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MAPPING AND ANALYSIS OF LAND USE AND LAND COVER FOR A SUSTAINABLE DEVELOPMENT USING MEDIUM RESOLUTION SATELLITE IMAGES AND GIS

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ABSTRACT
For proficient and sustainable management of Urban Areas there is an urgent need for comprehensive and effective monitoring of physical changes over time, the aim of this paper is to portray the quick and practical approach to Mapping and Analysis of Landuse and Landcover patterns and changes using medium resolution satellite images. The study was carried out in Onitsha urban and its environs in South-eastern Nigeria. For this purpose, multitemporal data consisting of existing Topographical map, NigerianSat-1, and LANDSAT ETM+ images were processed using spatial analysis tools of resampling, georeferencing, classification and post-classification overlay, to map the patterns and extent of landuse and landcover in the study area as well as determine the magnitude of changes between the years of interest, 1964, 2004 and 2006 respectively. The result of the study shows that the built-up areas have been on a constant positive and mostly uncontrolled expansion from 8.47% of the study area in 1964 to 30.66% in 2004 and to 64.62% in 2006. On the other hand, vegetation, including cultivated and uncultivated agricultural lands has been on a steady decline, from 77.77% in 1964 to 65.03% in 2004 and a mere 20.10% in 2006. The study recommended that the Government and public agencies concerned should develop policies and strategies to achieve a balanced, coordinated and sustainable development in the Urban Area and its environs.

KEY WORDS: Geoinformation/GIS, Land distribution, Land Management, Remote Sensing and Spatial Planning.

INTRODUCTION
Land use affects land cover and changes in land cover affect land use. A change in either is not necessarily the product of the other, however, for proficient and sustainable management of Urban Areas there is an urgent need for comprehensive and effective monitoring of physical changes over time. Monitoring and analysis operation of the environment make use of up-to date Land Use and Land Cover (LULC) information. Unfortunately, on the other hand, there is a general lack of accurate and current LULC in Nigeria, especially Onitsha Metropolis. Macleod and Congalton (1998) list four aspects of change detection, which are important when monitoring natural resources: Detecting that changes have occurred, identifying the nature of the change, measuring the areal extent of the change and Assessing the spatial pattern of the change.

The basic premise in using Satellite Images for change detection is that changes in land cover result in changes in radiance values that can be remotely sensed. Techniques to perform change detection with satellite imagery have become numerous as a result of increasing versatility in manipulating digital data and increasing computing power. A wide variety of digital change detection techniques have been developed over the last two decades. Singh (1989) and Coppin & Bauer (1996) both provide excellent and comprehensive summaries of methods and techniques of digital change detection. Coppin & Bauer (1996) summarize eleven different change detection algorithms that were found to be documented in the literature by 1995. These include: monotemporal, change delineation or post-classification comparison, multidimensional temporal feature space analysis, composite analysis, image differencing, image ratioing, multitemporal linear data transformation, change vector analysis, image regression, multitemporal biomass index and background subtraction.

An image differencing technique has been implemented in this change detection study. According to recent research by Coppin & Bauer (1996), image differencing appears to perform generally better than other methods of change detection; and such monitoring techniques based on multispectral satellite data have demonstrated potential as a means to detect, identify, and map changes in land use/land cover. Image differencing is probably the most widely applied change detection algorithm for a variety of geographical environments (Singh, 1989). It involves subtracting one date of imagery from a second date that has been precisely registered to the first.

In most developing countries, especially Nigeria, availability of relevant and current information about our environment and how it changes over time has been lacking. This problem therefore, has consequently been affecting the achievement of change detection and sustainable development, and as such, requires research for accurate and timely information, which is needed for environmental monitoring, planning and forecasting. Although series of works have been done in a conventional system to produce some information on the LULC in some cities in Nigeria, but no much studies have been done using Remote Sensing and GIS technique in its mapping and analysis. Therefore, the application of GIS using remotely sensed data for change detection analysis of Onitsha and its environs would definitely enhanced the available data for a Sustainable development.

Study Area

The study area is Onitsha North and South Local Government Area and its environs which include: Obosi, Nkpor, and Iyiowa Odekpe of Anambra state of Nigeria (see Figure 3). It is located between Latitudes $06^{\circ}02'56''N$ and $06^{\circ}38'34''N$ and Longitude $06^{\circ}37'30''E$ and $06^{\circ}59'30''E$. It is bound by Anambra-West/East Local Government Area and Oyi in the North, Idemili-North/South in the East, Ogbaru Local Government Area in the South, and in the West by the River Niger. It serves as the gate way between the South-Eastern and South-Western part of Nigeria. The population figure of Onitsha Metropolis according to 1991 and 2006 population census is presented in Table 1

Table 1: Population figures of the study area

S/N	Name of Area	1991 Population	2006 Population	2021 Population
1	Onitsha North	121,157	124,942	129,292
2	Onitsha South	135,290	136,662	141,012
3	Nkpor	64,732	94,697	99,037
4	Obosi	85,249	124,699	129,049
5	Iyiowa Odekpe	21,844	31,939	36,289

Source: Official Gazatte of Nigerian Government (FGP71/52007/2,500(OL24)

N.B: 2021 was projected using 2.9% Annual Rate of Change by the author.

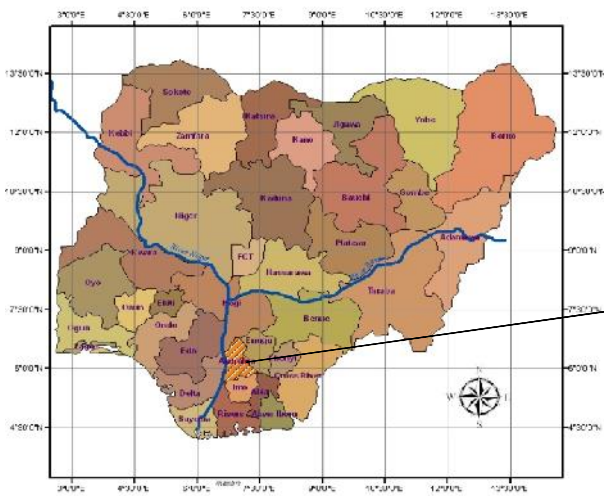


Fig. 1. Administrative map of Nigeria Showing Anambra state

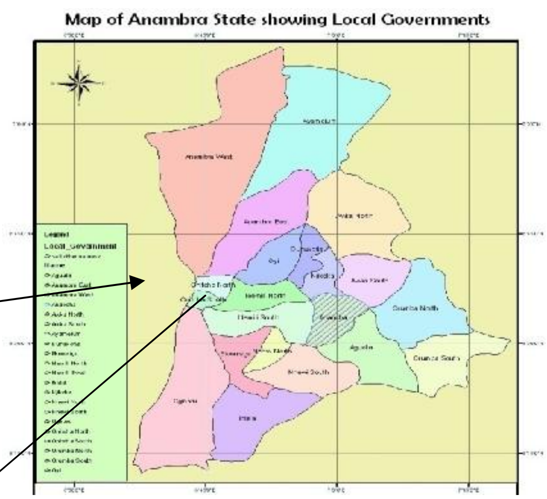
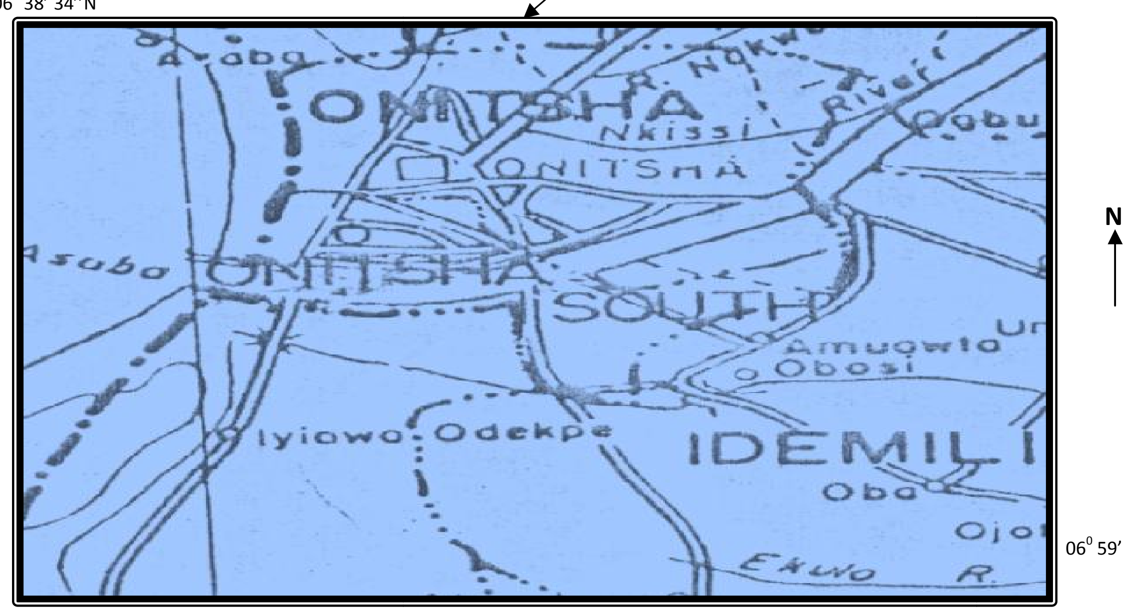


Fig. 2. Map of Anambra State Showing Local Government Areas.

$06^{0}\ 38'\ 34''N$



$06^{0}\ 59'\ 30''E$

$06^{0}\ 02'\ 56''N$, 6 30′ 00″E

Fig. 3: Showing the Study Site map, Onitsha Metropolis. **Source:** Ezeomedo, (2012)

METHODOLOGY

Data Used

This study involved primary data collection and secondary data collection. The topographic map of Onitsha and its environment was obtained from the ministry of Land and Survey, Awka. The NigeriansSat-1 (2004) and LANDSAT ETM+ (2006) image of study area were obtained from the Archives of the Department of Surveying and Geoinformatics, Nnamdi Azikiwe University Awka, Nigeria, with the following technical data (see Table 2). The census data were collected from the National Population Commission office, Awka branch. Then field visits to site was carried out to obtain ground control points for ground truth sampling.

DATA PROCESSING AND ANALYSIS

Resampling and Georeferencing:

The pre-processing and post image processing and analysis were carried out to enhance the quality of the images and the readability of the features using the spatial analysis tools of Integrated Land and Water Information System (ILWIS 3.3). The scanned and digitized old Topographical map of 1964 and satellite images of NigeriansSat-1, (2004) and LANDSAT ETM+, (2006) were geometrically corrected and the projection was set to Universal Transverse Mercator (UTM) projection system, zone 32. The spheroid and datum was referenced to WGS84. All the images were geometrically co-registered to each other using ground control points into UTM projection with geometric errors of less than one pixel, so that all the images have the same coordinate system. The nearest neigbourhood resampling technique was used to resample the Topographic map and NigeriansSat-1 into a pixel size of LANDSAT Enhanced Thematic Mapper plus during the image-to-image registration.

Classification and Change-Detection:

Classification and post-classification overlay was carried out and thematic land-cover maps for the year 1964, 2004 and 2006 were produced for the study area by supervised classifications using a maximum likelihood classifier. Four major landcover classes were mapped see Table 3 for more details: Built-up areas (BA), open/bare lands (OP), vegetations (VG) including the cultivated and uncultivated land and water bodies (WB); to be able to detect possible details, change trajectory of post classification comparison was used to map the patterns and extents of landuse and lancover in the study area as well as determine the magnitude of changes between the years of interest, 1964, 2004 and 2006, respectively.

Assessment of Classification Results Using Error Matrix

The error matrix-based accuracy assessment method is the most common and valuable method for the evaluation of change detection results. Thus, an error matrix and a Kappa analysis were used to assess change accuracy, (see Figure 7). Kappa analysis is a discrete multivariate technique used in accuracy assessments (Congalton and mead, 1983; Jensen.

Table 2: Technical Characteristic of the Images.

S/N	DATA	ACQUISTION DATE	RESOLUTION (m)	SOURCE
1	Topographical Map	1964	Scale: 1: 50,000	Ministry of Land and Survey, Awka, Nigeria.
2	NigeriaSat -1	2004	32	Department of Surveying and Geoinformatics, Nnamdi Azikwe University Awka; Nigeria
3	LANDSAT ETM +	2006	30	Department of Surveying and Geoinformatics, Nnamdi Azikiwe University Awka; Nigeria.

Table 3: Descriptions of classes adopted

S/N	Type of Land cover	Description (s)	Code	Colour Assigned
1	Urban or built-up areas	This class includes continuous and discontinuous urban fabric, industrial, commercial, transportation and other related built-up areas.	BA	Red
2	Open/ bare land	Sand plains, unpaved roads, excavation site, are considered as bare lands.	OP	Yellow
3	Vegetated areas	This comprises green urban areas, non-irrigated arable land, irrigated land, scrubs and forest cover,	VG	Green
4	Water bodies	Water related features such as water course, estuaries, Salt marshes and River.	WB	Blue

RESULTS AND DISCUSSION

The outcome of the data processing and analysis were presented in form of digital maps and attribute table, (see Figure 4 to 8 and Table 4 and 5).

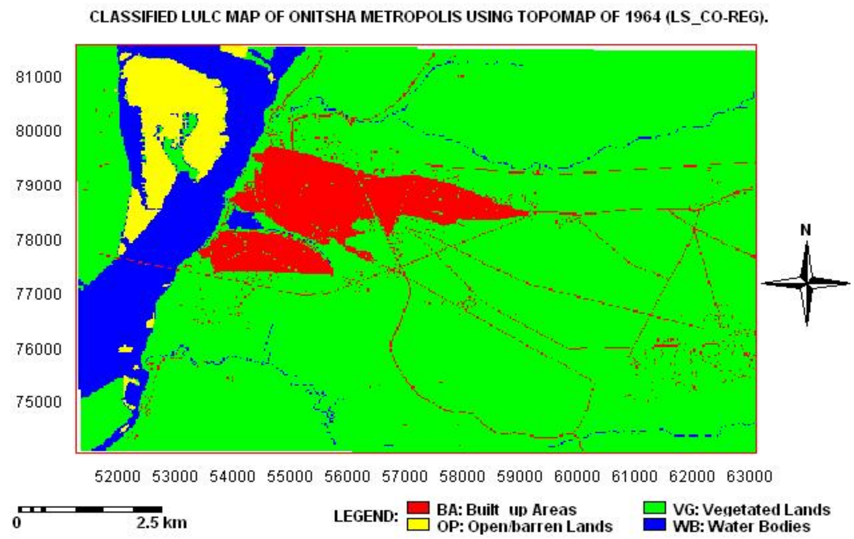


Fig. 4: Classified **Topographical Map** (1964) Resampled into LANDSAT ETM+.

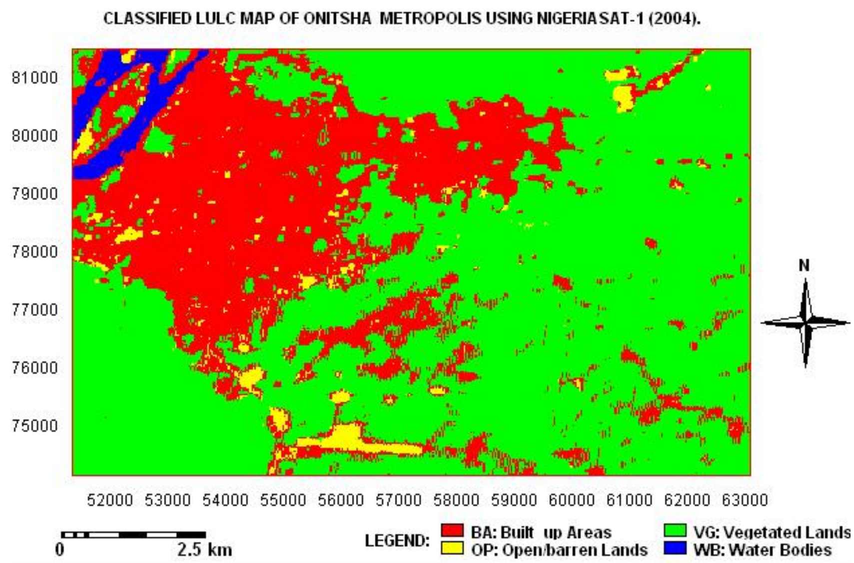


Fig. 5: Classified **NigeriaSat-1** (2004) Resampled into LANDSAT ETM+.

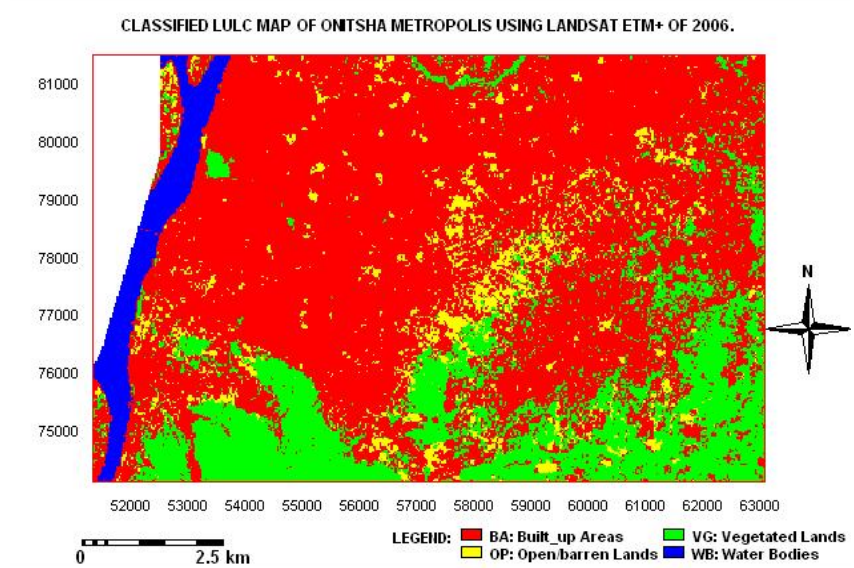


Fig.6: Classified **LANDSAT ETM+** (2006) image.

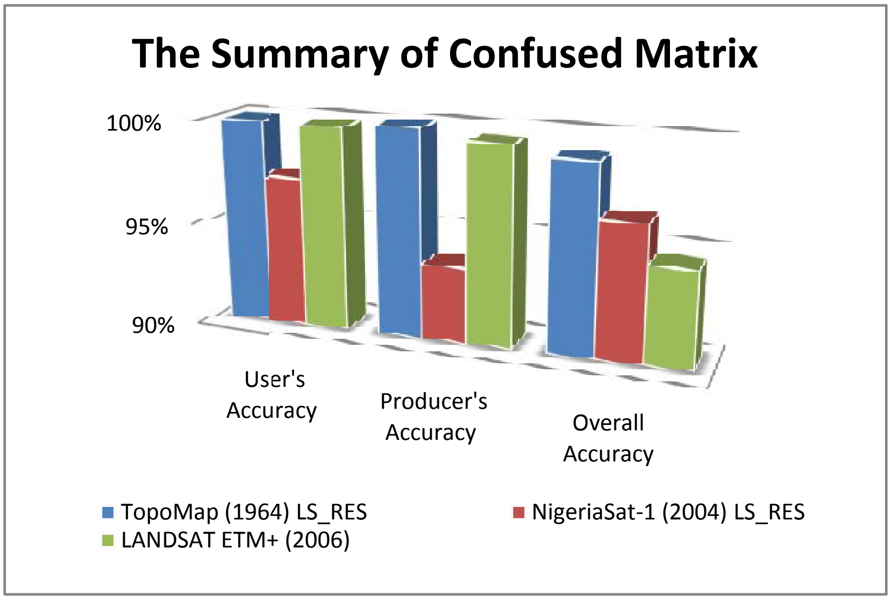


Fig. 7: The Evaluation of Classification Results using Error Matrix.

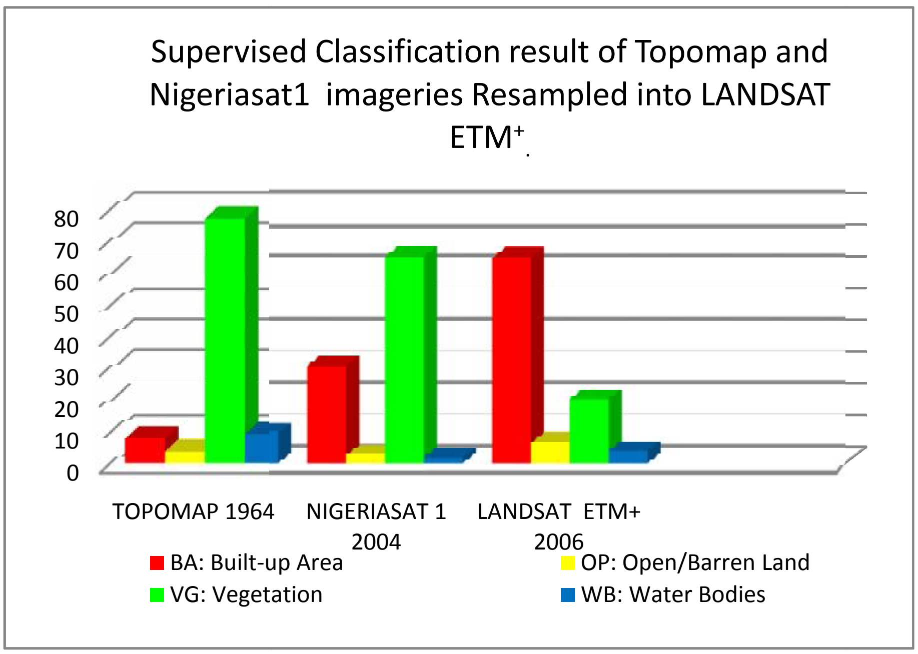


Fig. 8: The Summary of LULC Classification using Medium Resolution Imagery.

Table 4: The Result of Change Detection between 1964 and 2004 in Percentage **(%)**

CLASSES	TopoMap1964 (LS_RES)	NigeriaSat-1 2004 Image (LS_RES)	Change Detection 1964-2004 (40years)	Rate of Change	Projection: 2004 to 2021 (17 years)
BA	08.47	30.66	22.19	00.55	40.01
OP	04.01	02.49	-01.52	-00.03	01.98
VG	77.77	65.03	-12.47	-00.31	59.76
WB	09.62	01.82	-08.42	-00.21	-01.75

Table 5: The Result of Change Detection between: 1964 and 2006 in Percentage (**%**)

CLASSES	TopoMap 1964 (LS_Res)	LANDSAT ETM+ 2006 Image	Change Detection 1964-2006 (42years)	Rate of Change	Projection: 2006 to 2021 (15years)
BA	08.47	64.62	56.15	01.33	84.57
OP	04.01	06.37	02.36	00.05	07.12
VG	77.77	20.10	-57.67	-01.37	-00.45
WB	09.62	03.87	-05.75	-00.13	-01.92

DISCUSSION

The application of remote sensing and GIS is mostly in image analysis, mapping and monitoring of urban land use. It was applied to estimate various surface features and provide LULC information for planning. Accuracy assessment is a process used to estimate the accuracy of image classification by comparing the classified map with a reference map. It is critical for a map generated from any remote sensing data. It is considered as an integral part of any image classification. This is because image classification using different classification algorithms may classify pixels or group of pixels to wrong classes. The most obvious types of error that occurs in image classifications are errors of omission or commission. The common way to represent classification accuracy is in the form of an error matrix. An error matrix is a square array of rows and columns and presents the relationship between the classes in the classified and reference maps. Using error matrix to represent accuracy is recommended and adopted as the standard reporting convention. In this paper, overall, producer's and user's accuracy were considered for analysis. (See Figure 7) The Kappa coefficient, which is one of the most popular measures in addressing the difference between the actual agreement and change agreement, was also calculated.

Result of Land Use and Land Cover Classification

It is worth knowing that urban structures are dynamic and spatial morphology, population structure and activity patterns are in a constant process of change and growth. As cities grow, its land use pattern also changes. This change is more dynamic in urban/ rural fringe. Thus, the result of the land use/land cover change as was analyzed using object-oriented approach which is based on a supervised Gauss maximum likelihood classification method. Statistical means shows that there was both positive and negative change as depicted below.

Built-up areas

They were a great positive change in the built-up areas, more than hundred percent increases. From the statistical analysis of this research the built-up areas formerly occupied a proportion of 8.47% in 1964 and increased to 30.66% and 64.62% in 2004 and 2006 respectively. This is a clear indication of increase in population and infrastructure development in the metropolis, regardless of use or pattern.

Open/barren land

This class recorded both positive and negative change over the year under study. Bare surface proportions were 04.01% in 1964 but were decreased to 02.49% in 2004 and were increase again to 06.37% in 2006. This can be attributed to human activities, which includes, over grazing, indiscriminate bush burning, fire wood extraction which are some of the characteristics of most regions of Nigeria. Although, it was observed that development that are recent and their roofing was done with white aluminum roofing sheet have a conflicting spectral signature with this class.

Vegetation

Agricultural lands also regardless of type of crops and their level of intensity; cultivated or uncultivated show a negative increase. In 1964, what was obtainable was 77.77% and while in 2004 its 65.03%, again in 2006 were declined to 20.10%. This can be as a result of built-up areas above, which include construction of all capacity.

Water bodies

The proportion of the study area under water bodies recorded a negative change although very minimal in nature. In 1964 result shows 09.62%, while in 2004 and 2006 this class represents a proportion of 01.82% and 03.87% respectively. This may be due sand deposit, land reclamation and other developmental activities along the coast, again, the available NigeriaSat-1 imagery were slightly smaller in size around the water body's area.

CONCLUSION

Remote sensing systems have the capability for respective coverage, which is required for change detection studies. For ensuring planned development and monitoring the land utilization pattern, preparation of land use/land cover map is necessary. The present study demonstrates the usefulness of satellite data for the preparation of accurate and up-to-date land use/land cover maps depicting existing land classes for analyzing their change pattern for Onitsha metropolis by utilization of digital image processing techniques. Furthermore, the developed spatial map can serve as an efficient technical vehicle for spatial analysis and spatial modeling functions, to gain insights into development problems, e.g. to evaluate development impacts in the past, and to enhance regional development strategies through facilitating various scenarios. It is expected to be useful for formulating meaningful plans and policies so as to achieve a balanced and sustainable development in any region. It is concluded that satellite imagery can be very effective and fast in change detection of land use and land cover changes. Therefore to ensure food security and maintain a balanced ecological system in Nigeria and more especially in Anambra State were land is a hot cake, frequent management and monitoring of this scarce resource (land) must be sustained.

Government should encourage its personnel through funding so that changes on land use at regular and regular interval will be detected. Planning Agencies should constantly monitor our various land uses through change detection so that, sustainable development plans are followed. If such funds are made available more research should be focus towards the use of modern technology; satellite imagery, GIS and digital equipment to obtain fast and accurate digital data or information. Since ground survey methods are not convenient and aerial, and photographic maps productions are very expensive and time consuming.

With the establishment of new ministry of environment, this ministry both at federal and state level should encourage the mapping of various land uses, and detection of land use change; so as to avoid any development that may be dangerous to our environment, but rather plan for a more sustainable development.

REFERENCES

Congalton, R.G; and Mead, R.A, (1983). A quantitative method to test for consistency and correctness in photo interpretation. *Photogrammetric Engineering and Remote Sensing,* 49:69-74.

Coppin, P. and Bauer, M. (1996). Digital change detection in forest ecosystems with remote sensing imagery, *Remote Sensing of the Environment*, 13: 207-304.

Ezeomedo, I.C. (2006), ''Change analysis of land use/land cover of Yola metropolis'', to aid planning for a sustainable development. B.Tech. Project Submitted to the Department of Surveying and Geoinformatics, Modibo-Adama Federal University of Technology Yola, Nigeria

Ezeomedo, I.C. (2012), Urban Sprawl Identification, Analysis and Modelling Using Remote Sensing and GIS, A Case Study of Onitsha Metropolis; M.Sc. Thesis (M018) Submitted to the Department of Surveying and Geoinformatics, Nnamdi Azikiwe University Awka, Nigeria.

Federal Republic of Nigeria, (2007): National Bureau of Statistics Annual Report.

National Population Commission, (2007). 2006 Population Census of the Federal Republic of Nigeria. Official Gazette of Nigerian Government (FGP71/52007/2,500(OL24)*,* Lagos.

Singh, A; (1989), Digital change detection techniques using remotely-sensed data. *International Journal of Remote Sensing,* 10: 989-1003.

Jensen, J.R. (1996). Introductory Digital Image Processing. A Remote Sensing Perspective. Prentice-Hall, Englewood Cliffs, New Jersey.

Macleod, R. D. and Congalton, R. G. (1998). A Quantitative Comparison of Change-Detection Algorithms for Monitoring Eelgrass from Remotely Sensed Data. *Photogrammetric Engineering and Remote Sensing,* 64 (3): 207-216.