International Journal of Advance Research, IJOAR .org
Volume 3, Issue 12, December 2015, Online: ISSN 2320-9186

OBJECT-ORIENTED CLASSIFICATION USING AERIAL PHOTOGRAPH AND SPOT IMAGE OF EAGLE ISLAND PORT HARCOURT, RIVERS STATE, NIGERIA

J. U. RICHARD

Department of Special Survey, Office of the Surveyor General,
Moscow Road, Port Harcourt, Nigeria
(e-mail: jeremiah.uriah@yahoo.com, Tel. 07035290980)

KEY WORDS:

Aerial Photograph, Accuracy, Land Use/ Land Cover, Maximum Classification, Pixel Classification, Segmentation, Spot Image

Abstract

Remotely sensed data are major sources of data to most GIS users, especially when the need arise for the extraction of land cover types for change detection studies. For this reason remote sensing data and GIS technique was applied to study the urbanisation in Eagle Island, Pot Harcourt Nigeria after the layout master plan in 1979 by Rivers State Government to monitor change in land use/ land cover using object oriented and pixel base classification approach. The dataset used for the study include 2008 Aerial Photograph with spatial resolution 0.2mx0.2m and 2015 Spot satellite image having spatial resolution 2.5m. The GIS software used for the study is ArcGIS10.1 and Idrisi Taiga 16.0. The Aerial Photograph was clipped from the mosaic image of Port Harcourt and the Spot Image was clipped from Google earth image and georeferenced in ArcGIS 10.1. Object segmentation and pixel base classification was performed on both images using Idrisi Taiga 16.0. The overall Kappa 0.95 for segmentation and 0.90 for pixel approach was achieved. The study also shows net gain for Road, Built-up areas, Dredge sand, and exposed mud with net lost in mangrove, vegetation cover, and water body. The application of GIS and remote sensing in mapping land use/ land cover should be adopted in monitoring effects of urbanization in other areas in the city.

Introduction

One method of identifying land use and land cover using geographic information system (GIS) software is by classification of satellite imagery acquired over the area using specialized flat form at specific altitude. This features before now are classified using picture element (pixel) that are identical for a particular land use/ land cover categories of spectral pattern. Spectral pattern recognition involves categorization of pixel base on spatial relationship with surrounding pixture element [1]. This approach has been identified inaccurate for high resolution satellite imageries hence production of inconsistence classification results. The development of eCognition software which classified land use/land cover of high resolution satellite images was introduced in GIS to analysed remotely sense satellite imageries. Object-Oriented segmentation classification was adopted for the classification of high and medium resolution of satellite imageries [2]. Object-Oriented segmentation classification is defined according to [3] as the partitioning of image into continuous cluster of pixel segment. The segmented image defined object on the terrain surface which can be identified during training site selection for the classification of land use/ land cover categories. Object segmentation classification uses both the spectral information and spatial information to identified and categorized object segment within the study satellite imagery [4]. The spatial information defined object size, shape, and adjacency to other pixel while the spectral information represents segmented vector file image. [2] identified three stages of Segmentation which includes: Image segmentation, Training sites and signature development, and classification base on majority rule algorithm. Previous researchers have combined high and medium resolution satellite imagery to performed image segmentation and obtained accurate results. [4] combined Landsat TM and Aerial Photograph to assess accuracy of pixel and object-oriented classification and obtained higher accuracy in the object-oriented segment classification. Also [5] uses Landsat data and Quick Bird satellite imagery to study the land use/ land cover over South Austrialian Viveyard and obtained better accuracy in segment base classification than pixel base classification. In this study an attempt is made to use aerial photograph and Spot satellite imagery to perform image segmentation classification of Eagle Island Port Harcourt. The objectives of this study includes; (a) to perform object-oriented segmentation of the two epoch images (b) determine changes in land use/ land cover over this period of study.

Methodology

Study Area

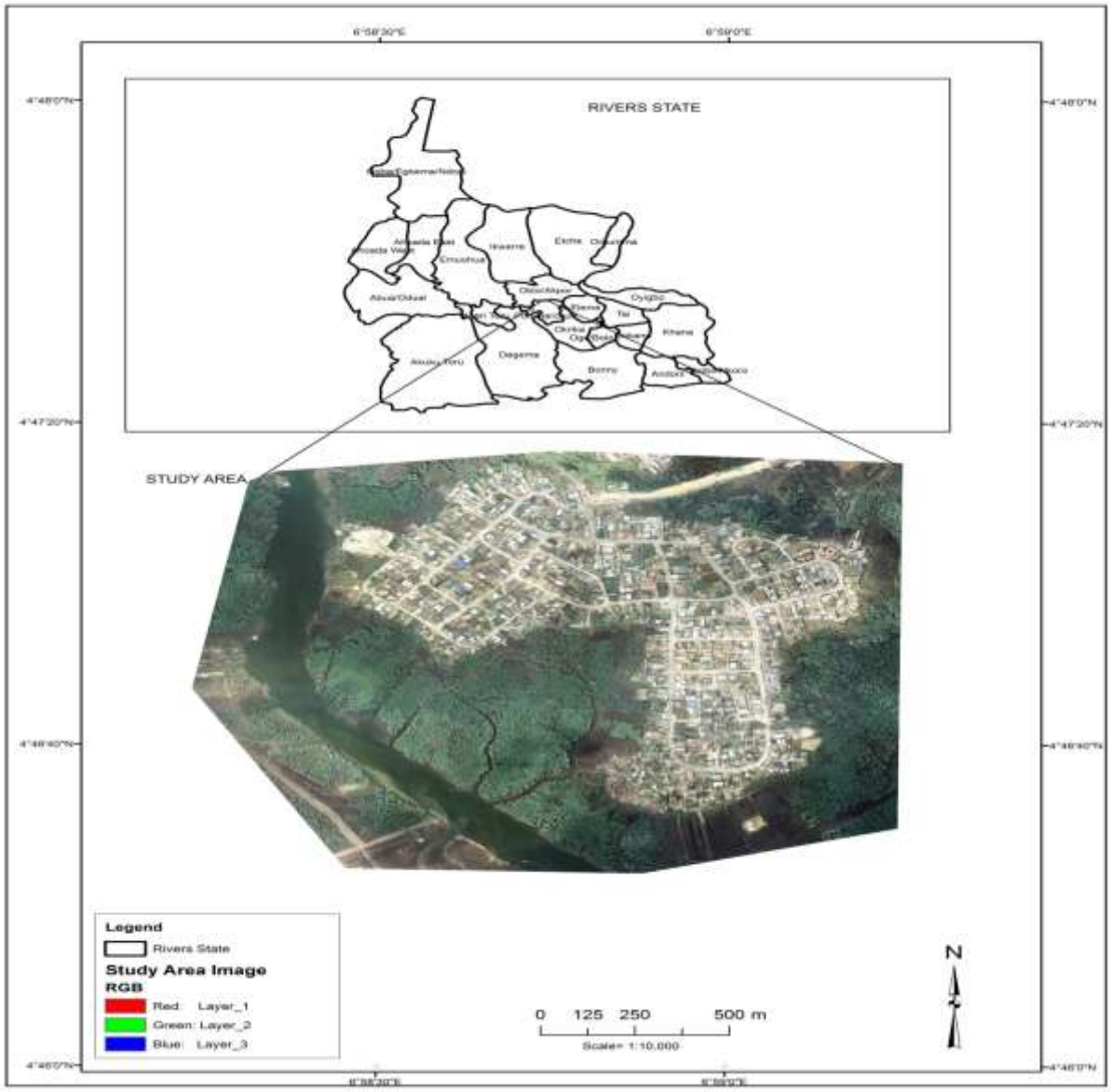

Figure 1. Study area location map.

Eagle Island is located in the North West of Port Harcourt Local Government Area, Rivers State, Nigeria. The study area lies between latitude 04º46'35"N - 04º47'30"N and longitude 06º58'15"E-06º59'16"E situated in zone 32N. The study area covers an area of 3.667sq. Km. with diverse human activities. The area was owned by the Ikwerre ethnic nationality whose major occupation was farming within the upland area and the River bank was occupied by the Andoni ethnic nationality whose major occupation is fishing. The elevation of the area varies from 4m towards the coast to 8m off the coastal area. The equatorial location of the study area has influence on the temperature. The average temperature varies between 25°c and 28°c with an annual rainfall between 2000mm in October and 2500mm in April. Prior to the development of the area by Rivers State Government, the available land in the area are used for farming purposes with most at commercial quantity while the River banks were resided by fishermen. The water body is salt water with different mangrove species. But the development of the area by Rivers State Government through layout plan in 1979 and the master plan was revised 1982 (Office of the Surveyor General Rivers State 1982) has transformed the area to urban status. The layout master plan was implemented solely by Rivers State Government who allocates plots to land

developers and monitor the development. Today, Eagle Island is an urban centre in Port Harcourt Local Government Area with different kinds of building types especially the development of sprawl settlements in water front, roofing design, and landscaping. This study examined change in land use/ land cover types over this periods using object oriented and pixel base classification techniques.

Software and Dataset

The following software was used for data processing and analysis;

ArcGIS 10.1 was used to perform all vector data processing, shape file creation by digitization of points, lines, and polygon, clipping of the study area extent, and exporting the clipped image to Erdas Imagine file format which is compactible in Idrisi Taiga 16.0 for processing.

IDRISI TAIGA 16.0 was used to perform all image classification and segmentation operation on Aerial Photograph and Spot satellite image in other to extract land use and land cover in the study area. But [6] uses eCognition and ASTRO software to performed object oriented classification in is study area.

The dataset required for the study include; RGB band high resolution Aerial photograph acquired by Rivers State Government 2008 with spatial resolution of 0.2m by 0.2m, WGS_84 Zone 32N, as shown in figure 2. The image was acquired for the purposed of creating a cadastral land information system and to facilitate the process of certificate of occupancy (C of O) under the office of the Surveyor General. The second data used for this study was Spot satellite image clipped from Google Earth using shape file of the study area and save in JPEG file format. The spatial resolution of the image is 2.5m obtained in 2015, WGS_84 Zone 32N in RGB band as shown in figure 3. This second image was to assist the determination of change in land use / land cover over the period of investigation and the accuracy of classification results.

Figure 2. Aerial Photograph of the study area. Figure 3. Spot Image of the study area.

Data Processing

GIS operations required all images that are to be used to be processed thereby making it fit for further analysis. The following image processing methods were taken during the study.

Clipping of Aerial Photograph was done in ArcGIS 10.1 using shape file created defining the extent of the study area. The clipping was done using raster clip from raster processing tool. The clipping runs for some minutes before displaying the clipped image portion. The image was resaved in Erdas Imagine file format that can be assessed in Idrisi Taiga 16.0. Similarly, the Spot image saved in JPEG file format was displayed in ArcGIS 10.1 and georeferenced using four known coordinates of control points. These coordinates were obtained from Google Earth place mark defining rectangular region on the image. Spot satellite image georeferencing created a uniform coordinate system with the Aerial image for future analysis. After georeferencing the Spot image it was clipped with the same shape file of the study area. The clipped Spot image was converted to Erdas Imagine file format through raster to other format tool of the ArcToolbox such that it can be compactible in Idrisi raster software.

Image classification of Aerial Photograph and Spot satellite image was done through maximum likelihood supervised classification [5] in Idrisi Taiga 16.0. The classification method adopted was supervised classification using level 11 [1] classification scheme. Supervised classification method was applied to classify the various land cover in the study area based on field knowledge during ground truthing. The land use/ land cover types identified and classified in the study area are water body mostly salt water, built-up area including all building types, road network, mangrove forest locating in the salt water, vegetation cover in some isolated area within the upland part of the area, exposed mud terrain which are areas that mangrove cover has been remove due to human activities especially for dredging purposes, and dredge sand aim at reclaiming some of the shoreline for urban development. Supervised classification is performed by defining aggregate of pixel as training site for land cover class. One major challenge of classifying high resolution using pixel base approach is low spectral information [4], which was overcome by image segmentation classification which is a method of breaking image object into segments.

Segmentation operation was performed on the Aerial Photograph and Spot image. The operation was performed using segmentation classifier from Idrisi Taiga 16.0 which created segmented image base on the input parameter. The three bands from each image was loaded and the parameter set as follows; weight 0.3333, similarity tolerance 20, window width 3, weight mean factor 0.5, and weight mean average 0.5. Similarity tolerance 20 was chosen to create a more homogeneous segment [2] and minimised generalization of segment results. The second step was to create training site for the segment image. The training set was created using segtrain and the training site for road, built-up areas, dredge sand, mangrove swamp, exposed mud, vegetation cover, and water body was created. Each segment class created is associated with segment ID, colour, and class ID for the land use/ land cover categories. The final stage was the classification of the images using segclass. The segmentation image was loaded followed by reference image obtained from pixel base classification. The algorithm run and produced segment classification image of the study area base on the seven land use/ land cover classes. The total pixel in square meters per class was extracted to determined change in land use/ land cover over the study period.

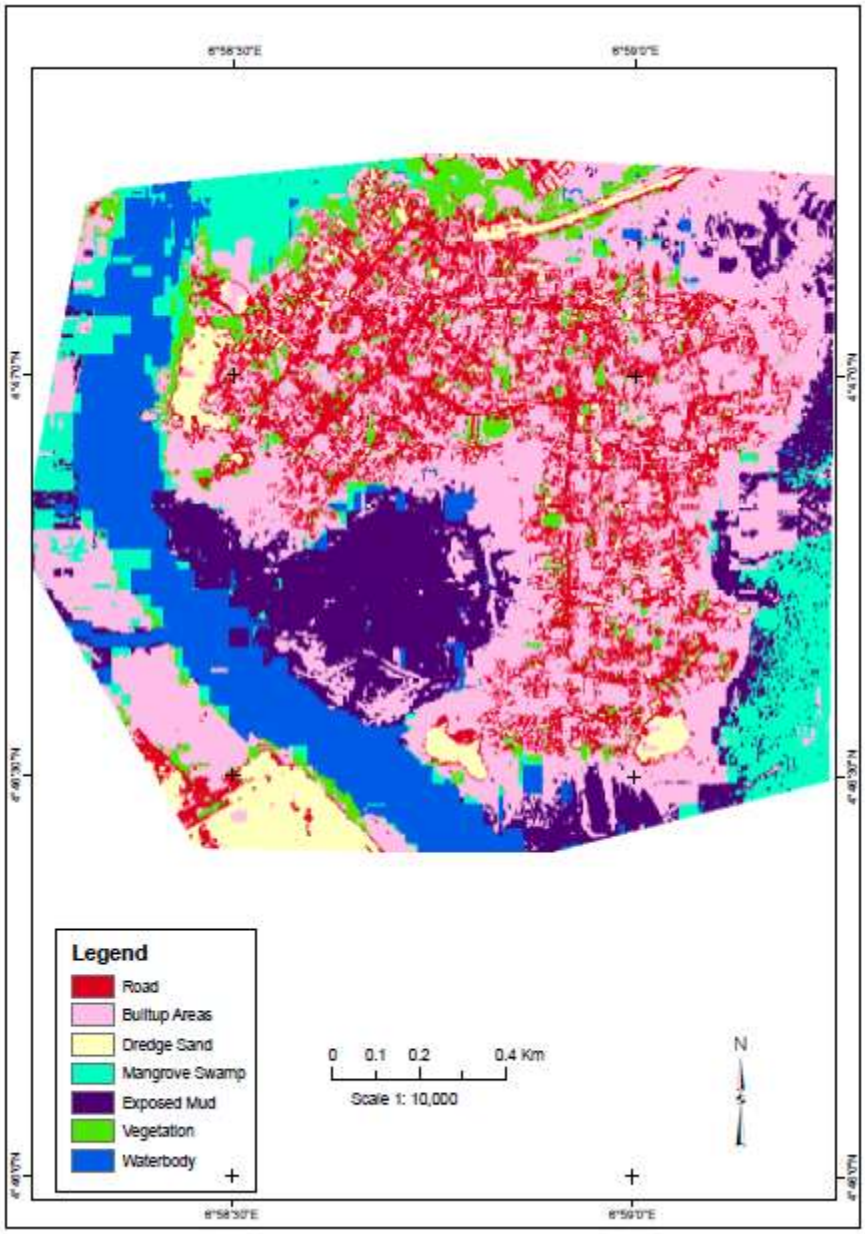

Figure 4. Pixel base classification of Spot satellite image.

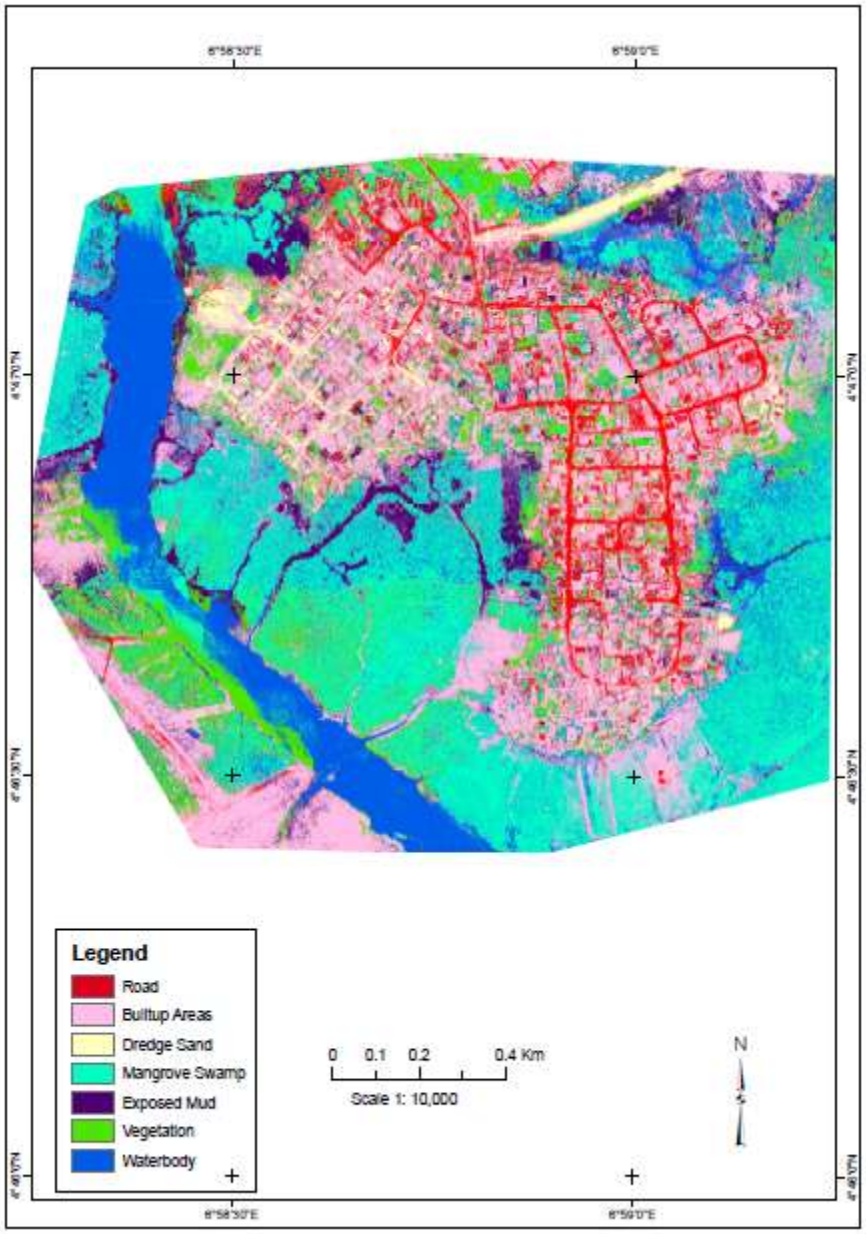

Figure 5. Pixel base classification of Aerial Photograph image.

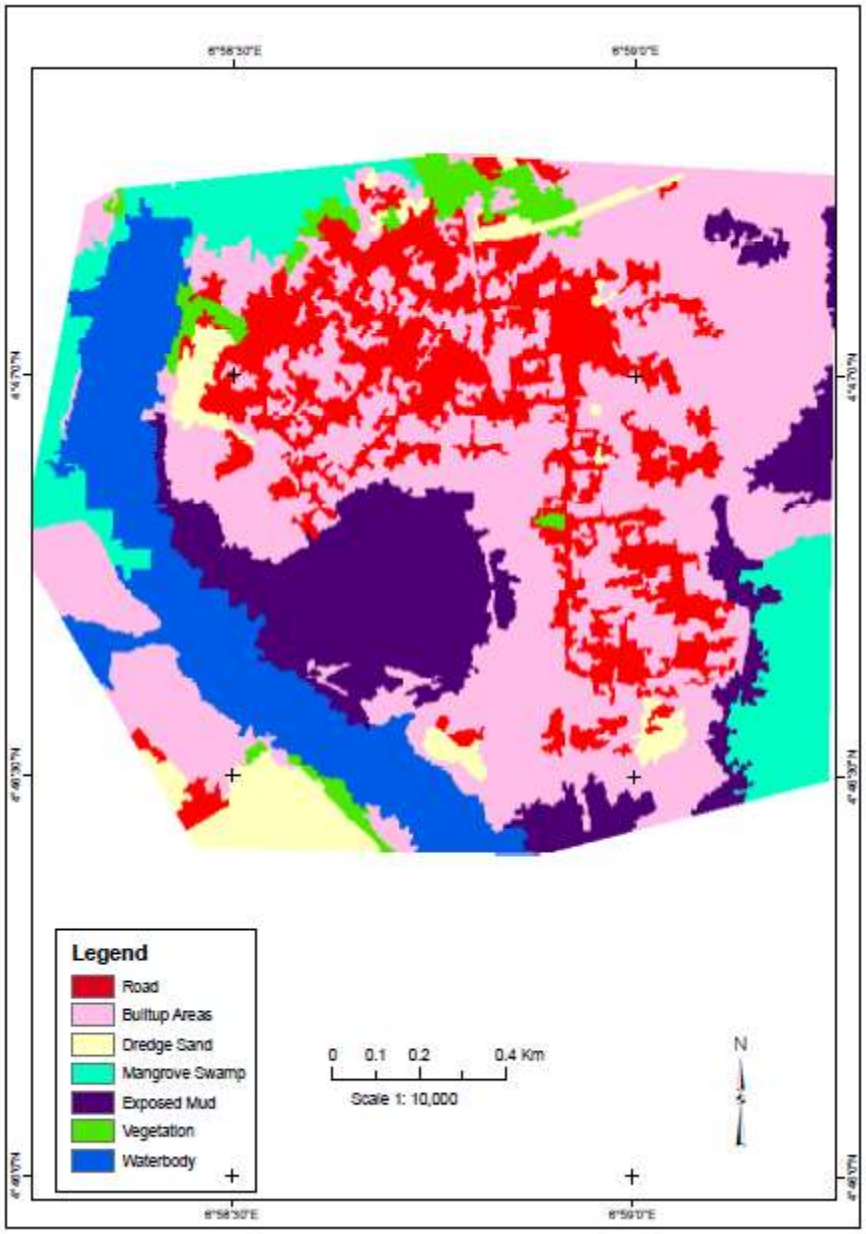

Figure 6. Object Oriented base classification of Spot satellite image.

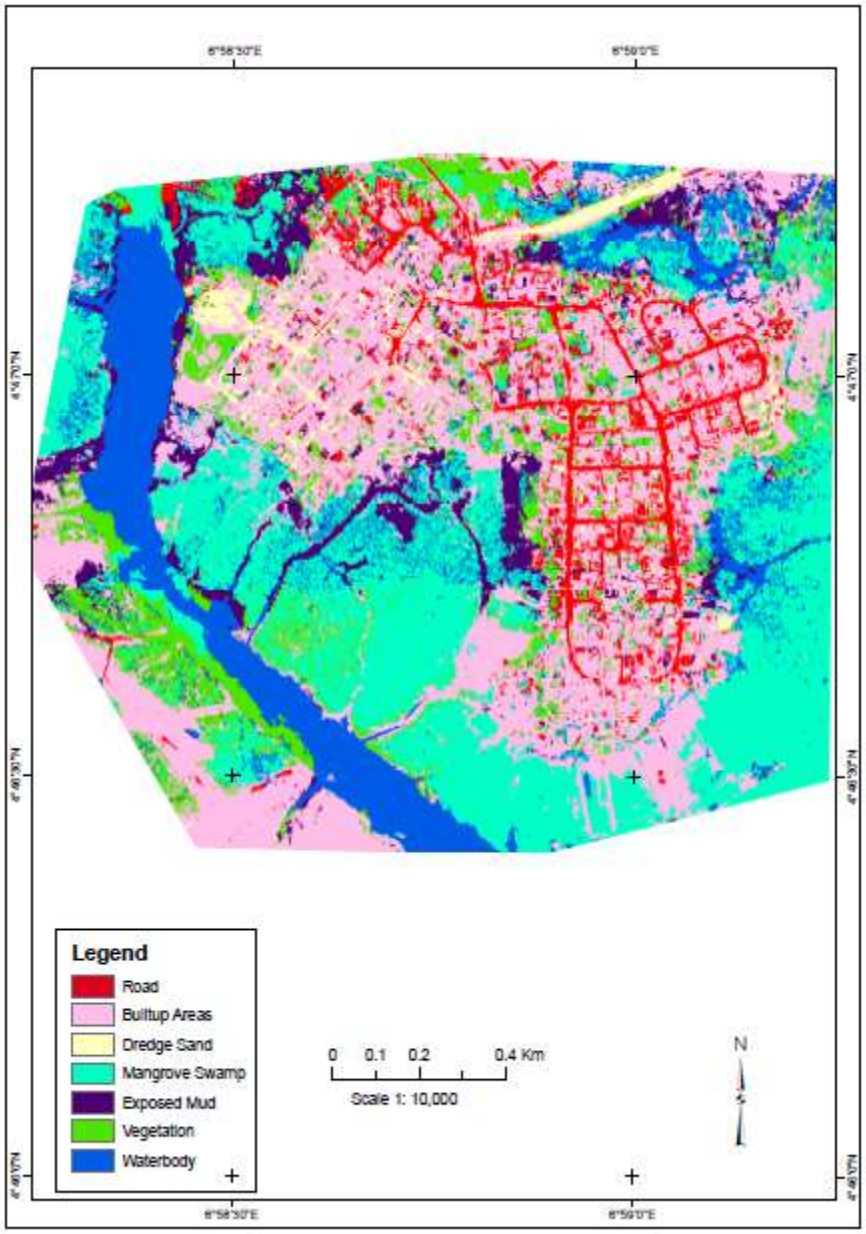

Figure 7. Object Oriented base classification of Aerial Photograph image.

Table1. Total pixel per class in square metres from the classification images.

Lu/ Lc Types	2015 Spot Image (sq.m)	2008 Aerial photo (sq.m)	Change (sq.m)	2015 %lu/lc	2008 %lu/lc	% Gain/ Lost
Road	452486	212982	239504	16.9	8	52.9
Built up	1035447	845142	190305	38.6	31.5	18.4
Dredge Sand	131834	57908	73926	4.9	2.2	56.1
Mangrove	232875	655135	-422260	8.7	24.5	-1.8
Exposed Mud	375169	202397	172772	14	7.6	46.1
Vegetation	127346	296865	-169519	4.8	11.1	-1.33
Water body	324549	409316	-84767	12.1	15.3	-26.1

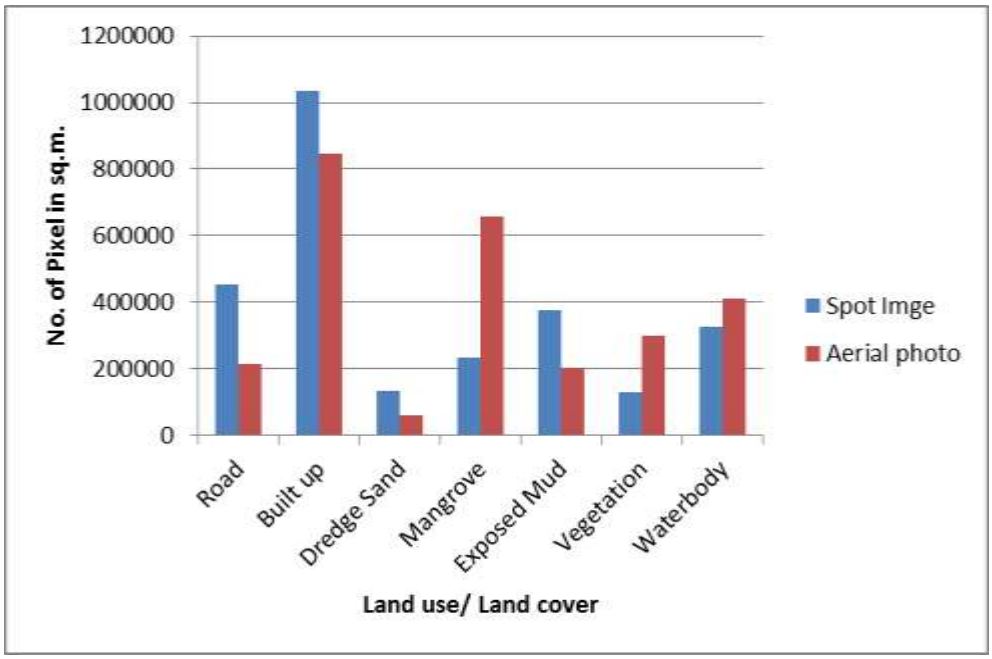

Figure 8. Graphical representation of change in lu/lc classification for the two images.

Accuracy Assessment

Object-Oriented base classification of land use/ land cover of low spectral information and high spatial resolution requires accuracy assessment. The accuracy was assessed using segment training site vector data and object base classification image as categorical image map. Similarly, for pixel base classified image, training site vector data and maximum likelihood classification image data was utilized. In this study, overall Kappa coefficient was used as a measured for accuracy assessment [5]. The Kappa coefficient for the two images was compared for all images.

Table 1a. Confusion matrix for the Object Base classification of Aerial Photograph image.

	Road	Builtup	Sand	Mangrove	Expomud	veg	waterbody	Total	ErrorC
Road	2727	0	2157	0	0	0	0	4884	0.442
Builtup	7777	18798	2204	0	0	0	0	28779	0.347
Sand	0	0	13159	0	0	0	0	13159	0.000
Mangrove	0	0	0	10405	0	3014	0	13419	0.225
Expomud	0	1367	0	0	27544	0	0	28911	0.047
Veg	2489	0	0	1292	0	1290	0	5071	0.746
waterbody	0	0	0	0	0	0	121329	121329	0.000
Total	12993	20165	17520	11697	27544	4304	121329	215552	
ErrorO	0.7901	0.0678	0.2489	0.1105	0.0000	0.7003	0.0000		0.0029

Overall Kappa= 0.95

Table 1b. Confusion matrix for the Pixel Base classification of Aerial Photograph image.

	Road	Builtup	Sand	Mangrove	Expomud	Veg	Waterbody	Total	ErrorC
Road	39772	50248	48	1	255	0	0	90324	0.560
Builtup	1327	132547	147	750	368	78	9406	144623	0.084
Sand	16	22	64948	0	0	0	0	64986	0.001
Mangrove	0	1297	0	260250	0	894	14623	277064	0.061
Expomud	281	3631	0	209	22490	7	1	26619	0.155
Veg	47	3057	1	22629	13	10381	9626	45754	0.773
Waterbody	0	322	0	22342	191	225	825802	848882	0.027
Total	41443	191124	65144	306181	23317	11585	859458	2013264	
ErrorO	0.0403	0.3065	0.0030	0.1500	0.0355	0.1039	0.0392		0.0706

Overall Kappa= 0.90

NOTE: ErrorO= Error of Omission, ErrorC = Error of Commission

Results and Discussion

The accuracy assessment of the classification results was performed on the land use/ land cover types for both the segmentation and pixel base classification procedure as shown in figure 5 and 7 of 2008 Aerial Photograph image. The accuracy results shown in table 1a and 1b suggested that object oriented segmentation procedure performed better in delineating all land cover types with an overall Kappa Index of agreement 0.95 against pixel classification method with overall Kappa 0.90; this represents net improvement of overall Kappa by 0.05. [4], [5] also achieved better overall accuracy when comparing segmentation and traditional pixel classification procedures. Segmentation classification also shows lower error of commission for both sand and water body due to distinct spectral characteristics on the image. The list error of commission achieved was in vegetation 0.746 partly due to close spectral information with surrounding buildings. [5] observed that shadows of 3D objects from building represent sources of problem for both object base and pixel base classification results.

The percentage change in land use/ land cover classes was examine for both images using object oriented classification results as shown in table 1. For the 2015 Spot image the total area cover by road from the classification lc/ lc was 16.9% and for 2008 Aerial Photograph was 8% representing net gain in road by 52.9%. In 2005 image percentage of lu/ lc by built-up was 38.6% while in 2008 image was 31.5% with a net gain in built-up area by 18.4% [7] .This gain was as a result of urban development within the master plan of Eagle Island. The number and extent of reclamation site in the area also increase from 2008 by 2.2% to 4.9% in 2015 of the total lu/ lc type representing net gain in dredge sand by 56.1%. This was as a result of increase in demand by developers and multi-national companies for land necessitated reclamation work at the river banks and creeks. The reclamation work at some of the banks has led to the removal of mangrove cover leaving the mud exposed. This study shows that in 2015 image the percentage of exposed mud was 14% as against 7.6% in 2008 representing gain in exposed mud by 46.1% in 2015 Spot image. The study also shows that there is net lost in mangrove by 1.8%, vegetation by 1.33%, and water body by 26.1% over this period of study. The lost in mangrove forest was cause by continuous removal of mangrove cover during reclamation for urbanization. In so doing, water body is also reclaimed as shown in the study with net lost. This change in lu/ lc categories for both images was also represented graphically in figure 8.

Conclusion

Classification of remotely sensed data using GIS software and tool is gaining momentum in the field of remote sensing and photogrammetry for the extraction of land use/ land cover categories. The introduction of segment base classification method using eCognition software improved accuracy of classification of remotely sensed data as against the traditional method. This study also shows an improvement in classification of high spatial resolution of satellite imagery using object oriented segmentation approach. More so, the use of two epoch images was considered helpful in examining change in land use/ land cover categories over seven (7) years. Finally, geographic information system is an effective tool in extracting and analysing land use/ land cover change and for displaying thematic map of interest.

For further study, small similarity tolerance value ranges from 3-6, and variable weight should be used for object oriented segmentation classification of remotely sensed data. Finally, change in land use and land cover types should be determine from two high spatial resolution at two epoch using Markov change analysis in Idrisi software. The change in lu/ lc will be better determine using segmentation classification classes.

Acknowledgement

My special appreciation goes to the Ministry of Lands and Survey Rivers State, Nigeria that sponsored my training in Master of Technology in Geographic Information Technology at RECTAS, in collaboration with Federal University of Technology Akure (FUTA). Also appreciating the assistance of the data management department, Office of the Surveyor General for giving me high resolution image of Rivers State Government free of charge to aid this study.

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