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Assessment of Environmental Changes in the Fufore Area of Adamawa State, Nigeria

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Abstract: *In Nigeria, since the last three decades there has been a tremendous stress on the environment with more serious attendant consequences. The objective in this study was to assess the rate and the causes of environmental changes (land use/cover) in the Fufore area of Adamawa State, through the application of Remote Sensing and GIS techniques. The images of Landsat MSS 1972, TM 1987, ETM 1999 and Nigeria sat-1 2007 were analyzed to derive information on environmental changes between 1972 and 2007. The results of the analysis revealed that the size of the forest cover in the area reduced from 1,504.45km^2 in 1972 to 1,038km^2 in 1987, and further declined to 898.98km^2 in 1999 and dropped to 371.55km^2 by 2007. On the other hand, housing and agricultural land uses expanded from 11.23km^2 and 108.76km^2 respectively between 1972 and 1999 to 66.41km^2 and 2,554.82km^2 respectively by 2007. The land cover changes in the area are estimated at the rate of 98.53km^2 per annum. The study recommends that state and local government authorities should address among other issues the over-reliance on fuel wood as the principal source of domestic energy supply through the provision of affordable alternative sources.*
Keywords: *Change Detection, LandSat, NigeriaSat-1, Image Classification, Landuse*

I. Introduction

In Nigeria, like in many other sub-Saharan Africa countries, there has been a serious concern on environmental changes since the last three decades. The country is increasingly faced with the challenges of desertification, deforestation, erosion and flooding, which have manifested in multi-faceted problems such as loss of agricultural soil and productivity. Abdullahi, et al, (2005), stated that Nigeria loses about 351, hectares of its landmass to desert conditions annually and that these conditions are advancing southwards at the rate of 0.6km per annum. This and the other environmental challenges have no doubt compounded the poverty levels of more than 80 million people that depend on agriculture for their sustenance. A number of studies (FAO, 2007, Robert, 2007 and Ayuba, et al, 2005) have attributed the varying environmental problems largely to deforestation as the principal causative factor, especially in the Sudano-Sahelian region of the country where semi- arid conditions prevail. However, the analyses of environmental changes arising from deforestation in the woodland (Guinea) savanna region of Nigeria have rarely been undertaken. This may be because the region is less susceptible to physical threats and have low population densities.

The objective in this study is to assess the rate and the causes of environmental changes (land use/cover) in the Fufore area of Adamawa state, Nigeria, through the application of remote sensing and Geographic Information System (GIS) techniques. The use of remote sensing and Geographic Information System (GIS) technologies in deforestation studies dates back to the time when the US Military used them to differentiate dead or dying vegetation from living ones and thus detect enemy hideouts in war times (Colvocoresses,1975). Today, these tools are extensively being used for the assessment of the rate and extent of deforestation taking place globally and its complex inter-relationship with other social and economic variables (Mittermier, et al (2004), Chittagon, Bangladesh, Mahmudur, et al, 2000, Tukur, Musa and Mubi, 2006). Thus, remote sensing and GIS techniques were applied in the assessment of deforestation in the Fufore area of Nigeria.

II. Study Area

Fufore area is situated roughly between latitude $8^0\ 45^1$ and $9^0\ 35^1$North and longitude $12^0\ 15^1$ and $13^0\ 15^1$ East. It has a total land mass of about 3,666 sqkm (Musa and Tukur 2009). The local government has a total population of 207,287 (National Population Commission 2006) which is projected to be 246,683 by 2012. The area is regarded as low lying with about 80% of the entire area being at less than 300m above sea level, while the remaining 20% are hills and mountains. The area is drained by a series of rivers and streams such as River Benue which takes its source from Cameroon, River Faro, Ine e.t.c., which all encourage arable cropping, livestock rearing and fishing (Fadama II, 2008). The area experiences distinct dry and wet seasons with temperature and humidity varying with season. The wet season is between April and October with average annual rainfall of 750 to 1000mm. The dry season period is between December and March and characterized by dry, dusty and hazy north – east trade winds that blow over the area from Sahara desert. Temperatures are relatively high almost all the year round. The temperature of the area ranges from 30^0Cto 42^0C with cold dry winds that reduce the temperatures to about 15^0C during Harmattan period with the hottest months being April and May, with mean average temperature of 34^0C (Adebayo, 1999).

III. Methods And Materials

The data used include satellite imageries such as landsat MSS 1972, landsat TM 1987, landsat ETM of 1999 and Nigeriasat-1 2007, all obtained from National Center for Remote Sensing (NCRS) Jos, Nigeria. Nigerian survey topographic map series, (NIGERIA 1:50,000), Fufore 1968, sheet 72B was also used.

High-speed memory digital electronic Pentium IV computer, CD writer/reader, colored flat bed scanner and Garmin 12 hand held GPS were also used. Integrated Land and Water Information System (ILWIS) academic version 3.1 and Arc View 3.2 Geographic Information System (GIS) soft- ware packages were also used to manipulate and perform feature identification, recognition and classification.

Image Interpretation

Digital Image Processing (DIP) technique was used for the satellite image interpretation. This involved the use of ILWIS Software for image data extraction and categorization. For the reconstruction of the forest history and to detect changes in the vegetation, all images were Geo-referenced and registered to each other. This was done by assigning the coordinates in the ILWIS subroutine EDITH/GEOREFERENCE, after which the images were automatically resampled in the process RASTER/RESAMPLE/AUTOMATIC subroutine. This was done by taking the Landsat MSS 1972 with spatial resolution of 79M as the base image to register all the other images.

Image Classification

To categorize the image features (pixels in the image) into cover types training sites were identified and grouped into cover classes. Thus a six class land cover types were identified and used in a supervised classification procedure. The ILWIS Software used, has a program classifier that implements specific procedures for image classification. From homogenous areas, representative samples of cover types (Training Sites) were then picked. These training sites constitutes sub-samples of images whose identity is completely known and they act as a yardstick with which unknown areas were measured and singled out for classification purpose (Ndukwe, 1990). Specific area covered by the feature classes or cover types identified during the ground truthing were identified on the multi spectral imageries and their spectral characteristics were then used to train and assign each pixel in the image to one of the classes. The identification of spectral characteristics was done through sampling, which is the assignment of class names to group of pixels, which have similar spectral values to those classes that have been identified on the ground.

Change Detection

Change that occurred in the study area for the study period,1972-2007,(36 years),were analyzed by crossing the classified landsat MSS 1972 image with the classified landsat TM 1987 image through the OPERATION/RASTER/PROCESSING/CROSS/SHOW subroutine. The same procedure applied on the remaining classified land sat images. Direct comparison of land use statistic was carried out highlighting the extent and rate of land use changes over the period of study. The results were presented essentially by maps, statistics tables and graphs and analyzed/interpreted to explain the rate and extent of deforestation and implications associated with it.

IV. Results and Discussion

The study area occupies an estimated total land area of 3666 sqkm. From the landsat MSS 1972 image classification for forest and non-forest land use/cover categories, a map showing the pattern of cover classes of the area was produced as shown in Fig.1 and the following land use/cover classes were identified: bare surfaces were found to occupy about 6.51 sqkm or 0.17% and are located close to water bodies. The built-up areas or settlements occupies about 11.23 sq.km and concentrated in the North-Western part of the area. The Cultivated land was just 108.76 sqkm of the total area. There was a very thick forest at that time (1972), which occupied about 1504.46 sqkm i.e. 41% of the total land as shown in Table 1. As at 1972, natural vegetation carried about 2015.56 sqkm i.e. 55% of the total land having the highest percentage because of the less farming activities at that time. The water bodies as displayed by the imagery occupied 19.28 sqkm or 0.52% of the area, thus Table, 1, presents the classification results.

Table 1: Landuse/Landcover classification from satellite Imageries of 1972-2007.

Years	Land Area	Classification of Land Use/ Land Cover						
		Bare Surface	Builtup Area	Cultivated Area	Forest	Natural Vegetation	Water Body	Totals
1972	LandArea (km^2)	6.51	11.23	108.76	1504.46	2015.56	19.28	3,666
	LandArea (%)	0.17	0.30	2.96	41.05	55.00	0.52	100
1987	LandArea (km^2)	19.62	29.70	1276.83	1038.00	1290.04	11.39	3,666
	LandArea (%)	0.54	0.81	34.83	28.32	35.19	0.31	100
1999	LandArea (km^2)	19.36	48.24	1797.09	898.98	876.75	26.23	3,666
	LandArea (%)	0.53	1.32	49.01	24.52	23.91	0.72	100
2007	LandArea (km^2)	31.77	66.41	2554.82	371.55	635.22	6.67	3,666
	LandArea (%)	0.87	1.81	69.68	10.13	17.33	0.18	100

Landsat TM 1987 image was classified to determine how much natural forest has been transformed to other forms of land use categories, and the map and statistical table are shown in Figure 2 and Table 1.

In 1987 bare surface have increased to about 19.62 sqkm as against 6.51 sqkm in 1972. Built- up areas also increased to 29.70 sq.km or 0.81% over the period of 15 years because of the increase in population of the area. Farmlands also found to have increased to about 1,276.83 sqkm as against 108.76 sqkm over the period of time (15 years). However, forest and natural vegetation were found to have reduced to about 1,038.00 sqkm and 1,290.04 sqkm respectively as against 1,504.46 sqkm and 2,015.56 sqkm in the previous period 1972. Water body also reduced to 11.39 sqkm as against 19.28 sqkm. This shows that about 36.18% of the total land has been encroached.

The landsat ETM 1999 image was classified and the map of land use pattern was produced as shown in Figure 3.

Built up area has again increased to about 48.24 sqkm instead of the 29.70 sqkm in 1987. Cultivated area also increased to 1,797.09 sqkm or 49.01% as against 1,276.83 sqkm in 1987, which indicate the increase in farming activities. Areas under forest and natural vegetation both reduced to 898.98 sqkm and 876.75 sqkm over the period.

The Nigeria Sat-1 (2007) image was classified and the map of land use pattern was produced as displayed in Figure 4.

Bare surface has increased significantly to about 31.77 sqkm and mostly concentrated in the North-Western part of the study area. Settlements also appreciated to 66.41 sqkm, this is not unconnected with the population increase experience in the area. Cultivated area also increased to 2554.82 sqkm of the total land area. While forest and natural vegetation both drastically diminished in size to 371.55 sqkm and 635.22 sqkm. Farming activities and the rise in settlements are accountable for the changes that have taken place in both the forest and natural vegetation between these periods (1999-2007), as shown in Table, 1.

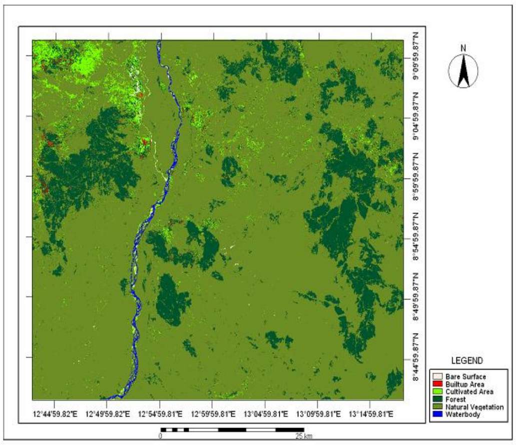

FIG. 1: CLASSIFIED LANDSAT MSS IMAGE (1972) OF THE STUDY AREA

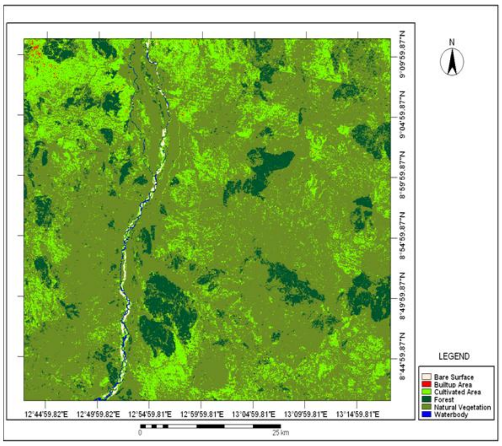

FIG. 2: CLASSIFIED LANDSAT TM IMAGE (1987) OF THE STUDY AREA

On completion of classification, however, accuracy checks have to be made to evaluate the performance of the classification. The most commonly used method is the test sample checking, often by comparing the results obtained from a digital classification of land cover, referred to as reference data. This is achieved by building an error matrix that compares the classification results with the reference data. The data sets are represented by columns and rows with the major diagonal of the matrix indicating the agreement between the two data sets. Tables 2 and 3, present the classification accuracy obtained in this study.

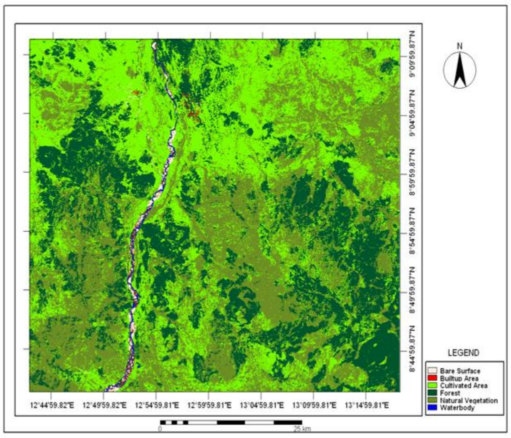

FIG. 3: CLASSIFIED LANDSAT ETM IMAGE (1999) OF THE STUDY AREA

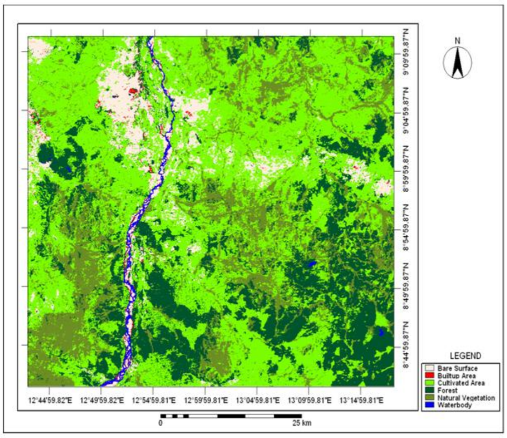

FIG. 4: CLASSIFIED NIGERIA SAT 1IMAGE (2007) OF THE STUDY

The overall accuracy for the 1972 image was 92.68%, 93.96% for 1987, and 93.63% for the 1999 while that of 2007 image was 95.35%. On the whole the overall accuracy achieved is remarkable, given the time frame between the acquisition and interpretation of the images and the changes occurred.

Table .2 Error Matrix table for land cover classification of landsatMSS1972.

Class (1972)	**Builtup Area**	**Vegetation**	**Cultivated Area**	**Water body**	**Bare Surfaces**	**Forest**	**Unclassified**	**Accuracy**
Builtup Area	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
Vegetation	**0**	**16**	**0**	**0**	**0**	**0**	**0**	**1**
Cultivated Area	**0**	**0**	**4**	**0**	**0**	**0**	**0**	**1**
Waterbody	**0**	**1**	**0**	**6**	**0**	**0**	**0**	**0.86**
Bare Surfaces	**0**	**2**	**0**	**0**	**6**	**0**	**0**	**0.75**
Forest	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**0.88**
RELIABILITY	**1**	**0.84**	**1**	**1**	**1**	**0.95**	**0**	

Source: Landsat MSS Data Analysis 1972
Average Accuracy = 92.14 %
Average Reliablity = 96.84 %
Overall Accuracy = 92.68 %

Table.3 Error Matrix table for land cover classification of Nigeria Sat-1 2007.

Class (2007)	**Builtup Area**	**Vegetation**	**Cultivated Area**	**Water body**	**Bare Surfaces**	**Forest**	**Unclassified**	**Accuracy**
Builtup Area	**9**	**0**	**3**	**0**	**0**	**1**	**0**	**1**
Vegetation	**0**	**12**	**0**	**0**	**0**	**0**	**0**	**1**
Cultivated Area	**0**	**0**	**9**	**0**	**0**	**0**	**0**	**1**
Waterbody	**0**	**0**	**1**	**8**	**3**	**0**	**0**	**0.86**
Bare Surfaces	**0**	**0**	**0**	**0**	**36**	**0**	**0**	**0.75**
Forest	**0**	**0**	**0**	**0**	**0**	**90**	**0**	**0.88**
RELIABILITY	**1**	**1**	**0.69**	**1**	**0.92**	**0.99**		

Source: Nigeria Sat-1 Satellite Data Analysis 2007
Average Accuracy = 89.32 %
Average Reliablity = 93.41 %
Overall Accuracy = 95.35 %

Change Detection From 1972-1987

The change that has taken place between, 1972-1987 was detected by crossing (supper imposed) 1972 image on the 1987 image and a change table was produced.

Table 4. Area of landuse/magnitude of changes (increasing or decreasing) between, 1972-1987.

Land use/ class	1972 land Area (sqkm) *A*	1987 land Area (sqkm) B	Magnitude of change B-A	% Change	Remark (Increasing or decreasing)
Bare surface	**6.51**	**19.62**	**+13.11**	**0.54**	**Increased**
Buildup Area	**11.23**	**29.70**	**+18.47**	**0.76**	**Increased**
Cultivated Area	**108.76**	**1276.83**	**+1168.07**	**48.66**	**Increased**
Forest	**1504.46**	**1038.00**	**-466.46**	**-19.43**	**Reduced**
Natural vegetation	**2015.56**	**1290.04**	**-725.52**	**-30.23**	**Reduced**
Water body	**19.28**	**11.39**	**-7.89**	**-0.32**	**Reduced**

It can be observed that farming activities in the study area in general took the largest share of both the forest and natural vegetation conversion which is 1168.07 sqkm or 48.66% of the total change, followed by buildup areas which is 18.47 sqkm or 0.76% of the total change. Bare surface accounted for 13.11 sqkm or 0.54% of the total changes in the study area for that period.

Change Detection From 1987-1999

The changes that occurred between 1987-1999 were detected by crossing the landsat TM (1987) image and landsat ETM (1999) image to produce a change in landuse of the study area.

Remarkable changes were noticed and are attributed to intensive cultivation and settlement expansion. This is equivalent to 538.8 sqkm or 48.7 % of the total land area as shown in table 5.

Table5. Area distributions of land use/class and magnitude of changes (increasing or decreasing) between 1987-1999.

Land use/ class	1987 land Area (sqkm) C	1999 land Area (sqkm) D	Magnitude of change D-C	% Change	Remark Increasing or decreasing
Bare surface	19.62	19.36	-0.26	-0.02	Decreased
Buildup area	29.70	48.24	+18.54	1.67	Increased
Cultivated area	1276.83	1797.09	+520.26	47.03	Increased
Forest	1038.00	898.98	-139.02	-12.56	Reduced
Natural vegetation	1290.04	876.75	-413.29	-37.36	Reduced
Water body	11.39	26.23	+14.84	1.34	Increased

Change Detection From 1999-2007

The change that has taken place between 1999-2007 was detected by crossing (Superimpose) 1999 image on the 2007 image and a change table was produced.

Table, 6: Area of land use/class and magnitude of change (increasing or decreasing) between 1999-2007.

Land use/ class	1999 land Area (sqkm) E	2007 land Area (sqkm) F	Magnitude of change *F-E*	% Change	Remark Increasing or decreasing
Bare surface	19.36	31.77	+12.41	0.78	Increased
Buildup area	48.24	66.41	+18.17	1.15	Increased
Cultivated area	1797.09	2554.82	+757.73	48.04	Increased
Forest	898.98	371.55	-527.43	-33.44	Reduced
Natural vegetation	876.75	635.22	-241.53	-15.31	Reduced
Water body	26.23	6.67	-19.56	-1. 24	Reduced

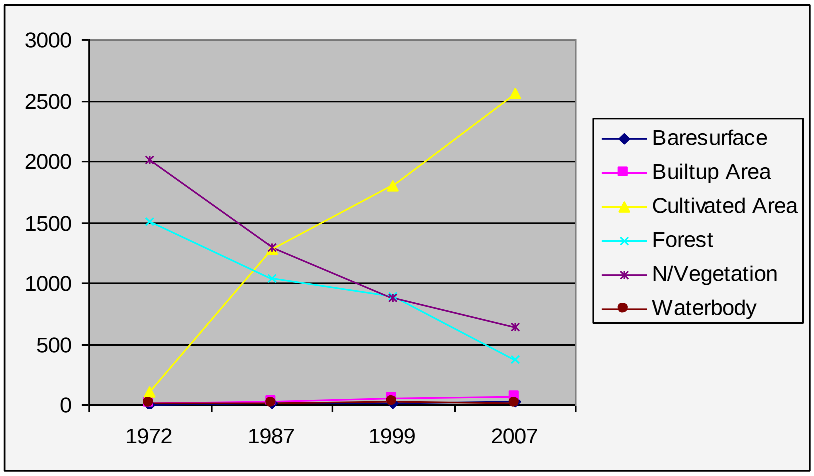

Figure 5: Line Graph of Land use/Land cover changes of Fufore LGA

The rate of deforestation in the study area therefore, estimated to be about 79.95 sq. km per year that is between 1972 and 1987. While for the period 1999-2007 the rate of deforestation was estimated to be 98.53 sq.km / year.

V. Conclusion And Recommendation

The main objective of this paper has been to assess the rate and causes of environmental changes in Fufore area of Adamawa State using remote sensing and GIS techniques. Based on the datasets obtained and analyzed, the study therefore concluded that:

i. There is an alarming increase in the rate of deforestation in the study area 98.53 sqkm per year (1999-2007). This loss in natural vegetation results to increase in bare surface, whereas increase in farmlands and built up areas leads to decrease in vegetation.

ii. Though the area once dominated by good vegetation and extensive forest (1972 image) has, from the results of this study been significantly altered. Land use/cover change seems to point to increased pressure on land leading to degradation such as Forest/Vegetation decrease and alteration.

iii. This study also demonstrated that fast and accurate inventory of land cover classes, that would help make better and more informed decisions on Forest/Vegetation related matters can be achieved through integrating remote sensing and GIS techniques/ data. This would make periodic monitoring of vegetal resources dynamics possible. However, the relevant authorities should ensure the availability of alternatives to fuel wood such as kerosene and gas at affordable rate.

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