Assessment of Land Use Patterns and Land Cover Change in Igwuruta Area of Rivers State, Nigeria

Kamalu, O. J. & Wokocha C. C.*
Crop and Soil Science Department,
University of Port Harcourt,
P.M.B.5323, Port Harcourt
*chima.wokocha@uniport.edu.ng, cchimawokocha@yahoo.com

Abstract

The study assessed land use land cover change in Igwuruta in the Niger Delta area of Nigeria within a thirty year (1986 – 2015) period. Land cover and land use (LCLU) analysis of Igwuruta (about 8.69 km^2 or 870 hectares), was appraised for the period using remote sensing, GIS and physical soil resources inventory techniques. Primary source satellite imageries were extracted from the maps of the LCLU by the application of computer-based image processing and analysis. A top of the atmosphere reflectance was computed for all the imageries acquired using Dark Object Subtraction (DOS) image-based atmosphere corrections. Four major land cover types: forest, fallow and farmland, bare ground and built-up or residential areas were identified. The most dominant LCLU in the area in 1986 was forest occupying 3.78km^2 or 43.52% of the entire space but reduced to 1.92 % (0.174 km^2) in 2015. Built up (residential area) occupied 1.82 km^2 (20.97 %) in 1986 and increased to 68.02 % (5.91km^2) in 2015. Farm land and bare ground also declined steadily within the period. The Greater Port Harcourt City (GPHC) project, an urban expansion programme, was noted for the rapid transition in demography and land use alterations in Igwuruta area within the period under consideration. High level of pedo-turbation and loss of the native topsoil due mainly to increased construction activities that are associated with the urbanization process of the area are accountable for the increasing sand content of the surface soils.

Key Words: land cover, land use, remote sensing, satellite imagery, urbanization

Introduction

Port Harcourt, the Rivers State capital, is agreeably Nigeria's third fastest growing city after Lagos and Abuja. It has become investor's hob. Igwuruta area is about the fastest growing part of Port Harcourt municipality being nub of the Greater Port Harcourt City Development (GPHCD) programme. There has been some pressure on land resources and food security with increasing demand for allocation of land to urbanization over agriculture. It is pertinent to embark on land use and land cover analysis of the area as an essential aspect of the region's planning and development agenda. Land-use planning is the formulation of policies and programmes for guiding public and private land use in areas where different uses compete for land. Land use patterns and land cover trends in an area is a reflection of natural and socio-economic factors and their utilization by man over time (Templer *et al.,* 2005). Studies in different eco-regions have shown that deforestation and subsequent cropping or pasture establishment result in decrease in soil organic carbon and plant available nutrients. Changes in land use will continue to be the dominant driver of environmental changes, especially in the tropics in the next several decades. These alterations have important implications for biogeochemical cycles in the plant-soil interface (Lal, 2002; Templer *et al.* 2005; Uche, 2006). As a natural resource land has attracted so many influences from

different points of interest. Because of the ever increasing need resulting in numerous activities of man, only few landscapes on earth still retain their natural state. Even these restricted landscapes are under threat of man's developmental targets, unless protected by policies and planning. Land use change and land cover analysis are central components in current strategies for managing natural resources and monitoring changes in the environment (De-Sherbinin, 2004)**.** Remote sensing (RS) and Geographic Information System (GIS) have provided new tools for land use and advanced ecosystem management (Wilkie and Finn, 1996). Remote sensing and GIS have had increasing impacts across the globe and disciplines in mapping land use patterns and changes that have occurred for decades even without records or database. Thus reasonable projections have to be made to predict the possible changes/impacts in order to enable planners and policy makers have a basic tool for planning. It is pertinent therefore to embark on a study of land use /land cover of Igwuruta to avoid associated problems of urbanization like many other towns in Nigeria. This study is predicated on the fact that Igwuruta area is very prominent in the ongoing Greater Port Harcourt City project. The study has assessed the land use of Igwuruta catchment area with a view to detecting the changes that have occurred in status between 1986 and 2015. The study has characterized the land use/land cover patterns and dynamics and has related present properties of the soils to land use change.

Materials and Method
The Study Areas
Igwuruta is located at latitude 4°57'15"N and 7°0'45"E and longitude 4°95'41"N and 7°01'25"E with an area of about 8696700m^2 (Figures 1 A & B). It is a town in Ikwerre LGA, Rivers State, Nigeria and is bounded by Omagwa (the community hosting the Port Harcourt International Airport), Rukpoku and Eneka. The landscape is relatively flat, and a partially dense settlement. The climate is a humid tropical type characterized by wet and dry seasons. The wet season begins towards the end of March and ends in October with average rainfall ranging from 2000 to 2500 mm and temperature between 23°C (min) and 32°C (max).

Data source
The data used in this research were mainly from satellite imagery and ancillary data from ground truth and soil survey and inventory reports of 1967 and 2015. The ground truth data were in the form of reference data points collected using Geographical Information System (GPS) used for assessment of accuracy in the classification results. Total area of (8696700m^2) was delineated on the Landsat scene (188/057). The land use/land cover mapping of the area was based primarily on LandSat Thematic Mapper (TM) of December 1986 at 30m resolution, LandSat 7 Enhanced Thematic Mapper Plus (ETM+) of December 2000 and January 2003 at 30m resolution and LandSat 8 Operational Land Image (OLI) and Thematic Infrared Sensor (TIRS) of 2015 at 30m resolution using spectral band combination of 2, 3, 4, 5 and 7 in the visible wavelength spectrum (Red, Blue and Green).

Land Use/Cover Detection and Analysis
A computer assisted-digital image processing was used in the classification of land use/land cover. Supervised classification method with maximum likelihood of algorithm (MLC) which is one of the mostly used supervised classification approaches in remotely sensed image data was used in the ERDAS image 9.3 Software.

Land Use/ Land Cover Change Detection and Analysis
A post-classification detection change comparison was done using GIS to depict land use/cover change and a pixel-by-pixel comparison was used to obtain information on change.

The changes were interpreted considering the information differences from 1986 to 2015. The quantitative area data of the overall land cover/ land use change, reduction and increment in individual class of the period under investigation was computed.

Field Inventory, Soil Sampling and Description
Four representative transects located at Umuchem, Ikpo-Igwuruta, Umuodukwu and the Igwuruta-Port Harcourt Roads were studied. In each transect four sampling stations were selected and sampled at 0 – 30cm. Typical morphological features (colour, texture, drainage, slope, etc) were observed. Land use characteristics and land cover types were also inventoried at each soil study location.
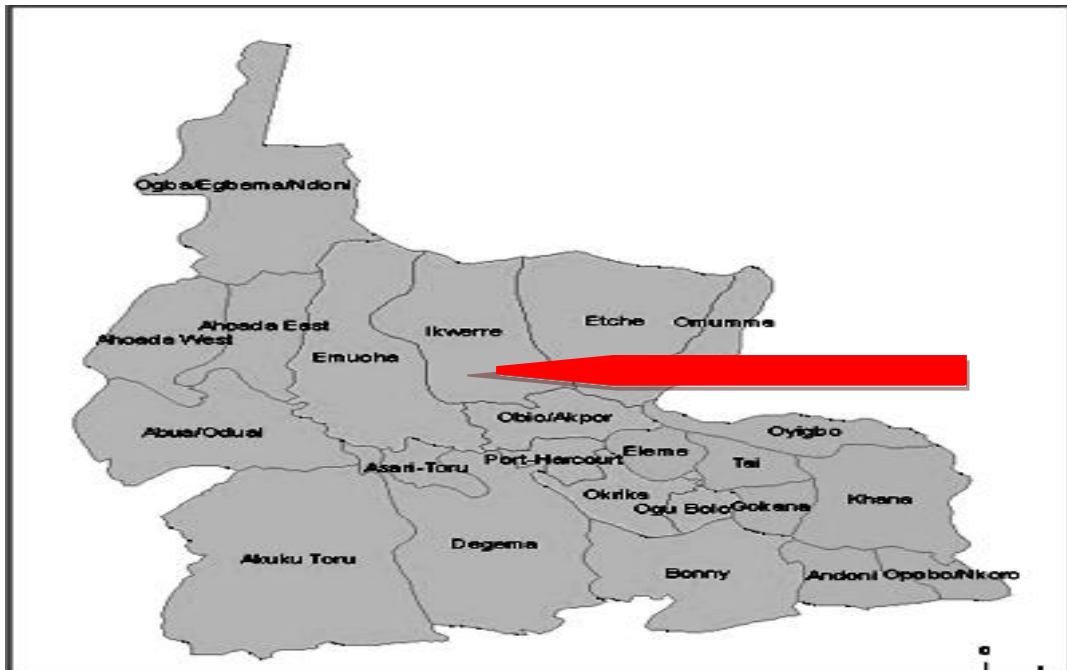

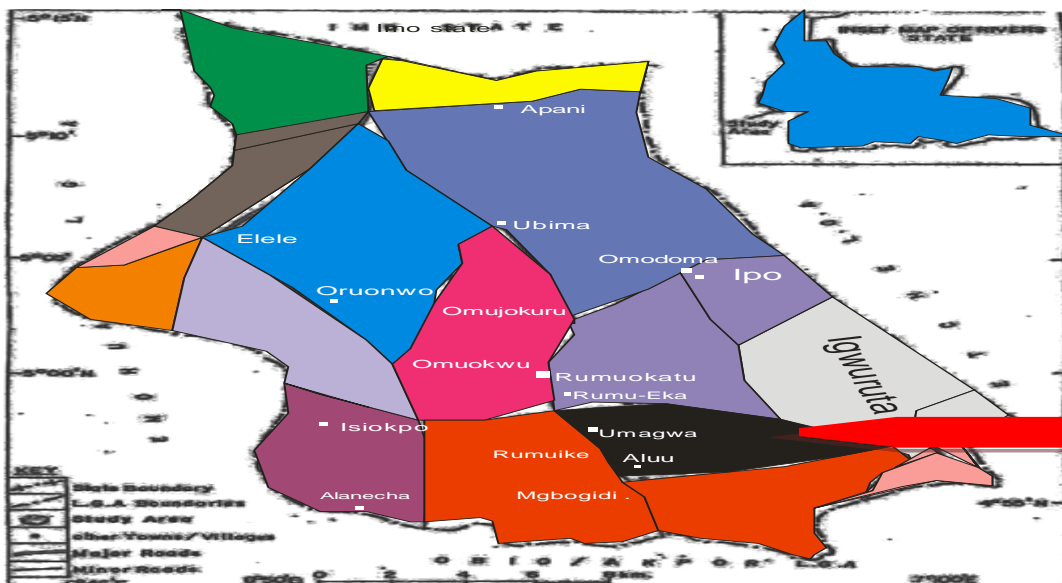**Figure 1A:** Map of Rivers State Showing Ikwerre Local Government Area

Figure 1B: Map of Ikwerre LGA showing the study area (Igwuruta)
Source: Ikwerre LGA Lands and Survey Unit

Results

Land Use/ Land Cover

The result of the data analysis of the land cover / land use of Igwuruta is presented in Figures 2 - 4. The area covered and the trend /changes detected in the study area across the period under consideration are shown in Table 1.0. Four major land cover/land use types were identified in the study area. These were forested land, farms and fallow lands, bare grounds and residential or built-up areas.

In 1986 the most dominant LCLU type was Forest occupying an area of $3.698km^2$ or approximately 370 hectares being 42.52% of the entire area. The area under farm and bare was $2.61km^2$ (30.05%), the second largest of the total land while built up had land consumption rate of 20.97% ($1.82km^2$) (Figure 2). In 2000,Forestry occupped about 15.62% ($1.36km^2$) of the entire study area .BVuilt up area occupied 58% while Farm land and Bare area both occupied 38.98% ($3.39km^2$) each.

In 2003 the total area covered by Forest was 13.36% ($1.16km^2$), built up was 13.69% ($1.19km^2$) and Farm land and bare remained top of the class, with 36.48 % ($3.17km^2$).

By 2015 built up had occupied a total of about 68.02% ($5.91km^2$)., Farm land had occupied 15.025 % ($1.304 km^2$), while Forest had a total of 1.92 % ($1.67km^2$).

Soil Resources Inventory

The inventory revealed a generally perfectly well drained landscape without any water body and characterized by sandy textured soils of strong brown to dark brown colours that have low organic matter status (Table 1). Specific field inventory along the four transects are presented below:

Transect 1: Transect 1 Along Igwuruta – Chokocho Road**:** The land is relatively flat. Land use is mainly farming, roads and residential. The soil texture is sandy loam. Strong brown dominated the soil colour 7.5YR 4/2 (moist) and one was dark brown -10YR 4/3 (moist). Vegetation is more or less of a secondary forest type; more of shrubs and moderate height wild oil palms.

Transect 2: Umuodukwu Igwuruta – Ali Road. Land use is mainly farm lands and fallow grounds. The soil is generally light in colous (strong brown). The terrain is mainly flat topography with good soil drainage.   The texture is sandy loam to loamy sand. The vegetation is predominantly shrubs and grasses

Transect 3: Along Igwuruta – Eneka Road. Land use is mainly residential, bare grounds and roads.   Most areas have lost the topsoil to roads and other construction activities. The soils all are of 7.5YR4/3 and 4/4 – pale brown (moist). The soil texture is generally loamy sand.

Transect 4: Along Igwuruta – Rukpoku / Port-Harcourt Road. Slightly undulating land form. Land use is mainly built up (residential), roads and developing public facilities. The area has a distinguishable topography, a slightly undulating land form. The Port Harcourt Road begins at the school round-about and ends at the border with Rukpokwu community on the southwest. It has the highest expansion almost entirely covered by buildings/ structures mainly of commercial and industrial categories.

Table 1.0: Field Inventory of Properties of Soils and Use Characteristics of Igwuruta

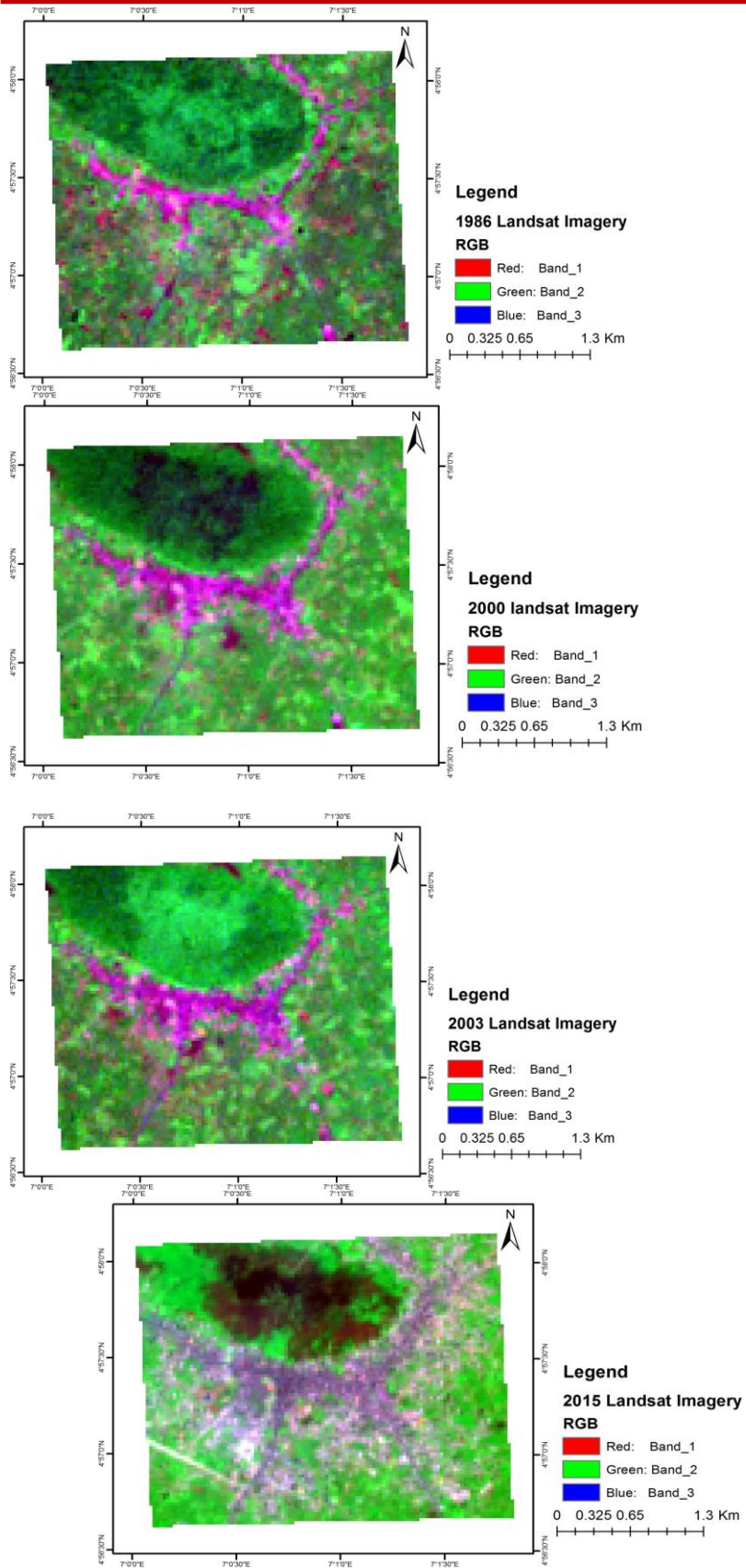| Sample Identity	Sampling Stations	Geographic Coordinate	Texture	pH	TOC	Dominant Land Use Features	Soil Characteristics
Transect 1 Along Igwuruta - Chokocho	1	N04º58.404 E007º02.363,	Sand	5.53	1.95	The land is relatively flat. Land use is mainly farming, roads and residential	• The soil texture is sandy loam. • Strong brown dominated the soil colour 7.5YR 4/2 (moist) and one was dark brown -10YR 4/3 (moist), • Vegetation is more or less of a secondary forest type; more of shrubs and moderate height wild oil palms.
	2	N04º58.370 E007º02.423,	Sand	5.48	1.27		
	3	N04º58.320, E007º02.479,	Sand	5.10	1.37		
	4	N04º533.286 E007º02.522.	Sand	5.03	0.89		
Transect 2 Umuodukwu Igwuruta – Ali.	9	04º57.817N 006º59.872E,	Sand	4.9	0.89	Land use is mainly farm lands and fallow grounds. The vegetation is predominantly shrubs and grasses	• sandy loam and loamy sand • flat topography, • good soil drainage, • The soil colours were dominated by strong brown.
	10	04º57.848N 006º59.880E,	Sand	5.30	0.84		
	11	04º57.900N 006º59.907E,	Loamy sand	5.76	0.39		
	12	04º57.995N 006º59.945E	Sand	4.87	0.20		
Transect 3 along Igwuruta – Eneka	5	04º55.800N 007º01.946E,	Sand	5.45	0.86	Land use is mainly residential, bare grounds and roads.	• Loamy sand. • The soils all are of 7.5YR4/3 and 4/4 – pale brown (moist). • Most areas have lost the topsoil to roads and other construction activities
	6	04º55.818N 077º02.008E,	Sand	6.10	0.86		
	7	04º55.822N 007º01.051E,	Sand	6.76	1.07		
	8	04º55.838N 007º02.086E	Sand	6.47	0.98		
Transect 4: Along Igwuruta – Rukpoku / Port-Harcourt Road	13	04º56.120N 007000.304E,	Loamy sand	5.00	0.92	Slightly undulating land form. Land use is mainly built up (residential), roads and developing public facilities	The area has a distinguishable topography, a slightly undulating land form.
	14	04º56.133N 007000.263E,	Sand	5.06	1.35		
	15	04⁰56.157N 007⁰00.182E,	Loamy sand	5.00	1.65		
	16	04⁰56.174N 007⁰00.120E.	Loamy sand	5.70	1.54		

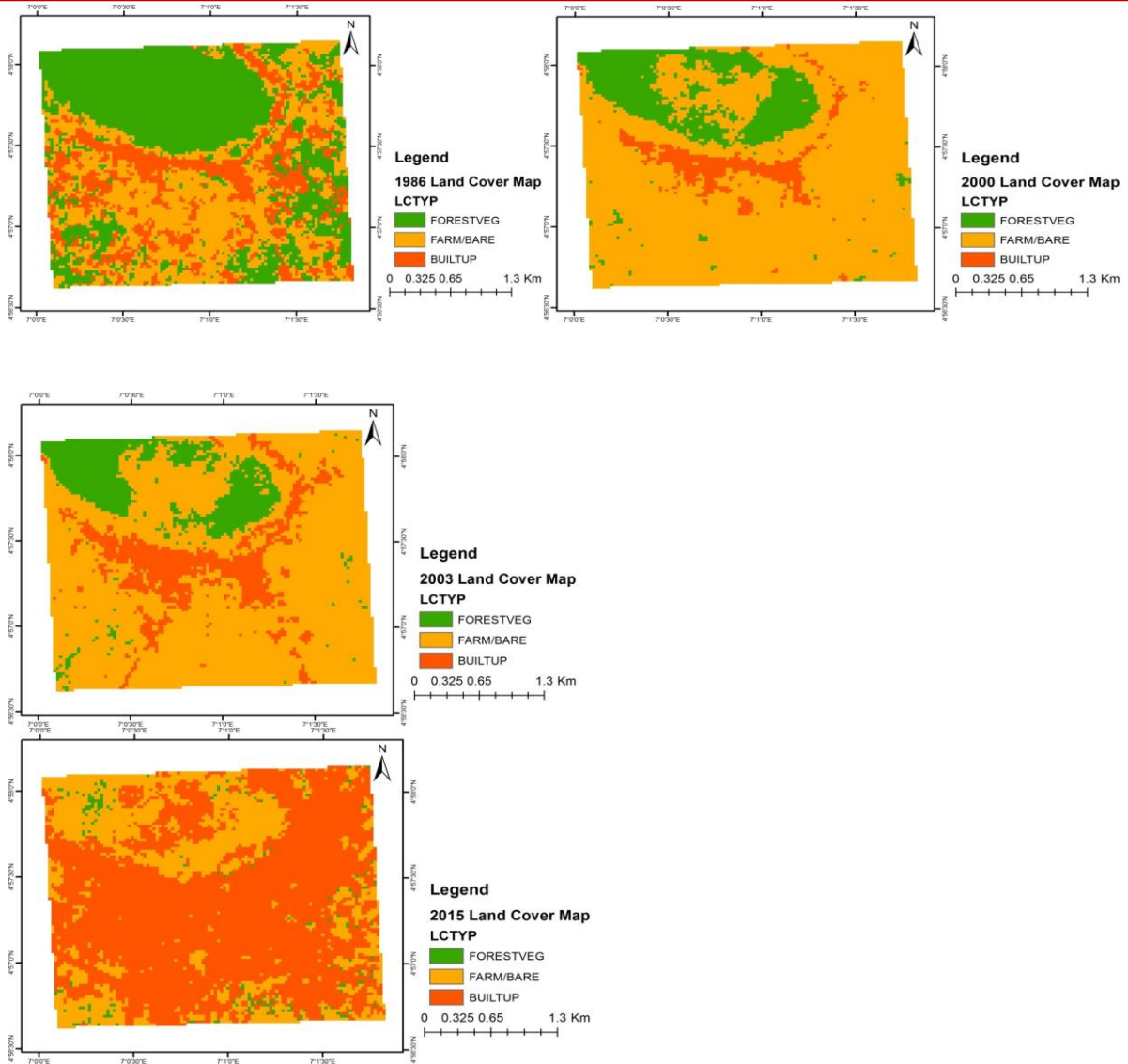**Figure 2: LandSat Imageries of 1986, 2000, 2003 and 2015**

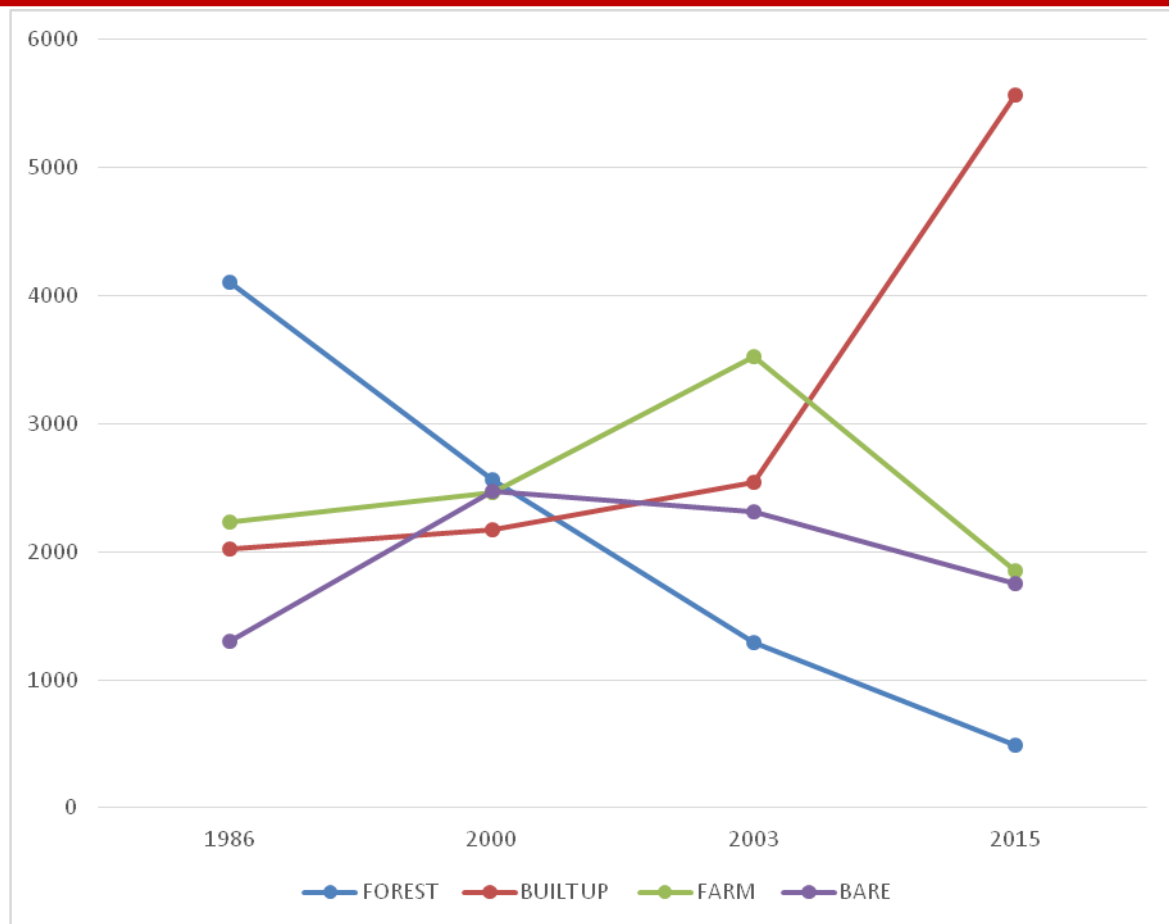**Figure 3: Land use / land cover Images of Igwuruta Between 1986 -2015**

Figure 4: Changes in Major Land Use / Land Cover Units in Igwuruta Area between 1986 and 2015

Discussion

The land resources of Igwuruta area for 30 years are presented using LandSat Imageries of 1986, 2000, 2003 and 2015. The inventory showed that the total land coverage of the study area was 8.69km^2. (869 hectares). The study showed that the land use had changed very quickly from a dominantly patchy rural agrarian community in 1986 to a growing urban setting in 2015.Urbanisation,deforestation, as well as industrialization were responsible for this. The erstwhile landscape of generally flat topography with sprawling forest vegetation and scattered consistence farm lands many years ago has changed to a semi-urban area with very little forest and limited agriculture.

Igwuruta has a total land area of 8696700m², and the land use change survey considered 30 years, 3 epochs of a 10year interval each 1986, 1996, 2015).The land cover change of Igwuruta has showed a steady decline in forest land cover over the past 30 years. Forest witnessed a consistent decline from 1986 to 2003.This was majorly due to industrialization and urbanization activities of man. The land area covered by forest reduced from 42.52% (3.69 km^2) in 1986 to 1.94% (0.174 km$^{2)}$ in 2015. The increase in consumption of the forest land use/cover type could be as a result of increase in population within this period. The acquisition of land for government projects and other uses which include commercial timber exploration, cutting of forest trees for fire woods accounted for the decline in foret land and corresponding increase in built-up area. In addition to these ineffective management of forests and forest disease do also play an important role in forest decline. The study area is also a great attraction for industrialization and development processes as it is located not too

far away from the airport. Bare surface area s which occupied space in the study area were areas where timber logging had occurred, and the surface left bare of vegetation. It also could be a reflection of continuous farming practices which have left soils bare and almost unproductive.

In the study area there was a notable decline in forest between 1986 and 2000. Within the same period there was also an increase in farming activities. This simply meant that a larger population in the study area got involved in farming activities for their source of livelihood. It is also noted that within this period the built up area percentage of the study area reduced. This is directly attributed to rural urban migration, whereby a large number of the people in the study area had migrated to the neighboring Port- Harcourt town in search of white collar jobs as well as greener pastures.

The area remained basically rural up till 2000. Build-up land use in Igwuruta area was in very small proportions in 1986, Forest and farms dominated the landscape of the study area until the early 2000.These land uses declined and reduced as urbanization activities extended to the study area. These three land use types declined at near equal rates. This process also translated to the fact that food security for the study area and its environs had reduced and the introduction of several kinds of health threatening diseases in association with industrial activities (alien customs) were introduced to the study area.

Therefore with the continuous decline in the forest, the study area was exposed to run-off hazards and soil loss through erosion, which also led to the reduction of amount and quality of arable land available for agriculture/farming. This trend has obvious food security challenges as well as high cost of agricultural products, (Arfan, 2008; Shafiq *et al.,* 1997; Ali *et al.,* 2000). Increment in the built-up class of the study area also signifies an increase of population and infrastructures. This scenario will result in overcrowding which will eventually also lead to health threat as well as pollution of the entire environment and other negative socio-economic trends in the near future. The lack of long term regional or urban development programme and poor land resources allocation in the study area can be said to be responsible for the inappropriate allocation and use of the most suitable agricultural land for urban development and industrialization.

Conclusion

The study conducted in Igwuruta community in Ikwerre LGA Rivers State supports that multi temporal satellite imagery plays a vital role in quantifying spatial and temporal phenomena. The study reveals that the major land use in the study area is built up. It also showed that changes occurred in the four land cover/use classes identified and classified in the study area across the three decades under investigation. This, study shows that remote sensing and GIS are important technologies for temporal analysis and quantification of spatial phenomena which is not quite feasible with conventional mapping techniques. Change detection is made possible by these technologies in less time, at low cost and with better accuracy. The result of the analysis revealed that the study area had experienced prominent continual changes in land use. Land use types changed consistently at various periods. Farm and bare ground classes declined at relatively moderate rates while built-up increased. Therefore, regional and land use planning programs should be instituted to restructure the land use for social and economic sustainability, and create healthy living environment.

References
Ali, M., Khan, S.J., Aslam, I., Khan, Z., 2008. Simulation of the impacts of land-use change on surface runoff of Lai Nullah Basin in Islamabad, Pakistan. Landscape Urban Plann. 102, 271–279.

Arfan, M., 2008. Spatio-temporal Modeling of Urbanization and its Effects on Periurban Land Use System (M.Sc. thesis). Department of Plant Sciences, Quaid-e-Azam University, Islamabad.

De Sherbinin, A., M.F.A.M. van Maarseveen, and R.V. Sliuzas. 2014. *Mapping the Unmeasurable? Spatial Analysis of Vulnerability to Climate Change and Climate Variability*. PhD Thesis. Enschede, Netherlands: ITC-University of Twente. http://ciesin.columbia.edu/documents/de_Sherbinin_2014_PhDThesis_UTwente.

De Sherbinin, Alex, Leah K. VanWey, Kendra McSweeney, et al. "Rural Household Demographics, Livelihoods and the Environment." *Global Environmental Change* 18.1 (2008): 38–53.

IUCN, 2005. Rapid environmental appraisal of developments in and around Murree hills. Retrieved from <http://www.iucn.pk> (accessed 28.06.13).

Shafiq, M., Ahmed, S., Nasir, A., Ikram, M.Z., Aslam, M., Khan, M., 1997. Surface runoff from degraded scrub forest watershed under high rainfall zone. J. Eng. Appl. Sci. 16, 7–12.

Templer, P.H., Groffman,P.M., Flecker, A.S. and Power, A.G. (2005). Land use change and soil nutrient transformations in the Los Haitie's region of the Dominican Republic. Soil Biol. And Biochem. 37: 215 – 225.

Uche, J.N. (2006). Effect of forest and land use systems on physic-chemical properties of an ultisol in southeastern Nigeria. M.Sc. Thesis, Abia State University, Uturu, Nigeria.

Wilkie, D.S., and Finn, J.T. 1996. Remote Sensing Imagery for Natural Resources Monitoring. Columbia University Press, New York. p. 295.