Analysis of Landuse and Landcover Changes of Aba Urban Using Medium Resolution Satellite Imageries

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Key Words: Landuse and Landcover, Change Detection, Medium Resolution Satellite Imageries, ILWIS 3.3, GIS.

ABSTRACT

This study focused on the analysis of Landuse and Landcover changes in Aba Urban Area using medium resolution satellite imageries (Landsat ETM+, 2000 and Nigeria Sat-1, 2005) acquired for Aba Township in order to detect the changes that have taken place within this time interval (1991 – 2005). Change detection being a process of identifying differences in the state of an object or phenomena by observing it at different times. In determining the Landuse/cover of Aba, Remote Sensing technique was applied using the ILWIS software in image processing and analysis. The Landuse map of the study area was produced using ArcGIS/ArcView software. Two multidate datasets (Landsat ETM+ image of 2000 and NigeriaSat-1 image of 2005) respectively and analogue base map of Aba main town (produced in 1991) were used. The base map was scanned, digitized and georeferenced in AutoCAD environment. The digitized base map was polygonized and classified. The Landsat ETM+ and the NigeriaSat-1 imageries were resampled to one resolution and classified. Through an overlay operation the various spectral and temporal changes in Landuses were obtained and analyzed. The result reveals that from 1991, 2000 to 2005, the **River** increased from 15.1% to 22.1% and finally to 22.4% due partly to increasing activities within and around the waterways, **Built-up area** increased from 21.7% to 26.8% and to 36.5%. Unlike river and built-up area, there is a significant disparity and trend in vegetation Landcover due to rapid urbanization and socio-economic activities. Thus, vegetal cover decreased from 63.2% in 1991 to 51.1% in 2000 and in 2005 it further decreased to 41.1%

However, it is recommended to Government that timely Landuse and Landcover mapping of the entire Aba Township should be embarked upon to forestall the ugly consequences of erratic and haphazard land utilization in the town. Government and relevant agencies should embark on the conversion of existing analogue maps of the state at different scales to digital maps and also update them to reflect the changes and development in the state. This will facilitate necessary Landuse planning and forestall the rising sprawl in Aba Township.

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1. INTRODUCTION

Research has proved that problems associated with environmental monitoring and control persists through the history of mankind. The situation is aggravated in recent times due to man's increasing intervention on the environment, hence, there remains few landscapes on the earth's surface that have not been significantly altered by human beings in some ways (Opeyemi, 2007).

Landcover refers to the natural surface of the earth undisturbed by human activities. It represents vegetation, natural or man-made features and every other visible evidence of Landuse e.g. forest, cultivated/uncultivated land, settlements, etc. Landuse on the other hand, refers to the use of land by humans. It is the alterations done to Landcover as a result of human activities such as farming, road construction, etc.

Landuse and Landcover change studies have become key components for managing natural resources and monitoring environmental changes. Igbokwe (2008) opined that Landcover and Landuse information should form part of the environmental data, which are kept in the form of inventories/infrastructures in many advanced and emerging economies. Most Landuse change factors such as water flooding, air pollution, urban sprawl, soil erosion, deforestation, occur without clear and logical planning which results in serious environmental degradation with notable consequences globally.

Land Use/Land Cover (LULC) classification can be seen on a continuum, starting with a basic estimation of land cover through broad categories, like farmland, and urban areas, to feature extraction, like road networks, buildings, and trees. A typical classification system might segment urban areas in the following four levels: level1- Urban or built-up, (b) level2-Reside ntial , level 3-Single-family Units and level 4-Single Story Units.(http:/www.digital globe.com)

Lower resolution multispectral satellites like Landsat and NigeriaSat-1 are very effective at mapping LULC at the first two levels, by identifying the spectral signature of a particular type of feature, and broadly classifying areas that contain that spectral pattern. With spatial resolutions of 15-30 m, Landsat can classify forests, grasslands and urban developments using the different spectral reflectance of each type of land cover. However, finer details cannot be reliably differentiated at these resolutions. Higher resolution multispectral satellites with traditional visible to near infrared (VNIR) bands are increasingly able to discern fine scale features. With spatial resolutions of 0.5-1 meter,these satellites have consistently demonstrated the ability to classify features at the third level, for example, discriminating between grasses vs. trees in an

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orchard, segmenting urban areas by housing types, and discriminating between paved and unpaved roads (http://www.digital globe.com).

Change detection analysis approaches can be broadly classified into post classification change methods or preclassification spectral change detection.(Lunetta,1999).The following methods are examples:

(a) Image differencing techniques: Two co-registered images of different dates are substracted pixel by pixel to produce new change image between the two dates.

(b) Image Regression:Considers differences in mean and variance between pixel values from two dates.

(c) Vegetation Index Differencing technique: There the ratio or vegetation indices is used enhance the spectral differences between strong reflectance of vegetation in the near – infrared part of the spectrum and chlorophyll-absorption band of the spectrum.

(d) Multi-date Principal Component Analysis:Two image dates of the same area are superimposed and analysed as a single image.

(e) Image Ratioing method: In this method, two co-registered image dates are rationed pixel by pixel in each band. The no-change area is characterized by ratio value of 1.

(f) Manual On-screen Digitization of Change: Usually used for high-resolution remote sensor data and aerial photographs.

(g) Post-Classification Method: Here multi-dates images are classified and labelled individually.Thereafter, the classification results are compared directly and areas of change extracted. This the technique adopted in this research work.

Remote sensing is used in the study of Landuse and Landcover changes and analysis because of its ability to cover large are as in a single image scene (Singh, A, 1984). Over the past years, data from earth sensing satellites has become indispensable in mapping the earth's features, natural resources management and environmental change studies .This technology has enabled the research into the land cover and land use changes in Aba main town using medium resolution satellite images of (Landsat ETM+ and NigeriaSat-1) images acquired in 2000 and 2005 respectively.

Aba is one of the fastest growing towns in Nigeria and the commercial nexus of Abia State. According to statistics from the Abia Land Information System (ALIS), the town has the highest land consumption rate in Abia State. However, no comprehensive effort has been made at detecting, evaluating and analyzing the changes in land use and land cover over a period of time. This observed gap obviously necessitated this research work.

The study was aimed at carrying comparative study/ analysis of the Landuse and Land cover changes of Aba main Town using RS and GIS tools. This aim was achieved through the following objectives:

(i) Selection and extraction of a sub-scene covering of Aba Main Township from the

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full scene of Landsat ETM+ (2000) and Nigeria Sat-1 (2005) images of the area.
- (ii) Co-registration, creation of a sub-map of the area and resampling of the imageries to one resolution to make the pixels coincide.
- (iii) Classifying the imageries and the polygonising the base map of the study area.
- (iv) Overlaying the classified datasets and obtain changes in Land uses and Land covers of the study area.

2. THE STUDY AREA The study area, Aba main town, is one of the three major towns in Abia State of Nigeria .It is located between latitudes 05° 2' 30" N and 5° 08' 00" N of the equator and longitudes 07° 20' 00" E and 07° 26' 00" E of the Greenwich meridian. The town lies within the tropical rain forest zone of West Africa. Two Local Government Councils make up the Aba main Township; Aba North and Aba South Local Government Council Areas.

The aborigines of the town are the Ngwa people and they are mostly Christians (NPopC, 2003). With a temperature of about 21^0C, the climate is humid tropical type and is characterized by wet and dry seasons. The Blue River traverses the town at the Ogbor-Hill end of the Aba- North local Government Areas. The predominant food crops of the town especially at the banks of the blue river are yam, maize, cassava, cocoyam, vegetables, oranges, palms and fruits. The agricultural practices depend solely on the annual rainfall which has a mean value of 200cm and relative humidity of 80%.

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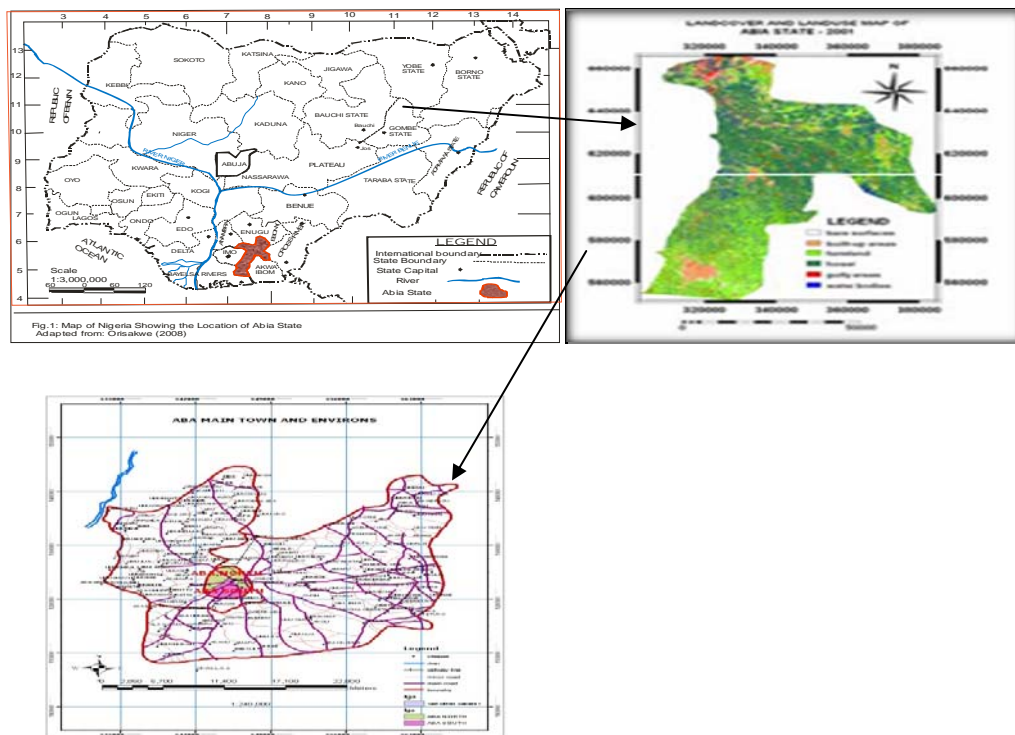Marrakech, Morocco, 18-22 May 2011

FIG 1.0 LOCATION MAP OF THE STUDY AREA

The current population of Abia State based on published National Population Commission (NPopC) census record is put at 2, 833, 999 people (NPopC, 2006). In 2004, Aba township alone (made up of Aba North and South LGA'S) is put at 820,900 (*http://www.abiastateonline.com/*). Previously, the National Census of Nigeria carried out in
1991 puts the provisional population of Abia State at 1,976,805. Out of this figure, 920,268 are males and 956,434 are females.

3. MATERIALS AND METHODS

The datasets used in this study are as follows:

(i)   Administrative map of Abia State showing Aba North and South Local Government Areas at the scale of 1:10000 (Plan NO:SUV/7881/03/91) by Ministry of Lands, Survey and Urban Planning Owerri and up-dated in 1996 by Ministry of Lands, Survey and Urban Planning Umuahia, Abia state .
(ii)   Landsat-1 ETM+ Satellite image of Aba of September 2000
(iii)   NigeriaSat-1 Satellite image of Aba of October 2005.

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(iv) Reference Analogue map of Aba made produced by Shell Petroleum Development Company, PortHarcourt Nigeria.

(v) The Landsat ETM+ Satellite image of Aba was obtained from the Global Land Cover Facility (GLCF) through the assistance of Prof. J.I Igbokwe of the Department of Surveying and Geoinformatics, Nnamdi Azikiwe University, Awka, Nigeria while the Nigeria Sat-1 image was also acquired through same source.

A Pentium based personal computer that has the following specifications:
360 GB Hard Disk (because of the large size of images used), 2 GB Random Access Memory (RAM),-1.8 Giga Hertz Speed, HP Scanner (A0-scanning, Topographic sheets, A3 and A4), HP Laser/DeskJet Printers (A4, A3 and A0 for data output based on requirement)

The following software were used in this study:
ILWIS 3.3 Academic Software, AutoCAD 2007 and Arc View 3.2a,

3.1 Image Preparations

The following steps were undertaken in above operations:

The analogue base map of the study area was first scanned in raster format using the Hewlett Packard A0 Scanner. The file of the scanned image was exported to AutoCAD 2007 for onscreen digitization.

The scanned base map was digitized onscreen using the AutoCAD 2007. The features were digitized in layers, i.e., each group of features occupying each layer. For example, all roads were in one layer. The map was saved in AutoCAD R14 compatible format. The digitized map did not show correct coordinates and was georeferenced.

The Georeferencing of the digitized base map was done in AutoCAD Map 2.0 environment using the Rubber Sheet method as against the transformation method. This step involved assigning ground control points (i.e. Georeferencing) using a given coordinate system and extracting different datasets (features) through a process called digitizing. Four distinct points on the Landsat ETM+ image of the study area were selected. The Landsat image already georeferenced in UTM coordinates. The three points selected and their coordinates are as follows:

Table 1: Georeferenced Points Coordinates

S/No	NAME OF POINT	ATTRIBUTE OF POINT	NORTHING	EASTHING	REMARKS

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1.	Road/Railway Junction	Near Ohabiam - Asaeme	314625.55	560549.21	UTM (m)
2.	Ariaria market Road/ Junction	Faulks Road Junction	314627.55	564725.21	UTM (m)
3.	River/Road Junction	Near World Bank Urban Development Project.	314622.57	564657.12	UTM (m)
4.	Enugu/PortHarcourt Road Junction	Near Asa-Nnetu market	320455.24	565628.97	UTM (m)

Source:Author's Analysis.

In ILWIS Raster Operation, Sub map editor was selected and activated in the menu option. The north-oriented Aba Landsat image was input and selected, the coordinate's entry option was chosen as against Lines and Columns or corners in the menu. First coordinate which was serial number 2: 312416.9288E, 568697.5241N as in table 1 above; and the opposite coordinate which was serial number 4: 322933.6105, 556232.5104 were input. The output raster Submap name Aba_Landsat_1 Submap was typed-in and defined to display the Submap. Submaps of other bands were created and stored as Aba_Landsat_2submap and Aba_Landsat_3submap. The Submaps of the Nigeria sat -1 imageries were also created and stored as Aba_Nigsat_1-1submap, Aba_Nigsat_1-2submap and Aba_Nigsat_1-3submap.

The Resample operation resampled a raster map from the map's current Georeference to another target Georeference. The coordinate of each output pixel is used to calculate a new value from close-by pixel values in the input map. Three resampling methods are available: nearest neighbor, bilinear interpolation, and bicubic interpolation. The resample operation was done to bring the two satellite imageries to one resolution since Nigeriasat_1 has 32m resolution and the Landsat has 28.5m resolution. Igbokwe (2010) noted that higher resolution image can be resampled to a lower resolution image and vice versa. In this study, the Nigeriasat-1 imagery was resampled to Landsat ETM+ image resolution of 28.5m. The resultant Nigeriasat_1 image has a common resolution to Landsat of 28.5m. This is a requirement for image post classification change detection analysis. This resampling operation brought all the imageries to a common resolution since classification is a pixel-wise operation.

The two resampled imageries and the polygonized and sampled base map were classified using the above mentioned classification scheme. The minimum distance (MD) supervised image classification method was used for the sampled imageries while the manual unsupervised classification was used for the polygonized and sampled base map based on minimum distance

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algorithm. This was carried out because the MD algorithm offered the best output in terms of details on Landuse and Landcover (LU/LC) classification as it defined the distance between two distinct codes (pixels) (Igbokwe,2010).

Using the ILWIS software, three major LU/LC classes were developed and colors assigned appropriately to depict the result in cartographic format for visual interpretation. The three classification schemes are:

-    **Built-up area:** This include all human constructions of any kind such as settlement, roads, infrastructures, etc. it also include bare surfaces as they both reflect the same spectral signature in cyan colour (using the false colour composite). In the classification scheme it was coded grey, being the representation colour of built-up area in cartographic format.

 -   **Rivers:** This scheme includes all forms of water body found in Aba, be it stream, pond, lake, etc. as water tends to look dark blue on a false colour composite, thus having the same spectral signature or Digital Number (DN) value. In the scheme it was coded blue, being the representative colour of river in cartographic format.

 -    **Vegetation:** No doubt, vegetation gave way to any human activities, be it construction of roads, settlement or other developmental activities hence, its scheme was equally provided. A critical look at the   false colour composite shows that it appears as red. In the classification scheme it was coded green, being the representation colour of vegetation in cartographic format.

Aba is within the rain forest region of Nigeria and obtaining information about the ecosystem is often difficult hence the application of Remote Sensing techniques review of the results shows a corresponding increase and decrease in some of the features owing to urbanization.
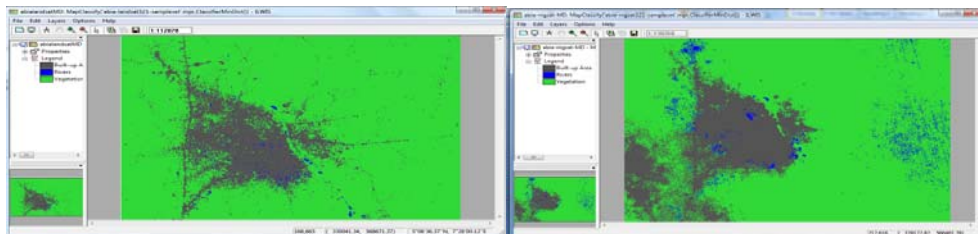

Fig.2:
(a) Classified 2000 Landsat ETM+   (b) Classified 2005 NigeriaSat-1
 MD Comparative View of Supervised Classifications of Aba Landuse/cover
SOURCE: AUTHORS LAB WORK

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4. RESULTS AND ANALYSIS

Table2: Aba Landuse/cover Change Analysis

Landuse	River 1991	2000	2005	Built-up Area 1991	2000	2005	Vegetation 1991	2000	2005
Area (Ha) Covered (%)	62	91	92	89	110	150	260	210	169
	15.1	22.1	22.4	21.7	26.8	36.5	63.2	51.1	41.1
% diff.	0	+7.0	+0.3	0	+5.1	+9.7	0	-12.1	-10.0

Source: Author's Analysis

As observed from the above summary table, the Landuse change of Aba since 1991 was significant. From 1991 to 2000 and 2005, the **River** increased from 15.1% to 22.1% and finally to 22.4% due partly to increasing activities within and around the waterways and increase in global warming thus giving rise to increase in water level. Within the same year under review 1991 to 2005), **Built-up area** on the other hand has increased from 21.7% to 26.8% and finally to 36.5%. Unlike river and built-up area, there is a significant disparity and trend in vegetation Landcover due to rapid urbanization and other socio-economic activities as explained earlier. Thus, vegetal cover decreased from 63.2% in 1991 to 51.1% in 2000 and in 2005 it further decreased to 41.1%.

5. ACCURACY ASSESSMENT OF THE LAND USE/LAND COVER CHANGE ANALYSIS TECHNIQUE

Table 3(a) ERROR MATRIX TABLE FOR 2000 LANDSAT ETM+

LANDUSE	Built-up	Vegetation	River	Total	Error of commission
Built-up	5966	42	1	6009	0.7%
Vegetation	20	28997	14	29031	0.05%
River	126	6	134	266	4.5%
TOTAL	6112	29045	149	70612	
Error Of Ommission	2.3%	0.02%	0%		

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Table 3(b) ERROR MATRIX TABLE FOR 2005 NIGERIA SAT-1

LANDUSE	Built - up	Vegetation	River	Total	Error of commission
Built-up	6972	5375	0	12347	43.5%
Vegetation	0	45831	0	45831	0%
River	50	598	63	711	8.9%
TOTAL	7022	51804	63	58889	
Error Of Ommission	0.7%	1.2%	0%		

The overall accuracy for Table 3 (a & b) obtained from the supervised classification of the multidate image data sets by ILWIS 3.3 cross operation are 99.41% and 89.77% respectively for Landsat ETM+ (2000) and Nigeria Sat-1(2005) imageries.

Figure 3 and 4c shown below represent the final Landuse/cover map overlay produced from the supervised imageries (Landsat ETM+ and NigeriaSat-1).The derived products (figure 3a and b) shows a significant change from 2000 to 2005 due largely to rapid urbanization occasioned by high influx of people for commercial reasons and rapid erection of buildings, was responsible for the gradual depletion of vegetal cover as shown in tables 3a and 3b respectively.

Abia State has two main urban centres, namely: Umuahia and Aba. Umuahia, the state capital, has become
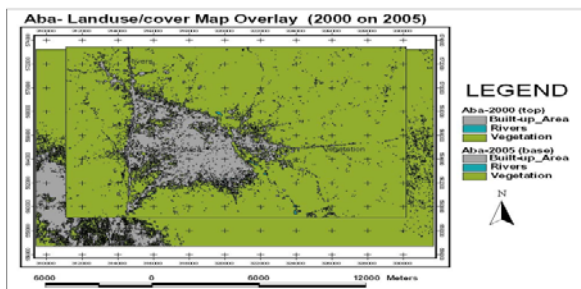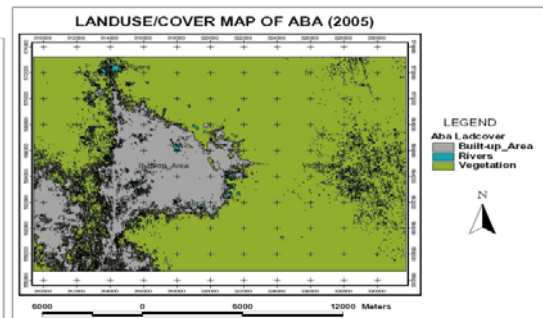
Fig.3: Map Overlay of Aba (2000 on 2005)   Fig.4a
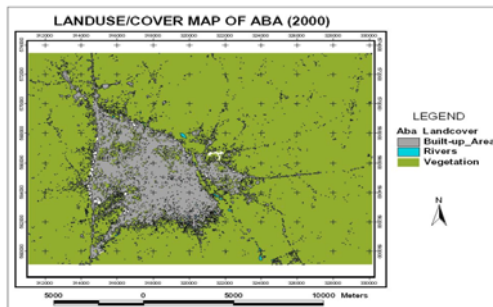
SOURCE: AUTHORS LAB WORK

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Fig: 4 b   Fig. 4c Landuse and Landcover Map of ABA
SOURCE: AUTHORS LAB WORK
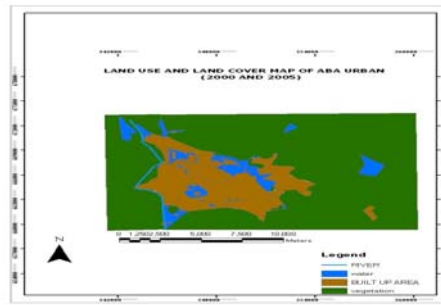
Aba is a city and a big trading center in Abia State, located on the Aba River. Aba was established by the Igbo people of Nigeria as a market town and then later a military post was placed there by British colonial administration in 1901. The city became a collecting point for agricultural products following the British made railway running through it to Port Harcourt. Aba is a major urban settlement and commercial center in a region that is surrounded by small villages and towns. The indigenous people of Aba are the Ngwa, an Igbo group. Aba is well known for its craftsmen. One can therefore acknowledge that the above brief background information is mainly responsible for the nature of distribution of Landuse/cover pattern in Aba. The results obtained from the classified images and the maps shown above (figures 3, 4a and 4b respectively) and table 2, showed the distribution of the Landuses within the period under review. From previous work on Aba in 1991, the distribution of the Landuses showed that vegetation had the highest area of about 260 hectares out of 411 hectares considered. This represents about 63.2% of the entire area of study. Also, the river occupied an area of about 62 hectares which represent 15.1% of the area of surveyed. In addition, the built-up area occupied about 89 hectares which represents about 21.7% of the area under consideration. This may be attributed to the fact that Abia State was yet to be created out of the old Imo State and the population and socio-economic activities is not as high as is obtainable today.

Table 3 also showed the Landuse distribution for the year 2000 (as obtained from Landsat ETM+). In this case, vegetation still ranked highest in the area occupied with about 210 hectares which represent 51.1% of the total Landuse considered. The built-up area increased from 62 hectares to about 110 hectares representing 26.8% of the total area within the period of nine (9) years. Also, the river also increased from 62 hectares to 91 hectares representing about 22.1%.

Similarly, Table 4 showed the Landuse for the year 2005 (as obtained from Nigeriasat-1 acquired in the year 2005). The river insignificantly increased from 91 hectares to 92 hectares. The vegetation this time decreased from 210 hectares in the year 2000 to 169 hectares in the year 2005 representing a decrease of about 41 hectares. The built-up area continued to be on the increase from 110 hectares in 2000 to 150 hectares in the year 2005.

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The histogram of figure 5 captured the scenario very vividly as the vegetation plunged below the abscissa line.
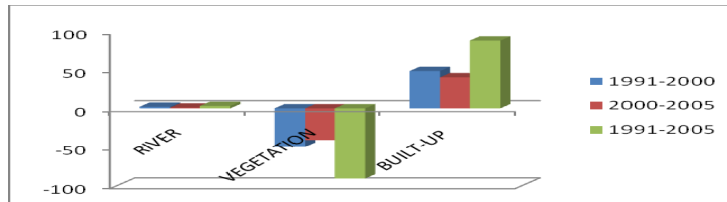

Fig. 5: Histogram of the Landuse changes from 1991 -2005
SOURCE: AUTHORS LAB WORK

6.   SUMMARY AND CONCLUSION

One of the main technical difficulties which have faced the application of analytical techniques to regional development analysis in many African countries has been the lack of relevant information (Ayeni, O.O, 2009). Aba like many other regions equally is confronted with similar problems. In determining the Landuse/Landcover of Aba, Remote Sensing technique was applied using the ILWIS software in image processing and analysis. The Landuse map of the study area was produced using ArcGIS/ArcView software.

Two multi-date datasets and analogue base map of 1991(Landsat ETM+ image of 2000 and NigeriaSat-1 image of 2005) were used. The base map was scanned, digitized and georeferenced in AutoCAD environment. The digitized base map was polygonized and classified. On the other hand, the two satellite imageries were Sub-mapped in the size of the base map. Thereafter the satellite images were resampled to one resolution before they were classified based on adopted classification scheme comprising, river, vegetation and built-up areas. Through an overlay operation, Landuse changes that took place over the period of about 14 years were obtained, analyzed and discussed. The result reveals that from 1991, 2000 to 2005, the **River** increased from 15.1% to 22.1% and finally to 22.4% due partly to increasing activities within and around the waterways and increase in global warming thus giving rise to increase in water level. Within the same years under review (1991 to 2005), **Built-up area** on the other hand increased from 21.7% to 26.8% and finally to 36.5%. Unlike river and built-up area, there is a significant disparity and trend in vegetation Land cover due to rapid urbanization and other socio-economic activities as explained earlier. Thus, vegetal cover decreased from 63.2% in 1991 to 51.1% in 2000 and in 2005 it further decreased to 41.1%.

A number of factors were adduced to be responsible for the Landuse change pattern. Several medium scale industries abound in parts of Aba which produce such items as plastic wares, textiles, food processing and machine tool fabrication. Aba is not only the major commercial centre of the State, but also one of the commercial nerve centers of the eastern states. Aba and the entire state is endowed with enormous mineral resources. The proper exploitation of these

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minerals has obvious economic and development implications Efforts to industrialize the state are equally being augmented by the private sector. Thus, three main categories of industries - public, partnership and private are found in Aba and all these are responsible for the observed Landuse/cover pattern of Aba. Apart from commercial activities, construction and farming equally play significant roles in forest depletion in Aba Town and environ.

7. RECOMMENDATIONS

Based on the aforementioned results and their analysis, the following recommendations are hereby made in this study:

i.   Since the vegetation land cover has been noted to be fast disappearing to other land uses,

adequate measures should be taken by the Abia State Government and the local

Governments authority concerned to mitigate the ugly trend.

ii.   That Government should as a matter of urgency embark on Landuse/Lancover mapping

in the entire region in order to facilitate accurate base map producing of abia State. This

will also enhance

ACKNOWLEDGEMENT

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