. Also political boundary and not the catchment or drainage areas were delineated in the work. To derive information on the socioeconomic and environmental changes and its connecting implications on flooding, 131 questionnaires of 17 items were also meted out.

3.2 Image Classification and Change Detection Analysis

To Classify the images into the respective themes, the supervised approached to classification was adopted using Arc GIS 10.1 software. The images were classified into five

major classes: water body, built up, vegetation, bare land and rock outcrop. Maximum likelihood classification algorithm technique was adopted. Area calculations of the arc GIS 10.1 software was used to derive the rates and magnitude of change. The extent and nature of change for the period of 2000 to 2016 years was ascertained by map overlay. Following [16], the following steps were carried out for the derivation of the changes in the study area:

- i) Calculation of the magnitude of change. This was derived by subtraction of observed change of post from the previous period of years.
- ii) Calculation of the trends: The percentage change of each of the land-use. This was done by subtracting the percentage of the previous land-use, from the present land use. Then the difference divide by the total land area multiplied by hundred.
- iii) Finally, calculation of the annual rate of change was by dividing magnitude change by number of study years.

4. RESULTS AND DISCUSSION

This section presents and analyses the data that were collected through the administration of questionnaire in the study area.

4.1 Socio- Demographical Characteristics of Respondents

The demographic status depicts that 91% of the sampled respondents are male. Of this were 53% and 47% from Fada and GyataAure respectively while 9% are female. Table 3 shows the age group of the respondents. The demographic data reveals 5% of the respondents below age 20. 31% were between age 21 and 30. Between ages 31 to 40, we have 29% of the respondents in this category while 35% of the respondents are above age 40.

Table 1. Date type and sources

Type	Acquisition date	Dimension (in pixel)	Actual spatial resolution	Acquisition source
Landsat 7 (Thematic Mapper)	July 2000	379 × 279	30 × 30	USGS
Landsat 7 (Thematic Mapper)	June 2012	379 × 279	30 × 30	USGS
Landsat 8 (Thematic Mapper)	July 2016	379 × 279	30 × 30	USGS

Source: Compiled by the authors

Table 2. Sampled wards and gender of respondents

Wards	Sex		Frequency	Percentage
	Male	Female		
Fada	63	8	71	54
Gyata Aure	56	4	60	46
Total	119	12	131	100

Source: Field survey, 2017

Table 3. Age group of the respondents

Age group	Frequency	Percentage (%)
Below 20	6	5
21-30	40	31
31-40	38	29
Above 40	47	35
Total	131	100

Source: Field survey, 2017

Table 4 shows the occupational status of the respondents. It is obvious that majority in the chosen wards are into farming business 61.8%. About 20% are engaged in Trading or Business. About 7 and 10% earn their livelihood through Artisan and white collar job respectively. It was also observed that there are ample numbers of respondents that engaged in two or more occupations.

Table 4. Occupational Structure of the Respondents

Variables	Frequency	Percentage (%)
Farming	62	47.3
Fishing	19	14.5
Trading/ Business	26	19.8
Artisan	9	6.9
Civil	13	9.9
Servant		
Others	2	1.5
Total	131	100

Source: Field survey, 2017

Table 5. Respondents years in Cultivation

Years in farming	Frequency	Percentage (%)
Below 10	2	3.2
11-20	11	17.7
21-30	21	33.9
31-40	19	30.6
Above 40	9	14.5
Total	62	100

Source: Field survey, 2017

The researchers believed that those inhabitants especially long term residents could have a reasonable idea of the extent of flooding in the

locality. The questions in Table 6 sought to ascertain how long the respondents have lived in the area. Close to 90% of the respondents had been in the study area for more than 20 years. It is assumed that they have a better chance of relating the story better.

Table 6. Duration of Respondents stay in the study area

Variables (Years)	Frequency	Percentage (%)
Below 10	11	8.4
11-20	62	47.3
21-30	38	29
31-40	11	8.4
Above 40	9	6.9
Total	131	100

Source: Field survey, 2017

Table 7. Perceived causes of Incessant flooding in the study area

Variables (causes)	Frequency	Percentage (%)
Floodplain	49	37.4
Encroachment		
Increase Rainfall intensity	61	46.6
Land use change (Deforestation, Constructions etc)	11	8.4
Low land area	10	7.6
Total	131	100

Source: Field survey, 2017

Regarding the incessant flooding in the study area, number one on the list on the general perception of the respondents who have lived more than 20 years and above in the study area locality affirmed that there has been increase in the rainfall intensity. About 47% of the respondents are attestants to this (Table 7). This corroborates the findings of [15]. Floodplain encroachment accounts for 37% while about 8% of the respondents support the fact that the low land terrain is the cause of the flooding. Even though only 8% of the respondents adduced

flooding to change in land use and land cover, the analyzed imageries show that between the spaces of 16 years, (2000-2016) the present built up area is fifth times of the capture in the year 2000 and that 16% of the vegetation cover has disappeared for other use (Fig. 3).

As regard whether the respondents are aware of the flood on decrease or increase, 93% (122) indicate that the flood is on increase every year (Table 8).

This section presents and analyses the data that were collected through the imageries in the study area.

4.2 Changes in Land Use/ Land Cover (2000, 2012 and 2016)

In this research, the imageries of 2000, 2012, and 2016 were evaluated and the obtained data

depicting the changes involved are summarized as follow:

4.3 Changes in Land Use/ Land Cover, 2000-2016

During this period, the built-up area increased by 137.7021 Km² (4%) with an annual rate of change of 8.6064 Km². The bare land also increased by 409.8324 Km² (12%) This increased were lost from the vegetal cover. Vegetal cover thus, lost as much as 541.1142 Km² (16%) with annual rate at 33.8196 Km². There is also change in the rock outcrop of about 3.8279 Km² (0.1%) with an annual rate of 0.2392 Km². The least change was in water body with decrease of about 2.5924 Km² (0.08%) having annual rate of change of about 0.1620 Km² (Table 11). The change trends are also graphically presented in Fig. 3.

Table 8. Respondents Response on flood Incidence in Donga

Wards	Sex		Frequency	Reduction in flooding	Increase in flooding	Indifferent
	Male	Female				
Fada	63	8	71	03	68	-
GyataAure	56	4	60	01	54	05
Total	119	12	131	04(3%)	122(93%)	05(4%)

Source: Field survey, 2017

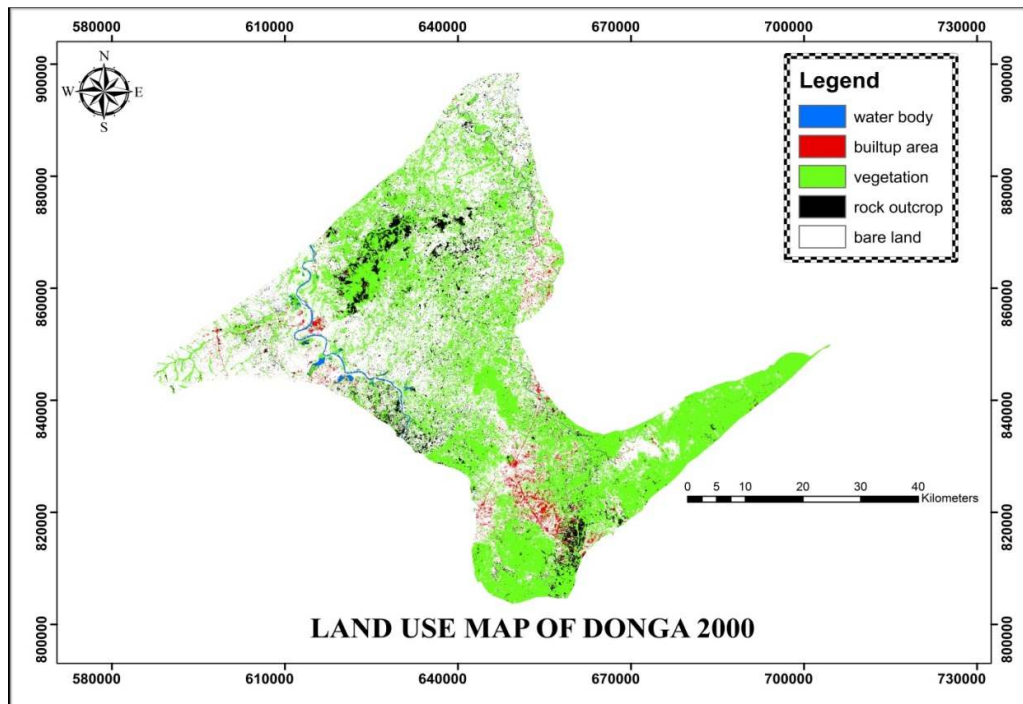


Fig. 2a. Land use/cover status of Donga in 2000 (Based on Landsat Thematic Mapper Satellite Imagery)

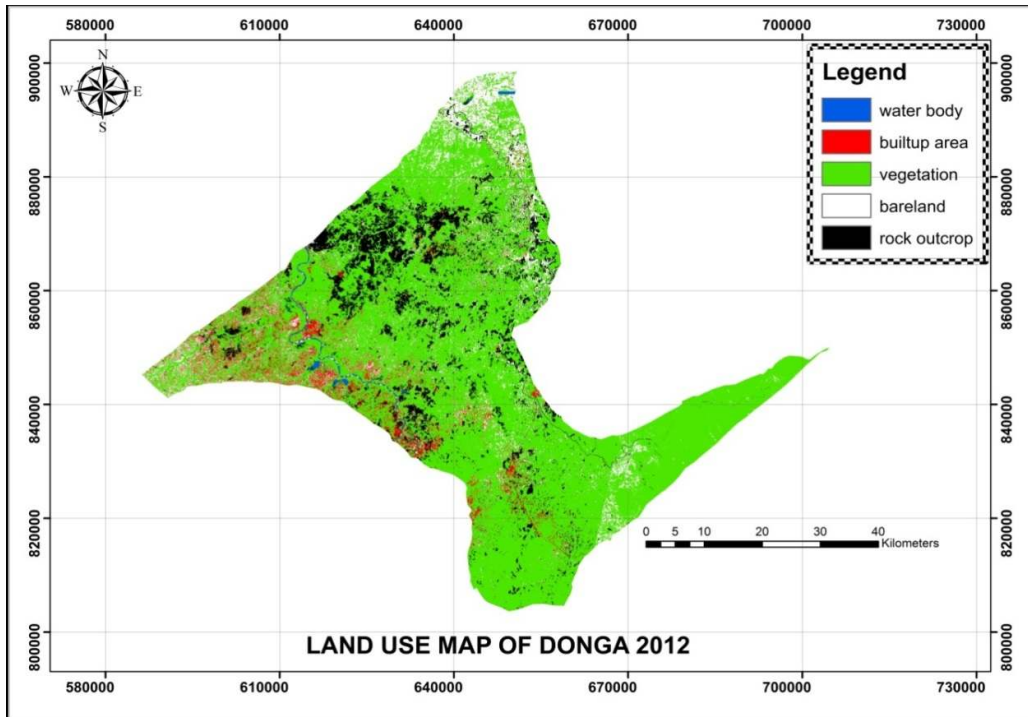


Fig. 2b. Land use/cover status of Donga in 2012 (Based on Landsat Thematic Mapper Satellite Imagery)

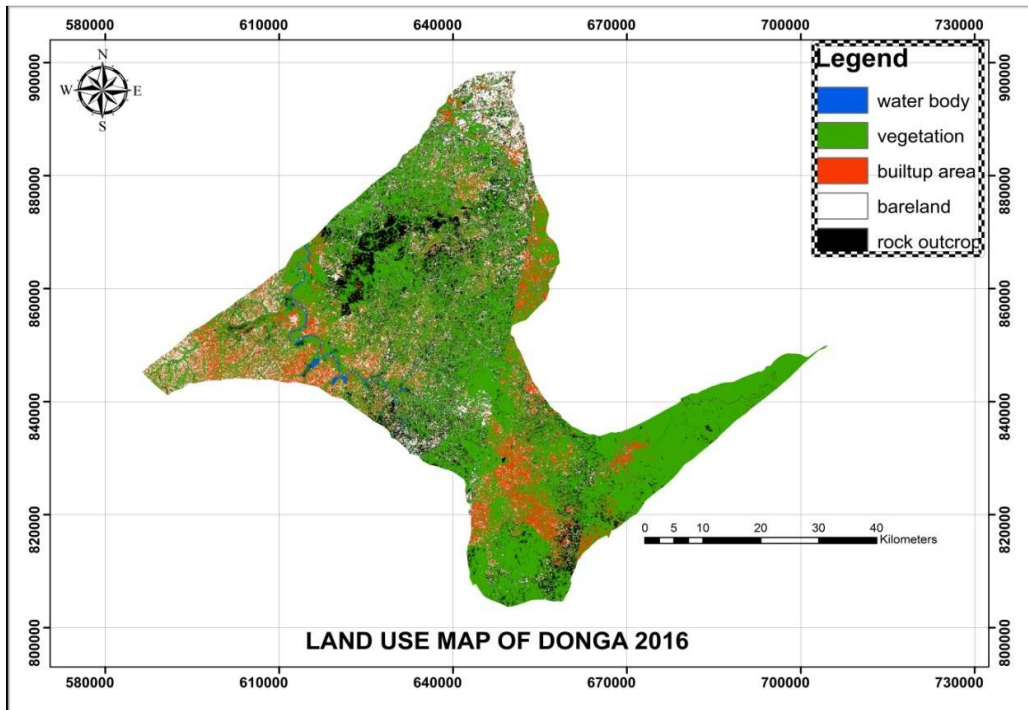


Fig. 2c. Land use/cover status of Donga in 2016 (Based on Landsat Thematic Mapper Satellite Imagery).

Table 9. Land Use/Land Cover (LULC) classification and area extent change between 2000 and 2016 in Donga

LULC classes	2000	%	2012	%	2016	%
	Area (Km ²)		Area (Km ²)		Area (Km ²)	
Water body	20.7368	0.6	20.6352	0.6	18.1443	0.5
Builtup area	34.3099	1	83.8213	2.4	172.0121	5.1
Vegetation	1770.9421	51.7	1496.7472	43.7	1229.8279	35.9
Bareland	1380.2624	40.3	1605.2726	46.9	1790.0948	52.3
Rock outcrop	213.8568	6.4	213.6316	6.2	210.0288	6.2
Total	3420.1080	100	3420.1080	100	3420.1080	100

Source: Fieldwork, 2017 classified satellite imageries

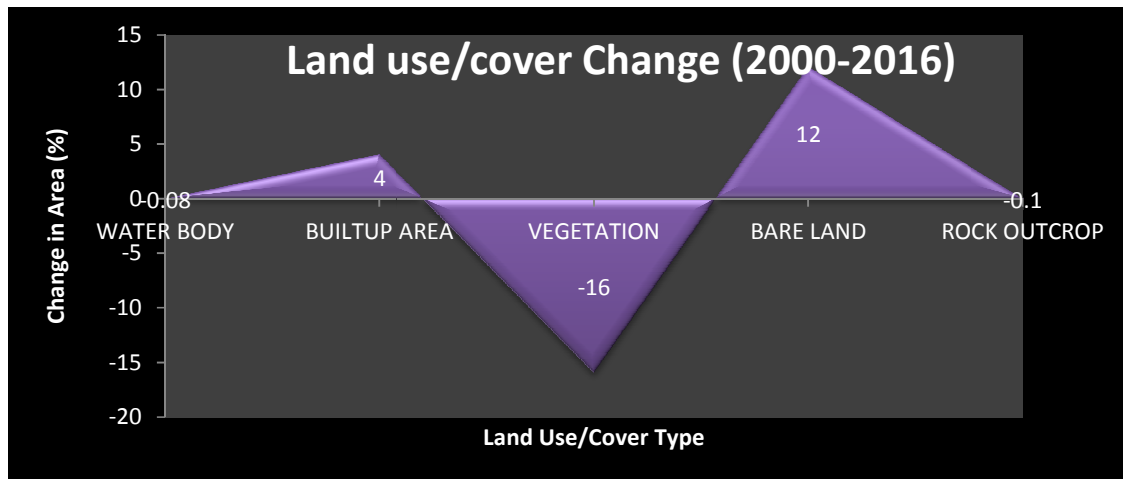


Fig. 3. Diagrammatic illustration of land use/land cover change in percent between (2000 and 2016) in Donga

Table 10. Area and total change in land use/land cover categories in Donga during the year 2000-2016

Land use	2000(Km ²)	2016 (Km ²)	Change (Km ²)	%
Water body	20.7368	18.1443	-2.5924	-0.0800
Built up area	34.3099	172.0121	+137.7021	4.0000
Vegetation	1770.9421	1229.8279	-541.1142	-16.000
Bare land	1380.2624	1790.0948	+409.8324	12.000
Rock outcrop	213.8568	210.0288	-3.8279	-0.1000
Total	3420.1080	3420.1080	0.0000	0.0000

Source: Authors' Data Analysis

Table 11. The magnitude, percentage and annual rate of change in Donga (2000-2016)

Land use	2000(Km ²)	2016 (Km ²)	Change (Km ²)	%	Annual rate of change	Remark
Water body	20.7368	18.1443	-2.5924	-0.0800	0.1620	Negative
Built up area	34.3099	172.0121	+137.7021	4.0000	8.6064	Positive
Vegetation	1770.9421	1229.8279	-541.1142	-16.000	33.8196	Negative
Bare land	1380.2624	1790.0948	+409.8324	12.000	25.6145	Positive
Rock outcrop	213.8568	210.0288	-3.8279	-0.1000	0.2392	Negative
Total	3420.1080	3420.1080	0.0000	0.0000	0.0000	

Source: Authors' Data Analysis

5. CONCLUSION AND RECOMMENDATION

The study reveals that the major land use in the study area is vegetation. The area under vegetation has decreased by 16% (541.1142 Km²) this is possibly not unconnected to logging and construction purposes. Logging with the common motor power handsaw is generally the daily notable activity of the teaming unemployed youths in Donga of recent. During the study period i.e (2000-2016), built up area has increased by 4% (137.7021 Km²). Construction of Donga bridge and rural roads by the Danbaba Danfulani Suntai administration with accumulation of income opportunities, and facilities along the road head were found as pull factors leading to increase in built up area. Closely follow to this is the bare land. Bare land area account for about 12% (409.8324 Km²) for the same reason that may not be too far from above discussed and as a result of some serious mining of granite for road construction.

As the amount of vegetation decreases and density of development increases, especially as the nation diversifies now, there is likelihood of increased erosion and flooding. 93% of the respondents are attestants to the fact that flooding is on the increase and 47% affirmed that increase in rainfall intensity is the major cause. Even though only 8% of the respondents adduced flooding to change in land use and land cover, the analysed imageries show that between the spaces of 16 years, the present built up area is fifth times of the capture in the year 2000 and that 16% of the vegetation cover has disappeared for other use.

The dependency on land and land cover could increase in order to get out of this present recession as agricultural sector top the recovering agenda in the Nation. So, the understanding of the intricacy of nature and the influence of land use and land cover change on the farming community is of necessity, more especially as the climate change and the government look inward to divert from mono economy. The increased unplanned logging (deforestation) in the town and development (encroachment) along the river banks in Fada and GyataAure, if not checked, could impact on the catchments and may further aggravate the present environmental degradation in the area.

The saying that Agricultural sector will be the panacea to getting us out of the present

economic recession and even create a more stable and sustainable economic development is a welcome idea, but there should be check and balances. The poor community farmers in Philippines have deconstructed the oppositional thinking inherent in the conventional literature: if one is poor, then one degrades. The poor, unemployed and the rural farmers can be positive agents of environmental sustainability. [17], gave scenarios and conditions where wise use of land can be put in place despites innumerable socio-economy lag, depression or hardship.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Fernando J. Estimating and modeling soil loss and sediment yield in the Maracas. St Joseph River Catchment with Emperical Models (RUSLE & MUSLE) and a Physical Based Model. An M. Sc thesis submitted to Civil and Environmental Engineering Department, McGill University, Montreal; 2007.
2. Naibbi AI, Baily B, Healey RG, Collier P. Changing vegetation patterns in Yobe State, Nigeria: An Analysis of the rates of change, potential causes and the implications for sustainable resources Management, International Journal of 826, 754 Geoscience; 2014. Available:<http://www.script.org/journal/ijg>
3. Bhawana KC. Land use and land cover change in relation to internal migration and human settlement in the middle Mountain of Nepal. Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente. 2015;66.
4. Hersperger AM, Gennaio M, Verburg PH. Linking land change with driving forces and actors: Four conceptual models. Ecology and Society. 2010;15:4.
5. Lambin EF, Geist HJ, (Eds). The IGBP Springer-Verlag, Berlin. 2006;222. (A Synthesis of LUC science).
6. Adelalu TG, Benjamin EB, Garba AH, Wuyep SZ. Climate induced crisis: A case study of IBI skirmish aftermath of 2012 flooding; 2012. DOI: 10.5539/jgg.v7n2p97

7. Jack H. How Nigeria's vortex of violence is being driven by climate change and desertification. RTCC- Response to climate Change Magazine; 2013. Available:<http://www.rtcc.org/magazine/rtc2013.pdf>
8. Bradshaw CJ, Sodhi NS, Peh, SH, Brook BW. Global evidence that deforestation amplifies flood risk and severity in the developing world. *Global Change Biology*. 2007;13:2379-2395.
9. Adepoju MO, Millington AC, Tansey KT. Land use/ land cover change detection in Metropolitan Lagos (Nigeria): 1984-2002. American Society for Photogrametry and Remote Sensing, Annual Conference, Reno, Nevada, May 1-5; 2006.
10. Zemba AA. Assessment of changes in land use and development of urban heat Island in Jimeta- Yola. An unpublished PhD. thesis submitted to Department of Geography, School of Environmental Sciences, Federal University of Technology, Yola; 2009.
11. Oyatayo KT, Songu GA, Adi TA, Abuh PO, Ndabula C. Assessment of people's awareness and perception of flooding in Donga Town, Taraba state, Nigeria. International Conference & Annual General Meeting of the Nigerian Meteorological Society held on 23rd – 26th Sokoto, Nigeria; 2015.
12. Inger A, Qusmane D, Martha J, Holder JC. The Niger River Basin; 2005. Available:www.revolv.com/topic/DongaRiverMay182017
13. Ileoje N. A new Geography of Nigeria. Ibadan, Longman, Nigeria Ltd; 1981.
14. Olorok JO. The climate of Gongola Lake Area. Annual Report of the Federal Ministry of Agriculture, Water Resources and Rural Development. National Institute for Freshwater Fisheries Research; 1995.
15. Jijingi HE, Yuguda TK, Dauda PA. An assessment of changes in land-use and land-cover within the Kiri Lake, Nigeria (1976-2014). *International Journal of Engineering Research*. 2016;5(7):606-609. DOI: 10.17950/ijer/v5s7/713
16. Ikusemoran M, Olorok JO. Monitoring the land-use and vegetation cover changes in the Kainji Lake Basin, Nigeria. *Africa Journal of Environmental Science and Technology*. 2014;8(2):129-142.
17. Robin B. The poor and the environment: friends or foes? Elsevier Science Ltd. *World Development*. 1994;22(6):811-822.

© 2017 Gabriel and Audu; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:
<http://sciencedomain.org/review-history/22446>