Dynamics of Land Use/Land Cover on Vegetation Cover in Southern Gombe (1986-2017), Gombe, Nigeria

***G. O. Abu[1], A.L. Tukur[2], A.A. Zemba[2]andR. D. Abu[3]**

[1]Department of Geography, Gombe State University, Gombe State, Nigeria
[2]Department of Geography, Modibbo Adama University of Technology, Yola
[3]Department of Geography, Federal University, Kashere, Gombe State, Nigeria

Abstract

The dynamics of vegetation is attributed not only to natural impacts but anthropogenic activities as well, and as such, brings to bear the urgent need for the use of modern techniques that can easily provide accurate data for efficient planning preference to the continual use of the conventional type. In view of this, this study monitored the land use land cover changes of southern Gombe between 1986 and 2017 using remote sensing and geographic information system (GIS) techniques. The study aimed at examining the changes on the vegetation cover. The methods adopted for this research involves the use of remotely sensed data from Landsat TM and Landsat ETM. Ground truthing was also carried out to corroborate the data from the satellite images. Secondary data from the literature relevant to the study were also obtained. The results showed that the vegetation class decreased (-150.83, -34.66 and -20.74) from 1986 to 1996, 1996 to 2006 and 2006 to 2017 while settlements increased (0.24, 0.72 and 9.57) from 1986 to 1996, 1996 to 2006 and 2006 to 2017in area coverage. Southern Gombe is expanding and leading to an inverse spill-over effect on the vegetation resources of the area. It is recommended that programs should be initiated that would promote the farming of forest trees and their products (fruits, wood, gums) around the homes to avoid cutting down of trees in the forest.

Keywords: Geographic information system (GIS), Remote sensing, Southern Gombe,Sustainable development, Urban growth and Vegetation resources.

Introduction

Remotely sensed data has become a spectacularly useful tool for mapping natural resources, including vegetation and land use/cover changes over geographical areas by overcoming many limitations of traditional surveying techniques to obtain a continuous and extensive inventory of ecosystems (Rogan and Chen, 2004; Gillanders, Coops, Wulder, Gergel and Nelson, 2008). With the use of remote sensing, it is possible to map and monitor the spatial extent of various factors influencing and contributing to environmental degradation, such as changes in vegetation cover, impervious surface, land use type, and human activities. Remote sensing is a cost effective tool for monitoring land use/cover changes that provides consistent and repetitive measurements of territorial processes (Wessels, Prince, Frost and Van Zyl, 2004).

Land cover change is driven by both natural processes, climate change inclusive and most importantly human actions. There has been a worldwide increasing awareness and studies on land use and land cover change analysis in the last decades. The importance of such studies to sustainable development plan has been universally noted.

Materials and Methods

Description of Study Area

The study area is Southern part of Gombe State located between latitude 9°30'N to 11^{0}30'N and longitude 10^{0}50'E to 11°40'E (Fig. 1). It covers four (4) out of the eleven (11) Local Government Areas of Gombe State which includes Balanga, Billiri, Kaltungo, and Shongom with a total land area of about 4,193.16km^2 out of 18,965km^2.

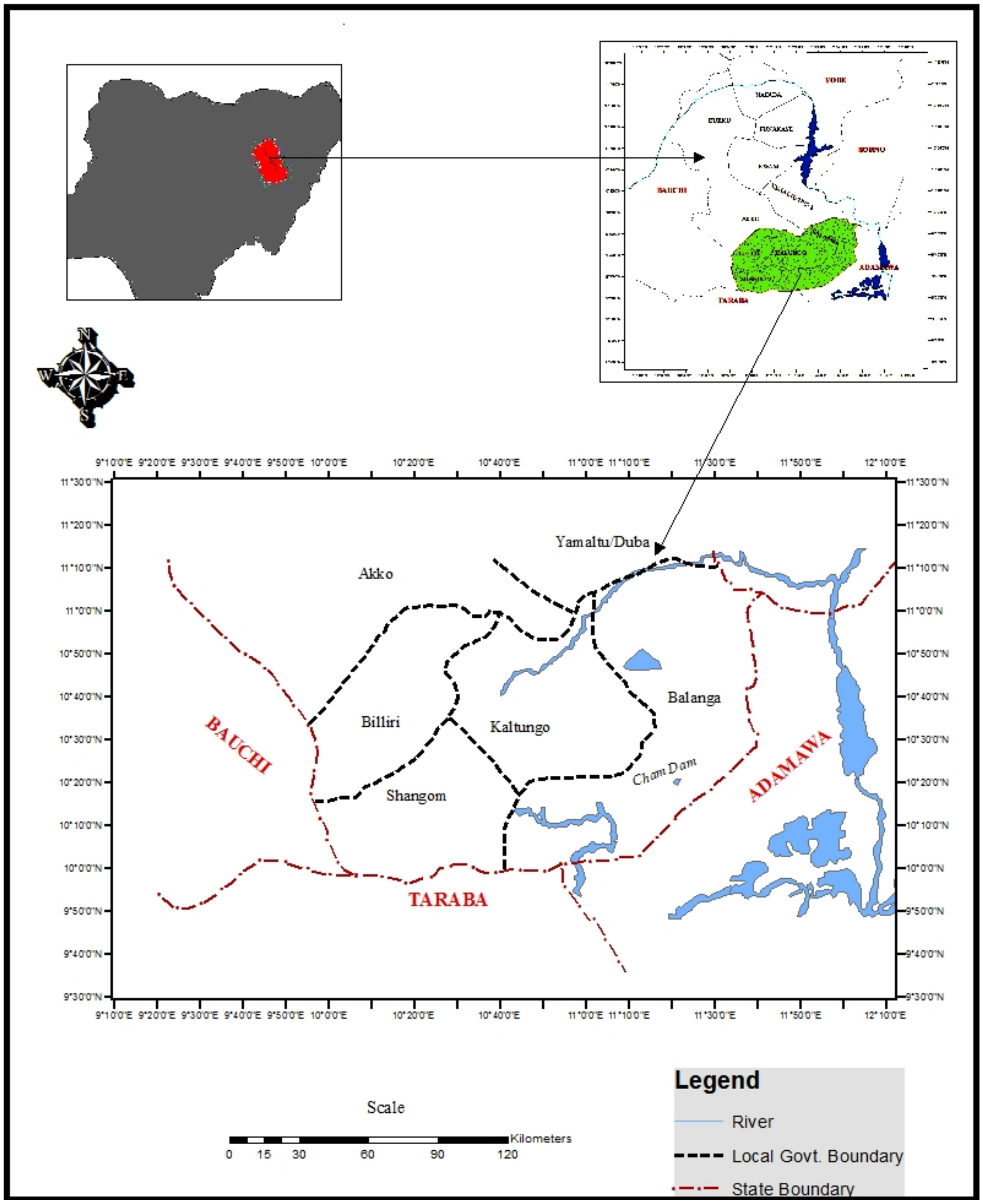

Fig.1: Location of the Study Area

The climate over Gombe is described as tropical continental climate of the A_w type. Temperature is high all year round with an average mean value of 30^0C. The highest temperatures of about 37^oCare recorded during the dry heat wave months of March and May. During the rainy season, the temperature drops considerably due to dense cloud cover between July and August as well as during the harmattan period of November to February (Balzerek, Werner, Jurgen, Klaus-martin and Markus,2003). Rainfall is strongly seasonal due to the oscillation of the inter-tropical convergence zone (ITCZ) which controls the Tropical Maritime and the Tropical Continental air masses of contrasting air moisture and relative humidity over the study area.

The topography of the study area is mainly mountainous, undulating and hilly to the southeast and flat open plains in the central. The plains generally separate the river basins from the upland areas. The Billiri LGA has most of its land area in the plains. The plains are generally utilized for agricultural, residential and industrial purposes. The highlands comprised of high mountain ranges and hills with altitudes above 590m above sea level. The nature of the topography gives rise to radial drainage pattern, that is, a pattern where the rivers flow to different directions away from a hill, highland or mountains.

The soils of Gombe are shallow impoverished sandy loams with iron concretion in some areas. The soils are developed based on the basement complex which supports agricultural practices. Ferruginous tropical soils which are highly weathered also developed on the sandy parent materials in the study area (Aitchison, Bawden, Carroll, Glover, Klinkenberg, DeLeeuw and Tuley, 1972). The vegetation in the study area is diverse as it reflects the pattern of the climate and physiography of the area. The existing vegetation of the area is described as Sudan savannah and the Mountainous vegetation in some part of the study area. It is characterized by high shrubs with scattered trees, open grass savannah which grows up to 3-5 feet and fringing forest especially in the river valleys.

Procedure for Data Collection and Data Analysis

Characterization of land use/ land cover changes within Southern Gombe was carried out using remote sensing and GIS techniques. This is possible through a technique known as change detection. Change detection simply is classifying (vegetation, bare surfaces/farmlands, rocky outcrop, wetlands and settlements classes) multispectral images of different times and comparing to discern what has changed over a period. The imageries were classified using the maximum likelihood classifier of the supervised classification. The area statistics of the land use/land cover classes of the periods under study were generated from the analyzed imageries using change detection algorithm. In order to determine if the change in the values of the vegetation cover classes between 1986, 1996, 2006 and 2017 are significant, the following hypotheses was tested: There is no significant difference in the vegetation change patterns from 1986 to 2017.

Table 1: Land Use/Land Cover Classification Scheme Adopted for this Study

Land Cover Classes	Description
Vegetation	Area covered by natural composition of trees, orchards, plantation as well as areas with shrubby plants, low tree height, bushes and grasses that provide pastures for livestock.
Settlements	Developed lands such as residential, commercial and constructions of any kind such as roads, infrastructure etc.
Bare surfaces/Farmlands	Exposed soil devoid of vegetal cover, that is, open spaces as well as all forms of agricultural land uses.
Wetlands	This includes all forms of water bodies found in the study area (River, streams, pond, dam, lakes etc)
Rocky outcrop	The study has part of its extremes covered by ranges of rocks of which some are been used for terrace farming.

Source: Field Work, 2016

To guide the focus of the study, hypothesis was employed which stated as follows:

Ho: there is no significant difference in the land use land cover changes in the study are within the period under investigation (1986 to 2017). The hypothesis was verified using the ANOVA analysis. The two way-ANOVA (F-Ratio) was used to test if the changes in vegetation pattern were significantly different between the years studied. The 95% confidence level corresponding to an alpha value of 0.05 was used in accepting or rejecting the hypothesis.

Results and Discussion

The study area located in Southern Gombe displays a mosaic of different landuse and landcover types which include human settlements, vegetation, rock outcrop, bare surfaces/ farmlands and wetlands. Table 2 represents the static area of land use/land cover classes for each year of 1986, 1996, 2006 and 2017, all of whichhave undergone changes over the years. Figures 1, 2, 3 and 4 show the spatial distribution of the land use / land cover of the study area.

Table 2: Land use Land Cover Change

LULC Classes	1986		1996		2006		2017		Rate of change		
	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)	1986/1996 (%)	1996/2006 (%)	2006/2017 (%)
Settlement	21.06	0.50	23.45	0.56	30.68	0.73	135.92	3.24	0.24	0.72	9.57
Vegetation	2826.80	67.41	1318.55	31.44	971.96	23.18	743.80	17.74	-150.83	-34.66	-20.74
Rock outcrop	628.18	14.98	1004.25	23.94	300.21	7.16	1172.75	27.97	37.61	-70.40	79.32
Bare surfaces/farmlands	695.36	16.58	1701.39	40.58	2860.34	68.21	2132.60	50.86	100.60	115.90	-66.16
Wetlands	21.76	0.52	145.52	3.47	29.95	0.71	8.09	0.19	12.38	-11.56	-1.99
Total	4193.16	100	4193.16	100	4193.16	100	4193.16	100			

Table 2 shows the entire study area covering 4193.16km. In 1986, vegetation constituted the most extensive land use / land cover occupying 2826.80km^2 (67.41%) and bare surfaces/farmland, rock outcrop, wetland and settlements occupied 695.36km^2 (16.58%), 628.18km^2 (14.98%), 21.76km^2 (0.52%), and 21.06km^2 (0.50%) respectively of the study area. However, in 1996, bare surfaces/farmlands expanded quite rapidly, increasing to 1701.39km^2 (40.58%) of the study area. The rock outcrop, wetlands and settlements increased to 1004.25km^2 (23.94%), 145.52km^2 (3.47%) and 23.45km^2 (0.56%) respectively. During the same period, vegetation decreased to 1318.55km^2 (31.44%). In 2006, settlement and bare surfaces/farmland increased to 30.68km^2 (0.73%) and 2860.34km^2 (68.21%) respectively. On the other hand, vegetation, rock outcrop and wetlands declined in areas to 971.96km^2 (23.18%), 300.21km^2 (7.16%) and 29.95km^2 (0.71%) respectively. By 2017, settlement, rock outcrop and bare surfaces/farmland had rapidly increased to 135.92km^2 (3.24%), 1172.75km^2 (27.97%) and 2132.60km^2 (50.86%) respectively, while vegetation and wetland declined to 743.80km^2 (17.74%) and 8.09km^2 (0.19%).

The pattern of land use / land cover change within the period under consideration indicated that between 1986 and 2017, settlements, bare surfaces/farmland and rock outcrop shows an increase except in 2006 where there was a decrease in the area expanse of rock outcrop. Within the period, vegetation and wetlands shows a general reduction in their area coverage. The unbroken increase in settlement resulted from the rapid physical development experienced in the study area. The increase in rock outcrop in 1986 and 1996 resulted from the deforestation and logging around rocks exposing parts that were not visible in earlier years. In 2006, rock outcrop recorded progressive decrease and the observed decrease are linked to increasing quarrying activities, massive construction and built environment on top of some of the rocks. The observed increase in rock outcrop in 2017 could have resulted from increases in deforestation that further exposed areas that were initially covered by vegetation. The observed increases in farmland resulted from increasing population density and increasing demand for food and agricultural commodities. The reduction observed in the surrounding vegetation probably resulted from urban expansion and construction activities and also the increasing tempo of logging activities.

Wetland is used to refer to all water bodies and in 1986 when the Balanga dam was completed, its extent was 21.76 km^2. In 1996, it recorded an increase of 145.52 km^2. This increase could probably be as a result of the emergence of minor water bodies and increases in the tributaries density that feed the dam and the several gullies and channel that conduct surface and base flow. The decrease noticeable in 2006 and 2017 could be attributable to fluctuation occasioned by landuse /land cover changes over the catchment which increases the inflow of sediments into dam and other channels thereby reducing their capacities.

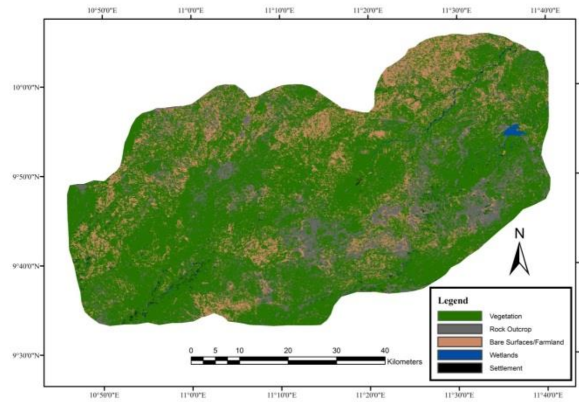

Fig.1: Classified LULC Map of 1986

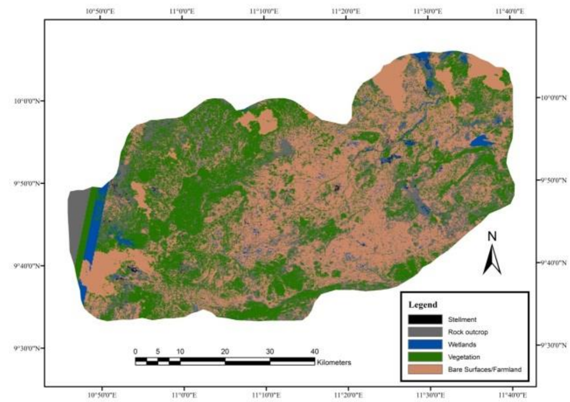

Fig. 2: Classified LULC Map of 1996

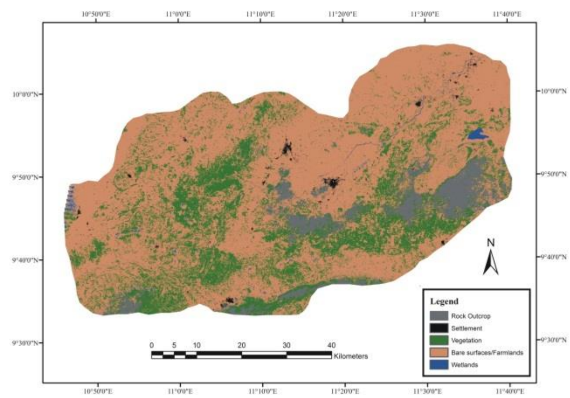

Fig. 3: Classified LULC Map of 2006

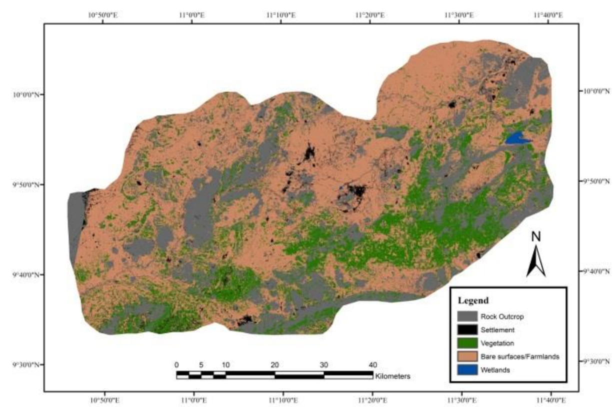

Fig. 4: Classified LULC Map of 2017

The Annual Change Rate

The rates of land use/ land cover changes from 1986 to 2017 (Table 2) revealed that rates of land use changes for the different land use classes over the periods were of different magnitude. The vegetation class has shown a decrease (-150.83, -34.66 and -20.74) from 1986 to 1996, 1996 to 2006 and 2006 to 2017, while settlements had increased area coverage (0.24, 0.72 and 9.57) from 1986 to 1996, 1996 to 2006 and 2006 to 2017 respectively. The annual rate of change of the remaining land use land cover classes fluctuated between the study periods.

Landuse/Landcover Changes between 1986 and 2017

The identified landuse/landcover classes in Southern Gombe study area was subjected to analysis of variance (ANOVA) at 0.05 level of significance to statistically confirm the significant difference in the magnitude (value) of the land use/land cover classes between 1986, 1996, 2006 and 2017.Table 3 shows the details.

Table 3 Analysis of variance for level of significance for land use/land cover classes

Source of variation	Sum of Square	Degree of Freedom	Mean of Square	F-ratio calculated (F_{cal})	F- critical (F_{tab})
Between class years	2316.55	3	772.18	0.000708	3.49
Within class years	13081265	12	1090105		
Total	13083581	15			

Table 3 shows the result of the analysis of variance and F_{cal} is 0.000708 while F_{tab} is 3.49 at 95% (0.05%) level of confidence and 15 degree of freedom. Since F_{cal} is less than F_{tab} (0.000708< 3.49), we do not reject Ho. Hence we accept the null hypothesis that stated that there is no significant difference in the magnitude (value) of land use/land cover classes between the years under study. Although spatial variations exist in some of the classes and the base year, there is no statistical proof to make a generalized statement.

Conclusion

It is clear from the analysis in the preceding section that the vegetation cover of Southern Gombe area has undergone considerable changes over the period under investigation. While the settlements and bare surfaces have expanded significantly during the thirty years period under study, the vegetation and wetlands has declined. Population increase and development has led to the expansion of houses and increased farmlands for agricultural purposes and thus contributed to the threat and disturbances on the vegetation. Several factors have been modifying the original form of land cover in the study area, these include human activities such as agricultural purposes and spread of settlements. The study reveals that various human activities are behindthis change and that these changes have led to the deterioration of the vegetal cover but on a positive side has indirectly contributes to household food security through income generation and employment.

Recommendation

It is recommended that alternative source of energy should be provided to the masses so that less tension may deter people from cutting trees as source of energy. Likewise, Government should initiate programs that promote the farming of forest trees and their products (fruits, wood, gums) around the homes to avoid cutting down of trees in the forest. Afforestation should be encouraged to reduce and address areas that are prone to erosion. Also conservation of the habitat should be enforced to safe wildlife from extinction.

References

Aitchison, P.J., Bawden, M.G., Carroll, D.M., Glover, P.E., Klinkenberg, K. and DeLeeuw, P.N and Tuley, P. (1972). The Land Resources of North East Nigeria: *The Environment,* Vol.1. Land Resources Division, Tolworth Tower Surbiton, Surrey, England.

Balzerek, H, Werner, F., Jürgen, H, Klaus-martin, M. and Markus, R. (2003). Man Made Flood Disaster in the Savanna Town of Gombe/NE Nigeria. *Erdkunde,* 57(2), 94-109.

Gillanders, S.N., Coops, N. C., Wulder, M.A., Gergel, S.E. and Nelson, T. (2008). Multitemporal remote sensing of landscape dynamics and pattern change: describing natural and anthropogenic trends. *Progress in Physical Geography,* 32 (5), 503–528.

Rogan, J. and Chen, D. (2004). Remote sensing technology for land cover and land use mapping and monitoring. Progress in Planning, 61(4), 301–325.

Wessels, K. J., Prince, S.D., Frost, P.E., and Van Zyl, D. (2004). Assessing the effects of human induced land degradation in the former homelands of northern South Africa with a 1km AVHRR NDVI time-series. *Remote Sensing of Environment, 91*, 47-67.