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Classification of land use/land cover of Aniocha north local government area, Delta state using satellite imagery

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Abstract

Remote Sensing (RS) and Geographic Information System (GIS) have been established as indispensable tools in the assessment of Land use / Land cover (LULC) change. RS and GIS are important for the monitoring, modelling and mapping of land use and land cover changes across a range of spatial and temporal scales, in order to assess the extent, direction, causes, and effects of the changes. Change detection has provided suitable and wide-ranging information to various decision support systems for natural resource management and sustainable development. The main objective of the study is to assess and evaluate the extent and direction of changes in LULC of Aniocha North Local Government Area (LGA), Delta State, Nigeria to explain the changes and identify some of their effects on both the livelihoods of the local people and the local environment, and also to explore some of the conservation measures designed to overcome problems associated with land use and land cover changes. Landsat 7 Enhanced Thematic Mapper (ETM+) of 2002 with 30 meters resolution and landsat 7 Enhanced Thematic Mapper (ETM) 2014satellite images as well as GIS techniques were used to monitor the changes and to generate maps of the LULC of the area in these periods. Supervised Land Use/Land Cover classification algorithm (Maximum likelihood with null class) was used in the analysis of classification. The classification result of LandSat ETM+ (2002) revealed that farmland accounted for 36.34% of the total LULC class, followed by savannah which accounted for 24.15%. Forest built up area, and waterbody constituted 20.42%, 16.46% and 2.62% respectively. Also, the result of LandSat ETM (2014) shows that forest accounted for 38.59% followed by farmland with 30.93%. Built up area covers 25.55% while savannah and river cover 2.86% and 2.08% respectively. The classification shows 83.26 % average accuracy and 79.16 % overall accuracy for 2002 while the 2014 accuracy assessment showed 95.06% average accuracy and 94.99% overall accuracy. Growing population pressure and its associated problems, such as the increasing demand for land and trees, poor institutional and socio-economic settings, and also unfavorable government policies, such as lack of land tenure security and poor infrastructure development, have been the major driving forces behind the LULC changes.

Keywords: Land use; Land cover; Satellite Imagery; GIS

1. Introduction

Land is a complex and dynamic combination of factors: geology, topography, hydrology, soils, microclimates, and communities of plants and animals that are continually interacting under the influence of climate and peoples activities (1). It is a natural resource which provides space and raw materials for various developmental and other activities. Studies have shown that there are only few landscapes on the earth that are still in their natural state. Due to anthropogenic activities, the earth surface is being significantly altered in some manner and man's presence on the earth and his use of land has had a profound effect upon the natural environment thus resulting into an observable pattern in the land use/land cover change over time (2).

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Land cover simply means the physical or natural state of the earth's surface while Land use is the way humans use the land and its resources. Environmental factors such as soil characteristics, climate, topography, and vegetation constrain the land use. Improper land use is causing various forms of environmental degradation. For sustainable utilization of the land ecosystems, it is essential to know the natural characteristics, extent and location, its quality, productivity, suitability and limitations of various land uses. Local land use and land cover changes are fundamental agents of global climate change at all scale and are significant forces that impact biodiversity, water and radiation budgets, and trace gas emissions (3).

The land use/land cover pattern of a region is an outcome of natural and socio – economic factors and their utilization by man in time and space. Hence, information on land use / land cover is essential for the selection, planning and implementation of land use and can be used to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population (4).

According to Moore P. (5), deforestation is one of the major causes of land cover change and it is the most pervasive concerns in developing countries, especially in tropical moist forests, which covers some 550 million ha of the globe, with an annual harvesting rate of over 2%. The forest cover of the world is declining continuously and has global environmental implications. Moore P. (5), indicated the world wide consequences of deforestation as - change in the way of life of local people, extinction species, loss of undefined reservoir of genetic resources, increased erosion from wind and water, and increased desertification; increased runoff to rivers, resulting in flooding and future erosion; reduced transpiration from vegetation and thus less precipitation, and change in the regional albedo.

The variety of land use and land cover data needs is exceedingly broad. Current land use and land cover data are needed for equalization of tax assessments in many States. Land use and land cover data also are needed by Federal, State, and local agencies for water- resource inventory, flood control, water-supply planning, and waste-water treatment etc. Many Federal agencies need current comprehensive inventories of existing activities on public lands combined with the existing and changing uses of adjacent private lands to improve the management of public lands. Federal agencies also need land use data to assess the environmental impact resulting from the development of energy resources, to manage wildlife resources and minimize man-wildlife ecosystem conflicts, to make national summaries of land use patterns and changes for national policy formulation, and to prepare environmental impact statements and assess future impacts on environmental quality.

Land use/Land cover change is one of the major influencing factors for landscape changes. RS and GIS are important for the monitoring, modelling and mapping of land use and land cover changes across a range of spatial and temporal scales, in order to assess the extent, direction, causes, and effects of the changes.

Change detection and monitoring involve the use of several multi-date images to evaluate the differences in LULC due to various environmental conditions and human actions between the acquisition dates of images (6). Successful use of RS for land use/land cover change detection largely depends on an adequate understanding of the study area, the satellite imaging system and the various information extraction methods for change detection in order to fulfil the aim of the present study (7).

Aim and Objectives of the Study

The aim of the study is to assess the land cover and land use changes in Aniocha North local government area, Delta State Nigeria from 2002 to 2014.

The specific objectives are:

- To acquire satellite images of the study area with at least five years interval.
- To create land use land cover classification scheme for the study area.
- To carry out spatial change detection and analyses of land cover/use in the study area.

2. Study Area

Aniocha North LGA of Delta State is the study area. Aniocha North was created in 1991 having been carved out of the old Aniocha local government. It has a total of seventeen communities with its administrative headquarters in Issele uku. It is located west of the majestic River Niger. It lies between longitude 06^0 14^1 and 06^0 30^1 North of the equator and Latitude 06^0 18^1 and 06^0 37^1 East of the Greenwich meridian. It is bounded to the North by Edo state, to the West by Ika

North-East local government area of Delta State, to the East by Oshimmili North local government area of Delta State and to the South by Aniocha South local government area of Delta State.

Aniocha North had a population of 104,711 by the 2006 population census. The towns that make up Aniocha North include; Issele-uku, Issele-azagba, Issele-mkpitime, Onicha-ugbo, Obior, Onicha-olona, Onicha-uku, Ugbodu, Ukwunzu, Ubulubu, Ogordor, Ugboba, Idumuogo, Obamkpa, Idumuje-unor, Idumuje-ugboko and Aniofu. Four of these communities, (Issele-uku, Issele-azagba, Issele-mkpitime, Onicha-ugbo) are enjoying urban status and are more affected by this waste management concerns. Most other communities have shown all the potential attributes to develop into major urban centre in the next few years. The people of the area are predominantly peasant farmers with low income literacy levels except for Issele-uku, the headquarter, Onicha-ugbo, Issele-mkpitime and Issele-azagba that are already grown into urban.

2.1. Status

Aniocha North local government has a tropical climate with two distinct seasons, the dry and wet seasons. Average rainfall is between 1800mm and 3000mm. average temperature is between 25°C to 32°C.

Figure 1a Map of Nigeria showing Delta State

Figure 1b Map of Delta state

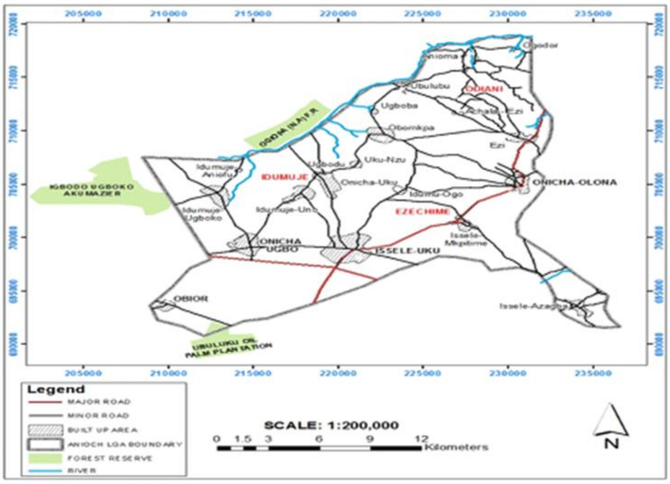

Figure 1c Map of Aniocha North LGA (Study area)

Source: Ministry of Lands, Delta State

The vegetation ranges from mangrove swamp along the coastal region and rain forest in the other places. Most of the communities are highly susceptible to erosion due to its nature of topography which is steeply particularly in the northern part of the local Government area.

The local government is situated on a highland and covered with clayey brick-red soil. Some traces of solid rock can be found in the towns located at the extreme north of the local government. The topography of the towns at the extreme north is also steeply and they are properly drained towards the north by river Ohe which is a tributary of the River Niger. River Ohe is actually the boundary line between Aniocha North and the neighbouring Edo state and runs through the entire northern corridor of Aniocha North local government. Consequently, most of the communities on the northern part are highly susceptible to erosion due to the steeply nature of the topography around that area.

Aniocha North has a tropical climate with two distinct seasons, the dry and wet seasons. The wet season comes from about April/May and ends about October/November of the same year while the rest is the dry weather/harmattan period. Average rainfall is between 1800mm and 3000mm.

3. Methodology

The data input for this study were remotely sensed satellite images downloaded from GLCF (Global landcover facility) and USGS (United State Geological Survey), which covered the study area and its environs for a period of 12 years. The two images used are the landsat 7 Enhanced Thematic Mapper (ETM+) of 2002 with 30 meters resolution and Landsat 7 Enhanced Thematic Mapper (ETM) 2014 also with 30 meters resolution. The toposheets on scale 1: 50,000 of Aniocha North was collected from the Ministry of Lands and Surveys Asaba, Delta State. ArcGIS Version 10.1 and ILWIS version 3.3 were used to carry out the various spatial operations on the satellite imageries while a handheld GARMIN GPS12 (12 Channels) receivers were used for collecting ground control points (GCP).

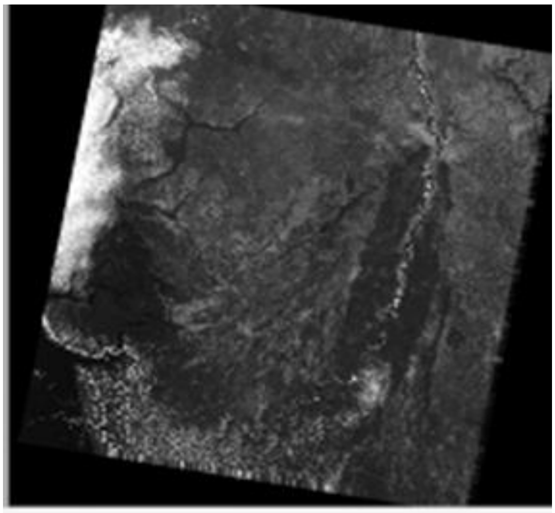

Figure 2 Landsat scene covering the study area, in Ilwis environment

The pre-processing activities were carried out in order to enhance the quality of the image and the readability of the features. A major preprocessing activity carried out was image restoration, which is concerned with the correction of distortion, degradations and noise introduced during the imaging. These errors can degrade the quality of the remote sensor data collected, which may have impact on the accuracy of human or machine assisted image. The radiometric enhancement was performed to sharpen the area of interest.

The coordinates of Ground Control Points such as road intersections and popular spots were collected using the handheld GPS.A standard technique is adopted for georeferencing the base map using PCI Geomatica V10.1 software. Image to image registration of the satellite image was made using the georeferenced base map. The landsat images of 2002, and 2014, acquired from the Global land cover facility were geometrically corrected and the projection was set to World Geodetic System (WGS 84) and UTM zone 32N.

Three bands (7, 4 and 2) were used in the color composite operation, the Pseudo Color composite were applied where red color was assigned to band 7. This is to display the built up area in Red color, the near infrared band 4 was used to display the spatial distribution of the vegetation in Green color and the band 2 was used to display the Water body in blue color.

Figure 3 The pseudo-natural colour composite of Landsat scene showing the subset study area in ArcGIS Environment

Supervised (full Gaussian) classification using the maximum likelihood algorithm in ILWIS ACADEMIC 3.3 was used to generate five main land use land cover classes for all images (Table1): (1) Built up area, (2) Farm land dominated by human exploitation like agriculture area, plantation area, bush burned, and bush cleared for road construction,(3) Forest area include area dominated by thick vegetation covered, (4)Water body: area covered by rivers, streams and its ramifications and (5) Savannah which is dominated by grass and few trees. Selected ground control points (GCP) that include the major land use and land cover classes were sampled to create a signature file to help train the software to classify the entire study areas. Care was taken to minimize error by avoiding mixed pixels.

Table 1 The Selection of land use / cover classes

Code	Classes	Description
1	Built up area	Area occupied by people for Habitation
2	Farmland	Farmland area including agriculture area, and plantation area and Savannah
3	Forest	Area occupied by Thick vegetation.
4	Water body	Areas cover by rivers and streams with its ramifications
5	Savannah	Areas dominated by grass and few trees.

Location of the ‘training sites’ in the image and selection of sample set was done. A sample set stores training pixels for supervised classification. Prior to image classification, training pixels were selected in a sample set. A map list, containing the set of images used for classification and a background map on which the training pixels are located, and a class domain was specified. Maximum likelihood was employed in the analyses of the classification in which the output image ‘max like’ was displayed. A supervised maximum likelihood classification technique was used because the data of the study area were available, and the author has a prior knowledge of the study area.

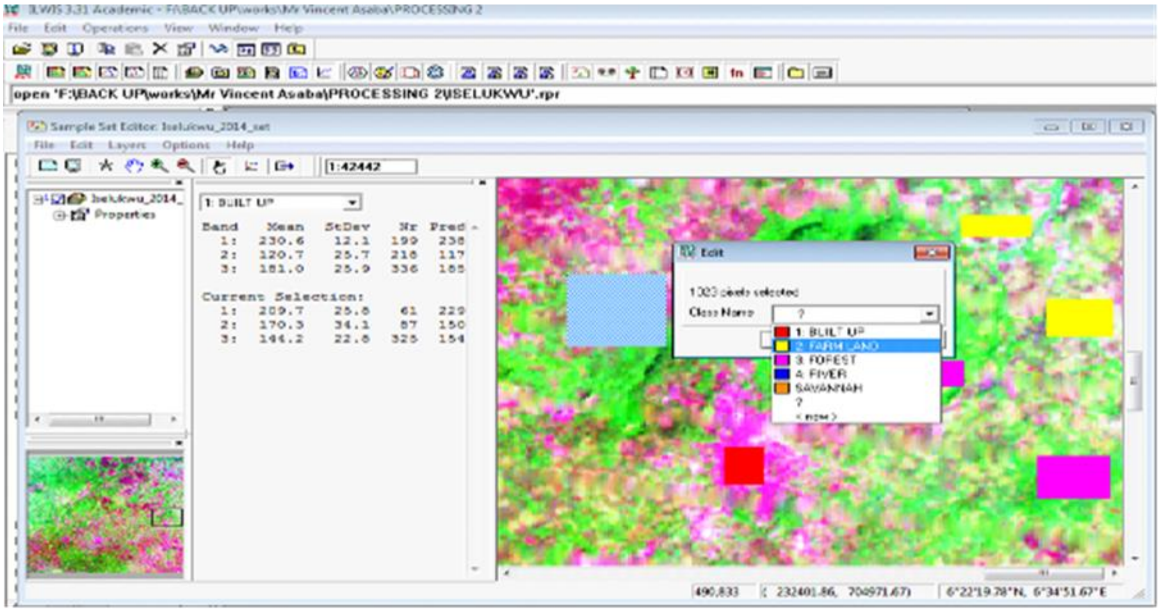

Figure 4 The selection of sample set in the training site environment

The change detection method used in this study in ILWIS ACADEMIC was the Cross Operation. Pixels on the same positions in both images are compared and the occurring combinations of class names, identifiers or values of pixels are stored. These combinations give an output cross map, and a cross table. The cross table includes the combinations of input values, classes or IDs, the number of pixels that occur for each combination and the area for each combination. The cross table of land use land cover change for study areas shows combination classes in the change matrix. The analysis is based upon area-based comparison so that recorded changes from one class to another represent actual features.

4. Results and discussion

The results indicating the different land cover classes and the amount of changes that had occurred are found in Figures 5 & 6. The changes that had taken place between the various land cover/use classes in the area for 2002 and 2014 are found in figure 4 and 5 respectively. Analysis of the 2002 Image revealed that farmland constituted the largest proportion of land in Aniocha North Local Government Area with a value of 36.34%, followed by savannah which accounts for 24.15 %. Forest and built up area constituted 20.42% and 16.46% respectively, while water body showed a mere 2.62%.

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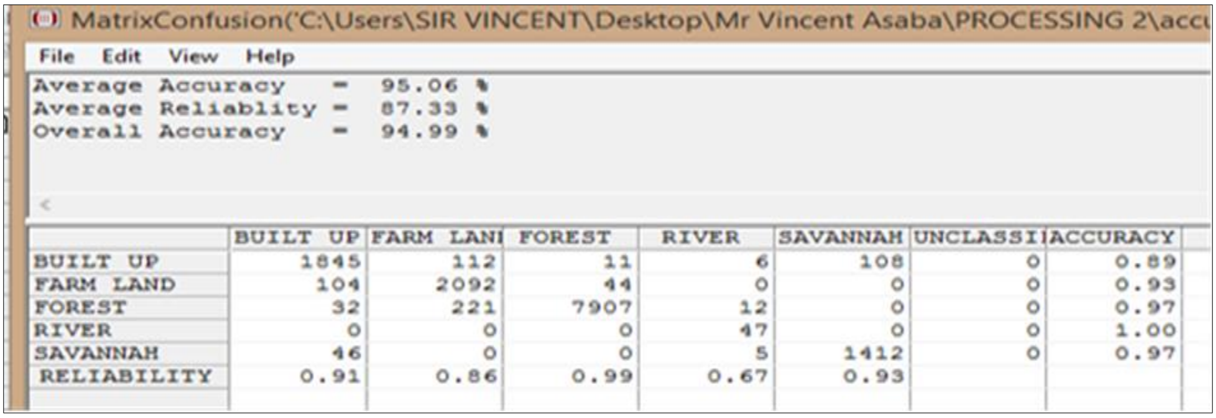
Average Accuracy = 83.26 %
Average Reliablity = 76.15 %
Overall Accuracy = 79.16 %

	BUILT UP	FARM LANI	FOREST	RIVER	SAVANNAH	UNCLASSI	ACCURACY
BUILT UP	854	220	9	4	226	0	0.65
FARM LAND	1026	3107	38	2	189	0	0.71
FOREST	1	5	1168	13	0	0	0.98
RIVER	0	0	2	71	0	0	0.97
SAVANNAH	681	167	12	9	4690	0	0.84
RELIABILITY	0.33	0.89	0.95	0.72	0.92		

Figure 5 Accuracy assessment for 2002 classification

The analysis of the 2014 image of the study area shows that forest covers the largest area with 38.59% followed by Farmland with coverage of 30.93%. Built up area covers 25.55% while Savannah and River cover 2.86% and 2.08% respectively. The implication is that between 2002 and 2014 the forest has increased thereby reducing the proportion of farmland that was available in 2002. This could be traceable to urban migration and the poor financial returns by farmers thereby making farming less attractive. Savannah also decreased significantly from 24.15% to 2.86%. This can also be traceable to new build up areas coming within the period under review. No significant changes have occurred with the rivers; however, it showed that there is a slight decrease between 2002 and 2014 (See Table 2 and 3). Figure 6 further explains the land use/ landcover dynamics from 2002 to 2014.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Average Accuracy = 95.06 %
Average Reliablity = 87.33 %
Overall Accuracy = 94.99 %

	BUILT UP	FARM LANI	FOREST	RIVER	SAVANNAH	UNCLASSII	ACCURACY
BUILT UP	1845	112	11	6	108	0	0.89
FARM LAND	104	2092	44	0	0	0	0.93
FOREST	32	221	7907	12	0	0	0.97
RIVER	0	0	0	47	0	0	1.00
SAVANNAH	46	0	0	5	1412	0	0.97
RELIABILITY	0.91	0.86	0.99	0.67	0.93		

Figure 6 Accuracy assessment for 2014 classification

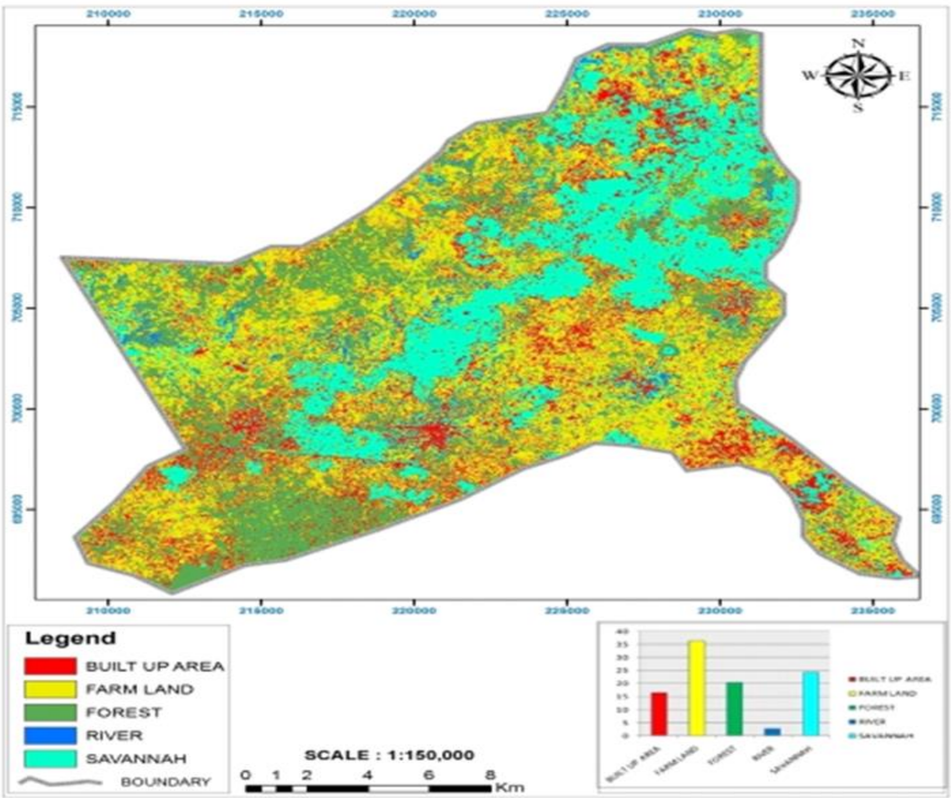

Figure 7 land use landcover Map of Aniocha North LGA, **Source**: Delta State (2002)

The accuracy assessment was performed with a confusion matrix which shows 83.26 % average accuracy and 79.16 % overall accuracy for 2002 while the 2014 accuracy assessment showed 95.06% average accuracy and 94.99% overall accuracy (See figure 4 and 5).

Table 2 Statistical table of land use landcover (2002) of Aniocha LGA, Delta State

Classes (2002)	Pixel	Area(M^2)	Area (%)
Built Up Area	72202	64981800	16.46
Farmland	159393	143453700	36.34
Forest	89569	80612100	20.42
River	11499	10349100	2.62
Savannah	105945	95350500	24.15
		394747200	100.00

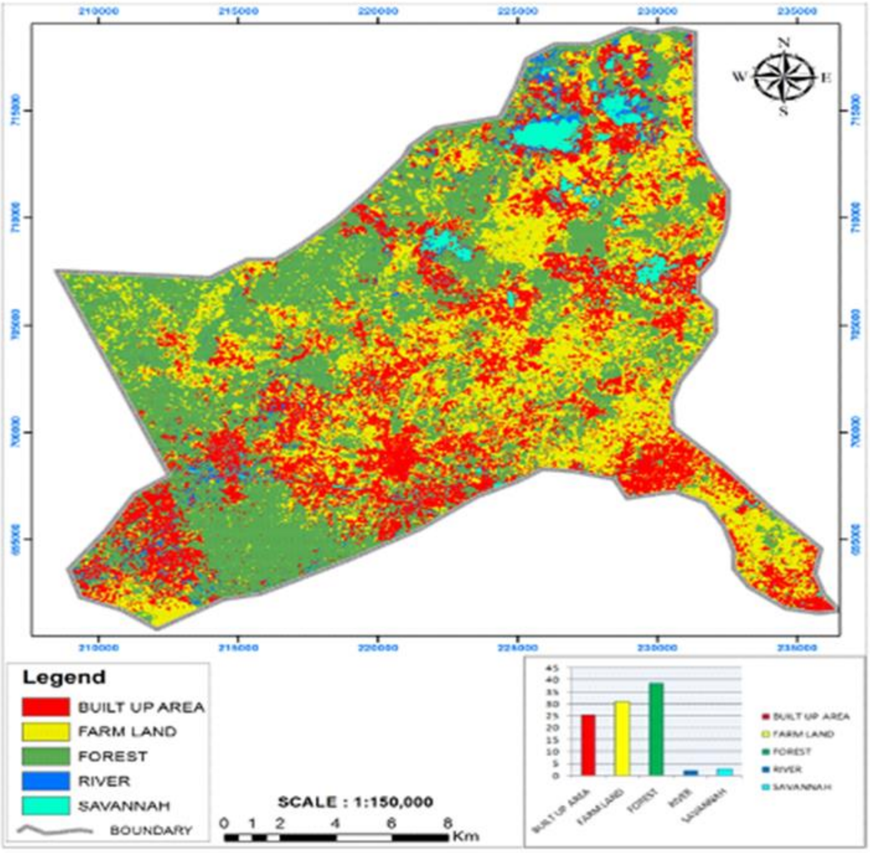

Figure 6 Showing land use landcover (2014) of Aniocha North LGA, Delta State

Table 3 Statistical table of land use landcover (2014) of Aniocha LGA, Delta State

Value	Classes (2014)	Count	Area(M2)	Area (%)
1	Built Up Area	112070	100863000	25.55
2	Farmland	135658	122092200	30.93
3	Forest	169238	152314200	38.59
4	River	9119	8207100	2.08
5	Savannah	12523	11270700	2.86
Total			394747200	100.00

Table 4 Comparison analysis of land use land cover change from 2002 to 2014

Classes	Area (%) (2002)	Area (%) (2014)	Diff (2014-2002)	Total (2002+2014)	Trend (Diff/Total)	Remark
Built Up Area	16.46	25.55	9.09	42.01	0.22	Increased
Farmland	36.34	30.93	-5.41	67.27	-0.08	Decreased
Forest	20.42	38.59	18.17	59.01	0.31	Increased
River	2.62	2.08	-0.54	4.7	-0.11	Decreased
Savannah	24.15	2.86	-21.29	27.01	-0.79	Decreased

Table 5 Conversion between land use/cover from 2002 to 2014 (cross tabulation)

Value	Classes 2002	Classes 2014	Count	Area(M^2)	Area (%)
1	Built Up	Built Up	15105	13594500	3.44
2	Built Up	Farmland	61885	55696500	14.11
3	Built Up	Forest	68440	61596000	15.60
4	Built Up	River	17736	15962400	4.04
5	Built Up	Savannah	56983	51284700	12.99
6	Farmland	Built Up	36257	32631300	8.27
7	Farmland	Farmland	21112	19000800	4.81
8	Farmland	Forest	8542	7687800	1.95
9	Farmland	River	794	714600	0.18
10	Farmland	Savannah	4572	4114800	1.04
11	Forest	Built Up	1644	1479600	0.37
12	Forest	Farmland	17537	15783300	4.00
13	Forest	Forest	35912	32320800	8.19
14	Forest	River	41316	37184400	9.42
15	Forest	Savannah	498	448200	0.11
16	River	Built Up	1404	1263600	0.32
17	River	Farmland	2923	2630700	0.67
18	River	Forest	8257	7431300	1.88
19	River	River	2594	2334600	0.59
20	River	Savannah	29131	26217900	6.64
21	Savannah	Built Up	1603	1442700	0.37
22	Savannah	Farmland	2665	2398500	0.61
23	Savannah	Forest	1629	1466100	0.37
24	Savannah	River	21	18900	0.00
25	Savannah	Savannah	48	43200	0.01

5. Conclusion

This research aims at investigating land use/land cover changes that occurred in Aniocha North Local Government Area, Delta State between 2002 and 2014 using remote sensing and GIS. The main changes observed for the time period between 2002 and 2014 were in the built-up and Forest areas. Data registered in table 5 reveal that there were positive and negative changes in the landuse/land cover pattern of Aniocha North Local Government Council during the period under study.

The study shows that multi temporal satellite imagery and GIS play very important role in quantifying spatial and temporal phenomenon which otherwise is not possible using conventional methods. The study reveals that the major land use in the study area is farmland which covers a total of 67.27% from 2002 to 2014, followed by Forest which has a total coverage 59.01%. Both of them also have positive or significant increase through the study period.

Finally, remote sensing and GIS have made change detection possible in less time, at low cost and with better accuracy than the conventional method.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest regarding the research, authorship and publication of this paper.

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