Spatio-Temporal Analysis of Land Use/Land Cover Change Trend of Akwa Ibom State, Nigeria from 1986-2016 Using Remote Sensing and GIS

Aniekan Eyoh[1], Okon Ubom[2]

[1, 2]Department of Geoinformatics & Surveying, Faculty of Environmental Studies, University of Uyo, Nigeria

Abstract: ***This research examines the spatio-temporal changes of Land use/Land cover of Akwa Ibom state from historical remote sensing dataset (Landsat TM, ETM+ and OLI images acquired on 1986, 2001 and 2016).Three set of Landsat images were classified into five land use/land cover classes (built up/bare lands, water, mangrove/primary vegetation, secondary vegetation and cultivated/mixed vegetation) using unsupervised and supervised algorithm in ERDAS IMAGINE and ArcGIS. The Overall Classification Accuracy and KAPPA (K^) STATISTICS was 91.50% and 0.8301; 90.77% and 0.8227; 91.81% and 0.8491 for 1986, 2001 and 2016 respectively. The spatio-temporal analysis of the change trend indicated that from 1986 to 2016, built up/bare lands increased by 62,828hectares (19.56%), water bodies decreased by 3,425 hectares (1.07%), mangrove/primary vegetation decreased by 96,333hectares (29.99%), secondary vegetation increased by 97,486hectares (30.34%) and Cultivated/mixed vegetation decreased by 61,191hectares (19.04%). The result demonstrated that historical remote sensing images can be used toinvestigate change trendof land use/land over of the study area. Also, the result raisesconcernover the unabated alteration of the natural environment particularly the depletion of mangrove/primary vegetation and conversions of arable cultivated lands to settlements, thus, calling for urgent review of land use planning process.***

Keywords: Land use/Land cover; remote sensing, GIS, change trend; spatio-temporal

1. Introduction

Throughout history, human activities have impacted on the natural ecosystem through the aggressive drive for development and livelihood. The study of land use and land cover change is one of the foremost arenas to understand the degree of interaction between man and environment. Since 1970s, remote sensing satellite-derived (such as Landsat Thematic Mapper-TM) has emerged as an important tool for precise mapping of Land use/land cover (LULC) and change detection. The term "land use" and "land cover" are often used simultaneously to depict maps that afford information about the types of features existing on the Earth's surface. Land cover refers to the physical individuality of Earth's surface, which is captured by vegetation, soil, water bodies and other physical features of the land. Land use refers to the way in which land has been used by humans and their habitat, usually for economic activities [4]. According to IPCC, the change of Land use/Land cover represents one of the most important factors influencing terrestrial and aquatic ecosystems. Land use/land cover changes play a major role in global environmental changes, as they significantly change the boundary relationship between the Earth and the atmosphere. Natural and anthropogenic changes in land use affect many landscape features, and interact in a variety of ways - for example on the global carbon cycle - with the climate system [3]. From the forgoing, research and investigations of Land use/Land cover changes have become more and more imperative. Detecting change digitally will help in determining the changes that have occurred in land use and land cover with the help of geo-referenced multi-dimensional remotely sensed data [2]. For this research, Satellite imagery with mediumspatial resolutions was used for the purpose of change detection both in spatial and temporal extents in the study area.The availability of imagery of the desire dates is one of the limitations of the study along with the availability of very high resolution satellite images. The research justifies the importance in keeping an eye on resources of the Earth using the remote sensing and GIS.

Aim and Objective

The specific aim of this research was to analyze the spatio-temporal change trend of land use/land cover of Akwa Ibom state, Nigeria from 1986-2016 using remote sensing and GIS.

The above stated aim was accomplished with the following specific objectives: Image preparation and generation/extraction of spatial extent of the study area from three scenes of Landsat images; LULC classification and Accuracy assessment; and Spatio-temporal analysis of LULC change trend

2. Study Area

Akwa Ibom State is situated in Niger delta region of Southern Nigeria. It lies between latitude $4^0 30^0$N and $5^0 30^0$N and longitudes $7^0 30^0$E and $8^0 15^0$E [Fig1]. It is the topmost oil producing state in the country. The state covers an area of about 8000sq.km. Mean annual rainfall over the area decreases graduallyfrom about 4050mm near the coastal area to about 2100mm in the north. The mean annual temperature is 26.9°C.Relative humidity except for the short period of dry season remains at an average of 70% to 80% throughout the year. The area is noted for its wetlands, sandy coastal ridge barriers, brackish or saline mangroves, fresh and saltwater swamp forests as well as lowland rain forest. It is crossedby a number of rivers and streams. The area has very high agricultural potentials and is rich in crude oil, gas and many other natural resources.

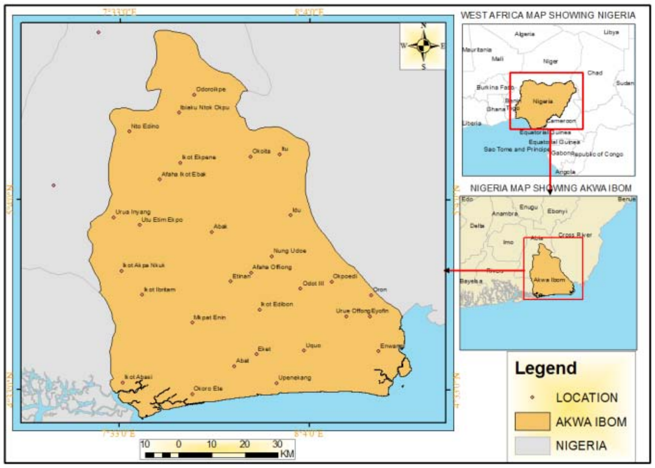

Figure 1: Location of Akwa Ibom State, Nigeria

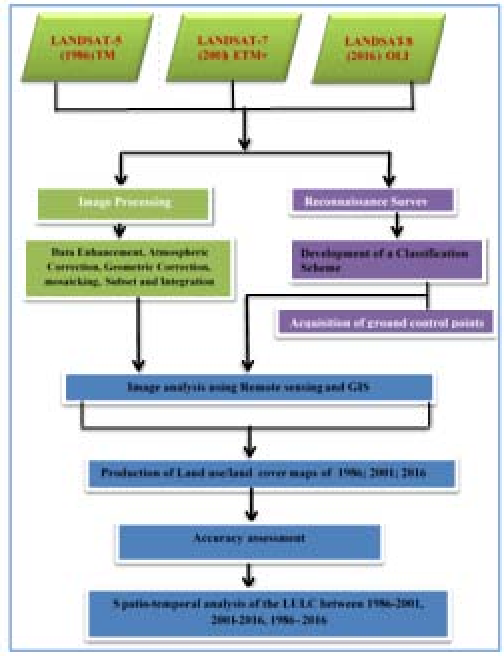

Figure 2: Research Methodology Flow Chart

3. Methodology

3.1 Data

Remotely Sensed satellite imagery of Landsat TM, ETM^+ and OLI images acquired on 1986, 2001 and 2016 were used for the land use/land cover classification and change trend analysis.The three Landsat scenes (path 188/row 56 & 57 and path 187 row 57) that covers the study area were obtained from the United State Geological Surveys (USGS) with a resolution of 28.5m.These datasets were all acquired in the dry season in order to minimize seasonality variations.

3.2 Image Processing And Data Preparation

Radiometric calibration and corrections is important component to the change detection [1], as it can eliminate or reduce image differences introduced as a result of changing atmospheric conditions. Hence, for the three set of images to be use together for change detection studies, necessary image processing was carefully carried using ERDAS IMAGINE software.Atmospheric and radiometric correction was carried out followed by image to image geometric correction. The geometric correction was done by correcting Landsat 5-TM and Landsat 7 ETM+ images using the corrected image of Landsat 8-OLI that was already geometrically registered using ground control points. Thereafter, mosaicking, Subseting and Integration was done to generate/extract the spatial extent of the study area from three scene of Landsat images.

3.3 Development of Image Classification Scheme and Image Analysis Using Remote Sensing and GIS

Image classification is the process of assigning pixels of continuous raster image to pre-defined land cover classes. Before the image were classified, field reconnaissance was carried out to identify and developed land use/land cover classes. The land use/land cover classes identified and used for the study were; built up/bare lands, water, mangrove/primary vegetation, secondary vegetation and cultivated/mixed vegetation. Table 1 shows the LULC classes and description.

Table 1: LULC classes and description

LULC Class Name	Description
Built up/bare lands	All settlements and bare soil .
Water	All the water bodies, ocean, rivers, stream etc.
Mangrove/primary vegetation	The mangrove and evergreen forested areas.
Secondary vegetation	Lightly forested area that has slightly been altered by human activities.
Cultivated/mixed vegetation	These were cultivated lands and farmlands mixed with light forestation.

Also, reasonable number of ground control points belonging to corresponding land use land cover classes were acquired in the field across the study area.

In this study image classification was done by performing unsupervised and supervised classification in ERDAS IMAGINE. Accuracy assessment was also carried out using ground control points acquired during field ground truthing along with historical map information of the study area.

4. Data Analysis and Result Discussion

All the three processed images that were classified were subjected toaccuracy assessment. The overall accuracy and kappa statistics as calculated is shown in table 3-5. The result of the LULC classification shownin table 2, figure 3, 4, 5and 6indicated that built up/bare lands increased from104,675ha in 1986 to 125,083ha in 2001 and further increased to 167,503ha in 2016.Water increased in 2001 but decreased in 2016. Mangrove/primary vegetation occupied an area of 229,917ha in 1986 and was greatly depleted to 160,217ha and further decreased to 133,584ha. Secondary vegetation on the other hand increased consecutively from 1986 to 2016 owing to anthropogenic activities in the primary vegetated areas.The cultivated/mixed vegetation recorded a steady decline across the years as a result settlement expansion.

Table 2: LULC Spatial Extent in 1986, 2001 and 2016

Class Name	1986 Area (Ha)	2001 Area (Ha)	2016 Area (Ha)
Built Up/Bare Lands	104,675	125,083	167,503
Water	114,328	115,659	110,903
Mangrove/Primary Vegetation	229,917	160,217	133,584
Secondary Vegetation	114,495	193,851	211,981
Cultivated/Mixed Vegetation	218,027	186,530	156,836

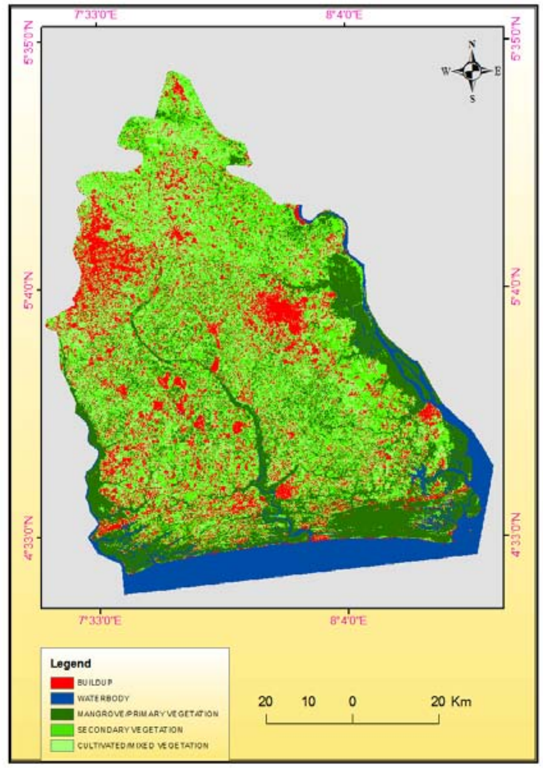

Figure 4: 2001 land use/land cover map ofAkwa Ibom State

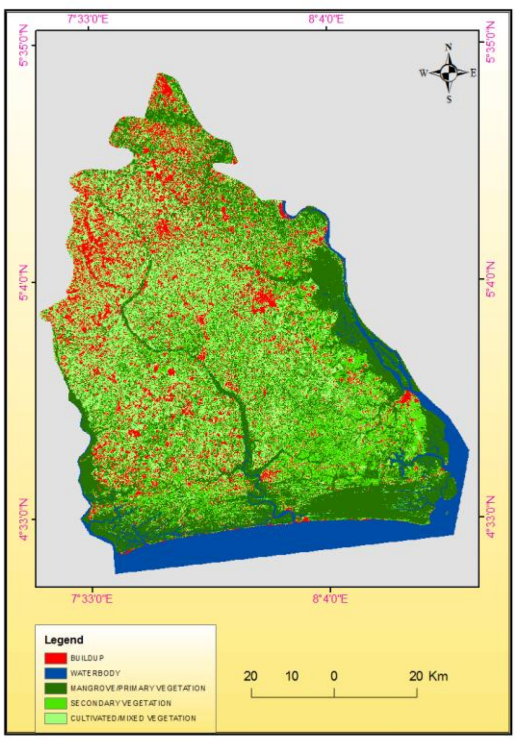

Figure 3: 1986 land use/land cover map ofAkwa Ibom State

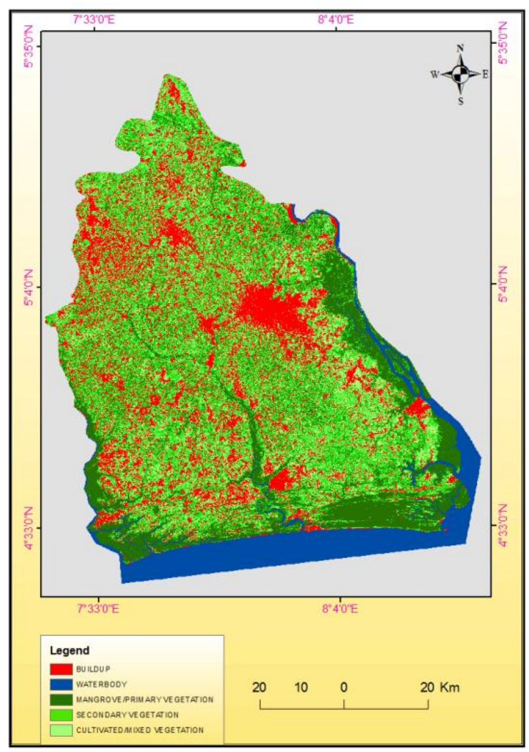

Figure 5: 2016 land use/land cover map ofAkwa Ibom State

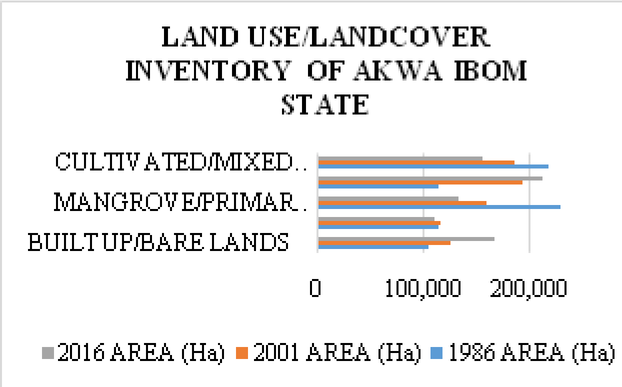

Figure 6: LULC Spatial Extent in 1986, 2001 and 2016

Table 3: LULC CLASSIFICATION ACCURACY – 1986

ACCURACY ASSESSMENT FOR 1986 CLASSIFICATION					
Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
BUILT UP/BARE LANDS	637	629	605	94.98%	96.18%
WATER	80	70	65	81.25%	92.86%
MANGROVE/PRIMARY VEGT.	83	103	81	97.59%	78.64%
SECONDARY VEGET.	55	39	34	61.82%	87.18%
CULTIVATED/MIXED VEGT.	59	74	52	88.14%	70.27%
Totals	918	918	840		
Overall Classification Accuracy =	**91.50%**				
KAPPA (K^) STATISTICS FOR 1986 CLASSIFICATION					
Overall Kappa Statistics = 0.8301					
Conditional Kappa for each Category.					
Class Name	**Kappa**				
BUILT_UP/BARE LANDS	0.8753				
WATER	0.9218				
MANGROVE/PRIMARY VEGET	0.7652				
SECONDARY VEGET.	0.8636				
CULTIVATED/MIXED VEGET.	0.6823				

Table 4: LULC CLASSIFICATION ACCURACY – 2001

ACCURACY ASSESSMENT FOR 2001 CLASSIFICATION					
Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
BUILT UP/BARE LANDS	677	651	641	94.68%	98.46%
WATER	72	81	63	87.50%	77.78%
MANGROVE/PRIMARY VEGT.	89	94	72	80.90%	76.60%
SECONDARY VEGET.	81	77	58	71.60%	75.32%
CULTIVATED/MIXED VEGT.	62	80	58	93.55%	72.50%
Totals	986	986	895		
Overall Classification Accuracy =	**90.77%**				
KAPPA (K^) STATISTICS FOR 2001 CLASSIFICATION					
Overall Kappa Statistics = 0.8227					
Conditional Kappa for each Category.					
Class Name	**Kappa**				
BUILT_UP/BARE LANDS	0.951				
WATER	0.7603				
MANGROVE/PRIMARY VEGET.	0.7427				
SECONDARY VEGET.	0.7312				
CULTIVATED/MIXED VEGET.	0.7065				

Table 5: LULC CLASSIFICATION ACCURACY – 2016

ACCURACY ASSESSMENT FOR 2016 CLASSIFICATION					
Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
BUILT UP/BARE LANDS	753	780	743	98.67%	95.26%
WATER	86	88	83	96.51%	94.32%
MANGROVE/PRIMARY VEGT.	105	88	82	78.10%	93.18%
SECONDARY VEGET.	126	114	93	73.81%	81.58%
CULTIVATED/MIXED VEGT.	97	99	72	74.23%	72.73%
Totals	1172	1172	1076		
Overall Classification Accuracy =	91.81%				
KAPPA (K^) STATISTICS FOR 2016					
Overall Kappa Statistics = 0.8491					
Conditional Kappa for each Category.					
Class Name	**Kappa**				
BUILT_UP/BARE LANDS	0.8673				
WATER	0.9387				
MANGROVE/PRIMARY VEGET.	0.9251				
SECONDARY VEGET.	0.7936				
CULTIVATED/MIXED VEGET.	0.7027				

4.1 Analysis of Change Trend and Discussion

Using equation 1 below, the percentage change trend was calculated as presented in table 6.

$$(\textbf{\textit{Trend}})\ \text{percentage change} = \frac{\text{Observed change}}{\text{Sum of change}} * 100 \text{ - - } (1)$$

The spatio-temporal analysis of the change trend indicated that from 1986 to 2001, built up/bare lands increased by 20,408ha (10.09%), water bodies increased by 1,331ha (0.66%), mangrove/primary vegetation decreased by 66,700ha (34.45%), secondary vegetation increased by 79,356ha (39.23%) and Cultivated/mixed vegetation decreased by 31,497(15.57%).

From 1986 to 2001, built up/bare lands increased by 42,420hectares (34.87%), water bodies decreased by 4,756 hectares (3.91%), mangrove/primary vegetation decreased by 26,633hectares (21.80%), secondary vegetation increased by 18,130hectares (14.91%) and Cultivated/mixed vegetation decreased by 29,694hectares (24.42%).

From 1986 to 2016, built up/bare lands increased by 62,828hectares (19.56%), water bodies decreased by 3,425 hectares (1.07%), mangrove/primary vegetation decreased by 96,333hectares (29.99%), secondary vegetation increased by 97,486hectares (30.34%) and Cultivated/mixed vegetation decreased by 61,191hectares (19.04%).

This result implies that so much of the evergreen vegetation and even the forest reserved down south and north central region of the state has been greatly depleted may be because majority of the people living in the study area are self-employed and their major occupation are farming, fishing and logging. Also, a large extent of the cultivated land lost in the state has been greatly lost to urban and suburban construction and development. Moreover, the general associated impacts on land use/land cover changes from other human activities on the primary and secondary forest and creeks could also be by acid rain from fossil fuel combustion, and oil exploration activities within the study area.

Table 6: Trend of Land use/land cover change in the study area

Class Name	Area Change 1986-2001 (Ha)	%change 1986-2001	Area Change 2001-2016 (Ha)	%change 2001-2016	Area Change 1986-2016 (Ha)	%change 1986-2016
Built Up/Bare Lands	20,408	10.09	42,420	34.87	62,828	19.56
Water	1,331	0.66	-4756	3.91	-3425	1.07
Mangrove/Primary Vegetation	-69700	34.45	-26633	21.8	-96333	29.99
Secondary Vegetation	79356	39.23	18130	14.91	97486	30.34
Cultivated/Mixed Vegetation	-31497	15.57	-29694	24.42	-61191	19.04

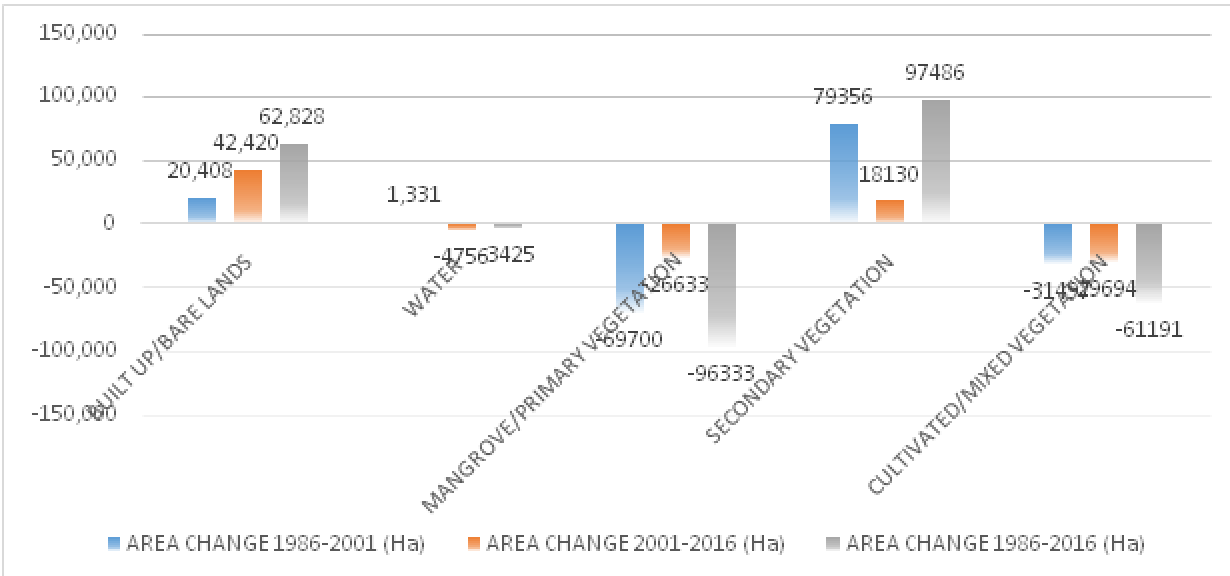

Figure 7: Land use/land cover change trend in the study area

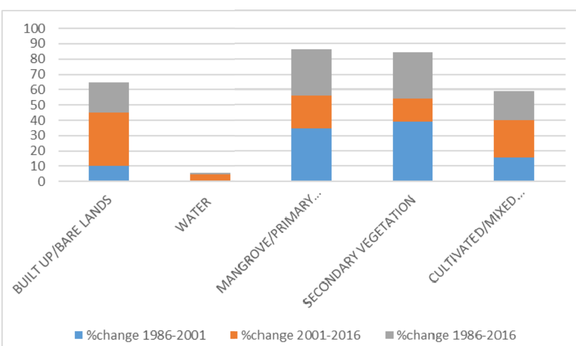

Figure 8: Land use/land cover stacked % change trend in the study area

5. Conclusion

I strongly believe that this research has explored the use of satellite remote sensing and GIS in analyzing Land use/land cover change trend.The spatio-temporal analysis of the change trend indicated that from 1986 to 2016, built up/bare lands increased by 62,828hectares (19.56%), water bodies decreased by 3,425 hectares (1.07%), mangrove/primary vegetation decreased by 96,333hectares (29.99%), secondary vegetation increased by 97,486hectares (30.34%) and Cultivated/mixed vegetation decreased by 61,191hectares (19.04%). These results will aid Environmental planners and policy makers in the state to effectively and efficiently understand Land use/land coverchange processes and its driving forces so as to make more precise projections of future planning and management, thus helping them generate plans which will foster sustainable development within the state.

6. Limitation/Future Scope

The availability of imagery of the desire dates is one of thelimitations of the study along with the availability of very high resolution satellite images. We are currently optimistic that the effort we have made to source for funds from our institution and other agency within the state to acquired high resolution satellite images of desired dates will materialize soon so that we can embark on modelling and prediction of future Land use/land cover scenarios. Nevertheless, we will be working on modelling and predicting future land use/land cover change scenarios using analytical models and multi temporal images within the study area.

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Author Profile

Aniekan Eyoh is a native of Itu Local Government Area, of Akwa Ibom State, Nigeria. He is currently a Lecturer in the Department of Geoinformatics and Surveying, Faculty of Environmental Studies University of Uyo, Akwa Ibom State, Nigeria. He is pursing PhD. Surveying and Geoinformatics from University of Nigeria, Enugu. He has completed M.Sc. surveying and Geoinformatics -2012 from University of Lagos, Lagos, Nigeria and B.Sc. Geoinformatics and Surveying -2006 from University of Uyo, Uyo, Nigeria. He was awarded as Best graduating student, Department of Geoinformatics and Surveying (B.Sc.-2006) and Best graduating student, department of Surveying and Geoinformatics (M.Sc.-2012). He is registered Surveyor, Surveyors Council of Nigeria and member Nigerian Institute of Surveyors. Publications & Conferences includes AniekanEyoh has 14 Publications in Peer-Reviewed Journal Publications (5 Intentional and 9 in Nigeria). He has attended several conferences (Local and International) and has two conference papers. He is the Principal Consultant of GEOMATICS CONSULT (A Surveying and Geospatial Information Consulting firm in Uyo Akwa Ibom state, Nigeria. The firm has in it employ, graduate Surveyors and other young upcoming professional in training).

Mr. OkonUbom (B.Sc Surveying &Geoinformatics, M.Sc Geographical Information Systems-University of Ibadan,Nigeria and Msc Geospatial & Mapping Sciences-University of Glasgow, Scotland) is a consummate geo-information scientist with experience across the spectrum of surveying, remote sensing, GIS, and survey geo-database management. He has been involved with key organizations including the Center for Management Training and Development, Lagos, Ministry of Lands, Housing & Survey (Akwa Ibom and Oyo states) and Shell Petroleum Development Company Ltd. and in recent times the Cross River State Geographic Information Agency, where he delivered services in the capacity of GIS Analyst. He is a currently a Senior Technologist (Remote Sensing & GIS) with theDepartment of Geoinformatics & Surveying, Faculty of Environmental Studies, University of Uyo, Nigeria.