Comparison of Pixel Based and Object Oriented Image Classification for Mapping Urban Greenery in Uwani Enugu

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Keywords: Image Classification, Object Based, Pixel Based, Mapping, Urban Greenery.

ABSTRACT

Traditional classification methods are all pixel-based and do not utilize the spatial and context information of an image object and its surroundings, which has potential to further enhance digital image classification. In this study, this traditional method was compared with Object based image classification. This involved the development of a pixel-based classification model using the spectral characteristics of the image pixels, and the development of an object-based classification model using the spectral, spatial as well as the contextual information of the image pixels. The same set of ground data was used for accuracy assessment in both classifications for consistency. In the Pixel-based classification, a supervised *Euclidean distance* algorithm was utilized; in Object-oriented classification, the *Bhattacharya* algorithm was used. Using the Object-based classification, an accuracy of 93.71% was achieved while 57.34% accuracy was achieved for pixel-based classification. This showed that the object-based classification result was higher than that of the Pixel-based classification by 36.37%. The greenery results (maps) from image classification was compared with the detailed map of Uwani urban in terms of spatial overlap and size in order to determine to what extent they agree. The Object-based classification method showed a 94.20% area agreement with the vector map, while the Pixel-based classification method showed 86.24% area agreement with the vector map of Uwani Enugu. Based on the greenery distribution of Uwani obtained from the classified map, a greenery program is therefore recommended for the residents of Uwani Enugu to improve the environmental condition and aesthetics in the area.

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1.0 INTRODUCTION

Man has played an increasingly large role in the modification of the global environment. With increasing population and developing technologies, he has emerged as the major most powerful and universal instrument of environmental change in the biosphere today. Human development activities have continually altered the stability of our natural environment especially in clearing the vegetation cover around us. However, in urban design, this lost natural environment is simulated by the introduction of open spaces and green area to regain that natural, and aesthetic environment which we had lost during uncontrolled urban development.

Environmental problems undermine sustainable development of cities. Environmental protection, and the protection of plants, in particular, is a compulsory element for sustainable urban management. Urban greenery is thus a key natural resource for a city; besides, vegetation has vast health and aesthetic significance for people. Plants are able to reduce many pollutants in the environment, and they create specific microclimates by decreasing wind, noise, and solar radiation. On the other hand, urban environmental effects on different aspects of plants' vital functions modify the state of vegetation vastly. These modifications touch individual physiological and morphological parameters, longevity, growth, and evolution, and increase the tolerance of urban plants to different pressures such as drought, cold or vermin. It is obvious that developing a system of monitoring urban greenery is an essential task for any city. This system is able to give information related to the current state of urban vegetation and forecast various situations.

To derive land-cover information from remote sensing imagery, however, can be a difficult task depending on the complexity of the landscape and the spatial and spectral resolution of the imagery being used. Several state administrators in Nigeria has gone ahead to study and improve on the greenery structure and distribution in their states such as, the Federal Capital Development Agency (FCDA), Abuja, the Lagos state government, and so many others. These greenery programs are based on first of all, the knowledge of the original greenery structure and distribution which is acquired with a very high level of accuracy. It therefore becomes necessary to compare, the accuracies of different approaches of deriving information from remotely sensed data (satellite imagery).

This work focuses on two Image Classification techniques (the pixel based image classification and the object oriented image classification), comparing them for mapping urban greenery, while exposing and comparing the accuracies derived from the two analysis results.

1.1 LITERATURE REVIEW

Chen et al. (2007) demonstrated the potential of object-oriented analysis to map urban land cover for the city of Beijing from ASTER data with a relatively high accuracy.

Addink (2007) demonstrated, in a very detailed study with 243 field plots, that the accuracy of parameter estimation for vegetation parameters, above ground biomass and leaf area index (LAI) in Southern France was higher for object-oriented analysis than for per-pixel analysis.

Similarly, Lackner and Conway (2008) used IKONOS images to automatically delineate and classify land-use polygons in Ontario, Canada, within a diverse urban setting; they obtained high overall accuracies for six- and ten-class maps, with 90% and 86% accuracy respectively.

Zhang et al. (2005c) used OBIA methods for the automatic extraction of land cover objects in the Three Gorges Reservoir, China. Kong et al. (2006) also employed an OBIA approach to extract urban land-use information from a high-resolution image.

In a study of apparently similar design, Mo et al. (2007) carried out land cover classification experiments in the Zhuzhou area, Desclée (2006) proved the effectiveness of OBIA-based change detection capability in detecting forest changes in temperate regions, while Duveiller (2008) investigated land cover change by combining a systematic regional sampling scheme based on high spatial resolution imagery with object based, unsupervised, classification techniques for a multi-date segmentation, to obtain objects with similar land cover change trajectories, which were then classified by unsupervised procedures. This approach was applied to the Congo River basin to accurately estimate deforestation at regional, national and landscape levels.

Ivits and Koch (2002) and Ivits (2005) analysed landscape patterns for 96 sampling plots in Switzerland, based on object based image analysis-derived patch indices for land-use intensities ranging from old-growth forests to intensive agricultural landscapes: landscape patterns could be quantified on the basis of merged Landsat, QuickBird and aerial photographic data.

Yan (2006) compared per-pixel and Object based Image Analysis (OBIA) classifications for land-cover mapping in a coal fire area in Inner Mongolia, and found the differences in accuracy, expressed in terms of proportions of correctly allocated pixels, to be statistically significant. They concluded that the thematic mapping result using an object-oriented image analysis approach gave a much higher accuracy than that obtained using the per-pixel approach.

2.0 STUDY AREA

The study area lies in the heart of Enugu urban area of Enugu state Nigeria between longitudes $7^o29'24''.958E$ and $7^o30'34''.329E$, and latitudes $6^o24'32''.558N$ and $6^o25'44''.818N$, stretching from Uwani layout through University of Nigeria Enugu Campus, Maryland layout, and Achara layout part of Enugu Urban.

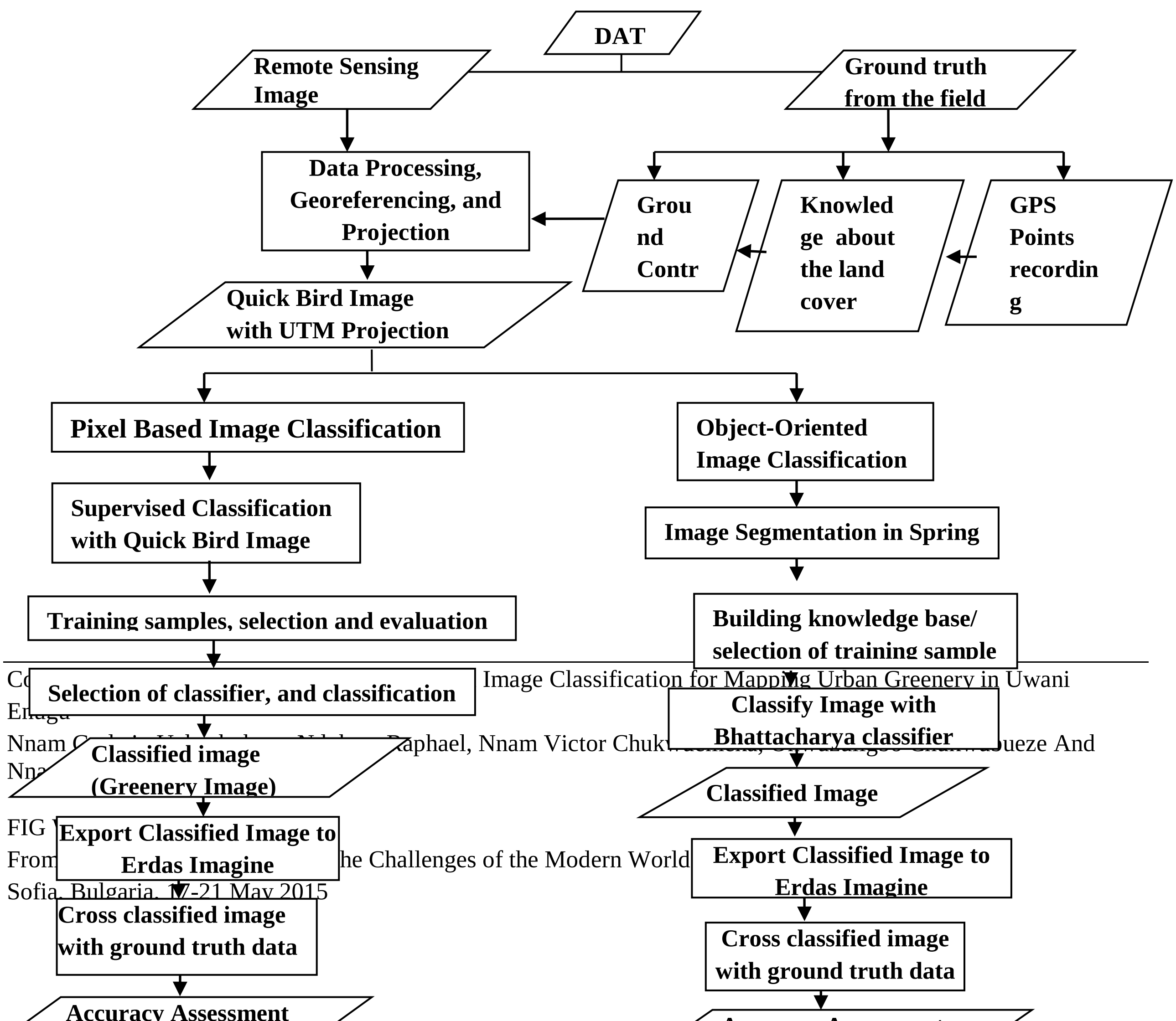
The study area being a well-developed urban area was chosen for this research because it possesses all the characteristics of a typical urban area as can be seen anywhere in the world.

3.0 DATA

Two datasets were used in this study, they are;

i. Remotely Sensed data (QuickBird image 2008)
ii. Field survey data (this data was obtained using a hand-held GPS-Garmin 78Sc).

3.1 METHODOLOGY



4.0 DATA PROCESSING

The Tiff image was imported into *Spring* (*Impima*), all the bands in the image were selected and saved in Spring format (Pixel.spg). A database was created for this project (Pixel) in *Spring.* A project was created and named Pixel_Project. Then the image (Pixel.spg) was imported with all the bands.

4.1 Pixel Based Image Classification

On the classification window, context was created, here one have to chose whether it is Pixel or Region (Object-based) classification that one wants to do. We created context for Pixel with the name *Pixel_Detail*. Using this context now created we carried out *training* of samples on the image. During the training exercise, we created four themes;

a. Buildings
b. Greenery
c. Paved Area, and
d. Shadows

Samples of these themes were randomly picked across the image so as to get a reliable classification. In the training, we got the following set of values for each theme;

Buildings: 313,372pixels

Greenery: 75,671pixels

Paved Area (Open space): 611,807pixels

Shadows: 23,610

During classification the *Euclidean Length* algorithm was used. This classifier was chosen because it gives results that depict a configuration of the study area closest to reality in the pixel based method.

The classification method by Euclidian Length is a supervised classification procedure which uses the Euclidian distance to associate a pixel to a class.

In the supervised training, the groupings representing classes are defined.

In the classification, each pixel will be incorporated to a grouping, through the similarity measure analysis of the Euclidian distance, which is given by:

d (x,m) = (2x - 2m) ½ ------------------ EQ. 1

where:

x	=	"pixel" that is being tested
m	=	grouping average
N	=	number of spectral bands

The classifier compared the pixel Euclidian Length to the grouping average and the "pixel" was incorporated to the grouping presenting the smallest Euclidian Length. This procedure was repeated until the whole image was classified. After specifying this classifier, the acceptance threshold was set at 99.9%, output image (data model) was set to *image,* and the sample analysis was carried out, then the image was classified.

After classification, Class Mapping was done to associate the grouped classes to their respective themes which established the connection between them. This action makes the classified image very useful for further analysis unlike ordinary coloured raster which it was before it was mapped.

4.2 Accuracy Assessment Of The Pixel Based Image Classification Method

This accuracy analysis was done in Erdas Imagine 9.2. Before the accuracy assessment was done, the classified images were reprojected in ArcCatalogue to reassign the projection system which had been lost during export from *Spring* to *Tiff* (.tif). Then the image was georeferenced in Erdas Imagine 9.2.

To assess the accuracy of the classified map, we imported the ground truthing data, that is, the coordinates of the corresponding reference points with their *Reference ID* which enabled the assessment of the accuracy of the classification. The result of the accuracy assessment showed that the Pixel-based classification had up to 57.34% accuracy.

4.3 Object-Based Image Classification method

In this classification technique, we have the following steps

1 Image Segmentation
2 Sample Training
3 Classification
4 Class Mapping
5 Reprojection in ArcCatalogue
6 Georeferencing
7 Accuracy Assessment in Erdas Imagine

On the classification window, the context was created for Region (Object-based) as was done in the case of Pixel based with the name *Object_Detail*. Using the selected segmentation and the context now created, we then went ahead to carry out training on the image objects segmented from the image. By training, we defined sample objects for each theme to guide the software in grouping the image pixels accordingly. During the training exercise, four themes were created;

a. Buildings
b. Greenery
c. Paved Area, and
d. Shadows

Samples of these themes were randomly picked across the image so as to get a reliable classification. Classification was done using the training data and the Bhattacharya algorithm in the object-based method. The Battacharya distance measure is used in this classifier by regions, to measure the statistical separability between a pair of spectral classes. That is, it measures the average distance between the spectral classes' probability distributions. The idea is similar to the one used by the Isoseg classifier, but the distance measurement used was the Battacharya distance. The *Battacharya* classifier is different from the *Isoseg* which is an automatic process, requires the user interaction, through training. In this case, the samples will be the regions formed in the image segmentation.

The spring software, while classifying, took note of segment size, shape, context, tone, and texture. After specifying this classifier, threshold was set at 99.9%, output image (data model) was set to *image*, sample analysis was carried out, and the image was classified.

During the process of exporting the image, the raster dataset lost its projection and therefore needed to be restored. This we achieved by reassigning the same projection (UTM Zone 32N) to it in ArcCatalogue.

4.4 Accuracy Assessment in Erdas Imagine

To assess the accuracy of the classified map, we imported the ground truthing data, that is, the coordinates of the corresponding reference points with their *Reference ID*. With this we were able to assess the accuracy of the classification. The result of the classification showed that the Object-based classification had up to 93.71% accuracy.

4.5 RESULTS AND ANALYSIS OF RESULTS

Many comparative analyses were made in order to show the difference between the two methods of classification. They are shown as follows;

4.5.1 Analysis and Comparison of Results from Both methods

	PIXEL-BASED CLASSIFICATION	OBJECT-BASED CLASSIFICATION

	AREA IN HECTARES (ha) PIX	AREA IN SQUARE METRE (m^2) PIX	PERCENTAGE OF AREA PIX	AREA IN HECTARES (ha) OBJ	AREA IN SQUARE METRES (m^2) OBJ	PERCENTAGE OF AREA OBJ
GREENERY	**107.779857**	**1077798.57**	**22.85%**	**98.724119**	**987241.19**	**20.92%**
BUILDINGS	**133.276614**	**1332766.14**	**28.25%**	**179.932306**	**1799323.06**	**38.14%**
PAVED AREA	**159.666103**	**1596661.03**	**33.84%**	**142.875469**	**1428754.69**	**30.29%**
SHADOW	**71.039904**	**710399.04**	**15.05%**	**35.981483**	**359814.83**	**7.63%**
TOTAL	**471.762478**	**4717624.78**	**100%**	**471.762478**	**4717624.78**	**100%**

Table 1: Area Comparison Table

Comparing the Land use (theme) area calculated in Table 1, the object based classification method was sensitive enough to separate a theme that does not match any of the training data supplied as shown in figure 2, as Unclassified while the pixel based classification, due to its method of grouping pixels based on their pixel values, mistakenly classified this area into the four land uses (themes), bringing differences in the area calculated for each theme.
The area calculated by the object based image classification is more accurate as it corresponds with the area from the vector map of the area than that of the pixel-based. The vector map shows that the area predominantly characterized by Buildings, followed by greenery Paved Area, then the greenery of 93.4120126151ha as against 98.724119ha (20.92%) which was calculated in object based method and 107.779857ha (22.85%) which was calculated in the pixel based method.

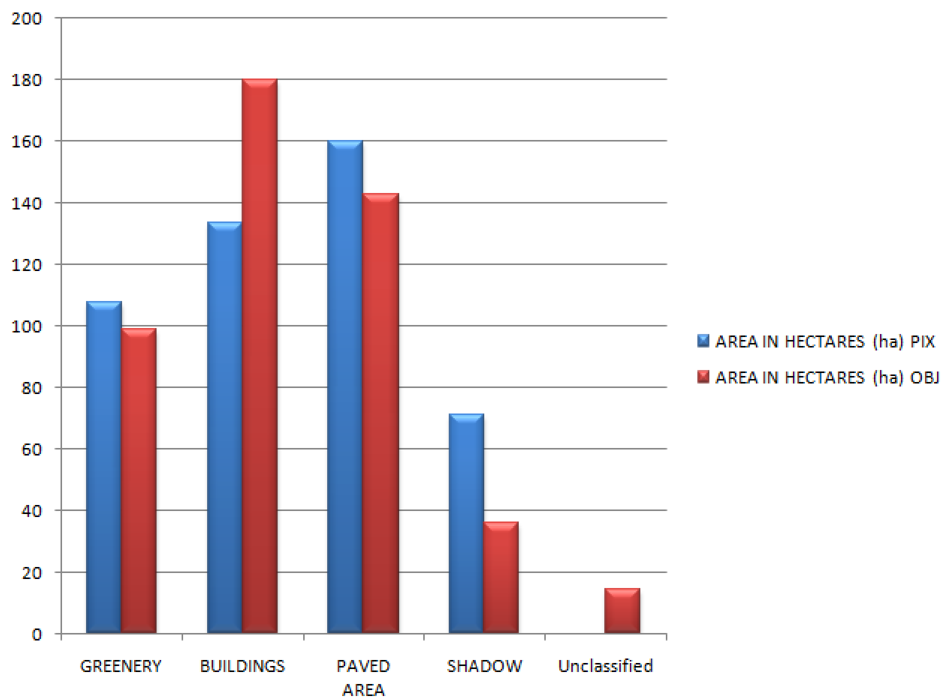


Fig 2: Histogram showing Comparism of Area Calculated by Pixel-based Method and Object-based Method.

The area calculated by the object based image classification is more accurate as it corresponds with the area from the vector map of the area than that of the pixel-based.
The vector map shows that the area predominantly characterized by buildings, followed by greenery Paved Area, then the greenery of 93.4120126151ha as against 98.724119ha (20.92%) which was calculated in object based method and 107.779857ha (22.85%) which was calculated in the pixel based method.

4.5.2 Comparison of the Accuracy Assessment Results

Table 2: Classification Accuracy

	PIXEL-BASED CLASSIFICATION	OBJECT-BASED CLASSIFICATION

Class Name	Referenc e Totals	Classified Totals	Number Correct	Producer s Accuracy	Users Accuracy	Referenc e Totals	Classified Totals	Number Correct	Producer s Accuracy	Users Accuracy
GREENERY	**32**	**31**	**17**	**53.13 %**	**54.84 %**	**32**	**33**	**30**	**93.75 %**	**90.91 %**
BUILDINGS	**40**	**38**	**22**	**55.00 %**	**57.89 %**	**40**	**39**	**37**	**92.50 %**	**94.87 %**
PAVED AREA	**34**	**35**	**17**	**50.00 %**	**48.57 %**	**34**	**36**	**33**	**97.06 %**	**91.67 %**
SHADOW	**37**	**39**	**26**	**70.27 %**	**66.67 %**	**37**	**34**	**34**	**91.89 %**	**100.00 %**
Overall Classification Accuracy			**57.34%**					**93.71%**		

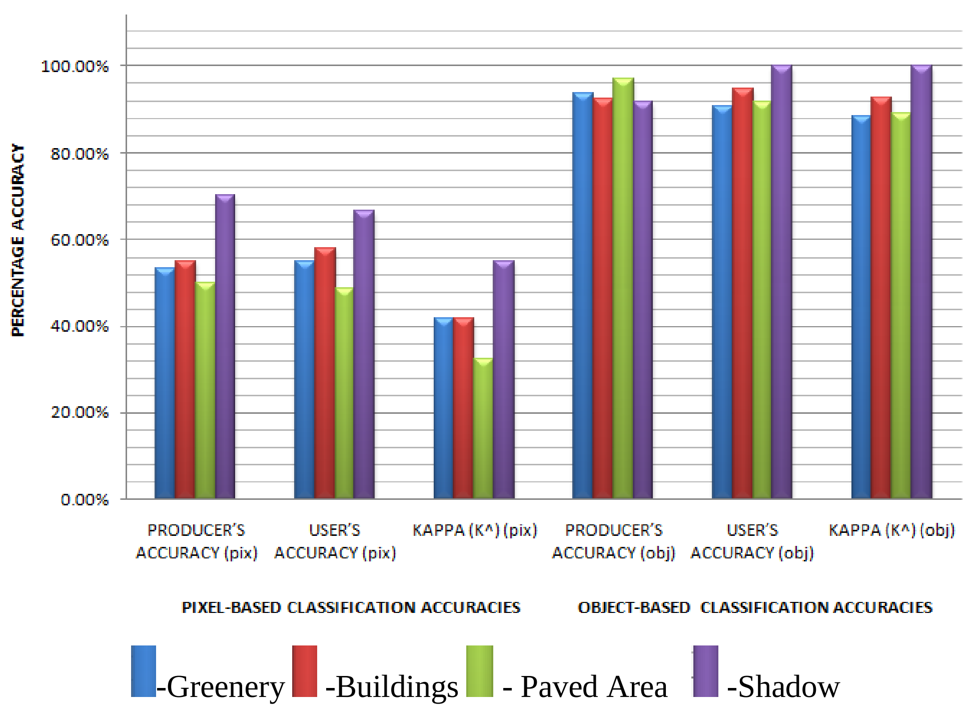


Fig 3: Comparison Histogram of Pixel-based Analysis and Object-based Analysis

TABLE 3: Classification and KAPPA Accuracy

	PIXEL-BASED CLASSIFICATION			OBJECT-BASED CLASSIFICATION		
Class Name	**Producer's Accuracy**	**User's Accuracy**	**Kappa (K^)**	**Producer's Accuracy**	**User's Accuracy**	**Kappa (K^)**
GREENERY	**53.13%**	**54.84%**	**0.4182**	**93.75%**	**90.91%**	**0.8829**
BUILDINGS	**55.00%**	**57.89%**	**0.4154**	**92.50%**	**94.87%**	**0.9288**
PAVED AREA	**50.00%**	**48.57%**	**0.3253**	**97.06%**	**91.67%**	**0.8907**
SHADOW	**70.27%**	**66.67%**	**0.5503**	**91.89%**	**100.00%**	**1.0000**
Overall Classification Accuracy	**57.34%**		**0.4300**	**93.71%**		**0.9162**

Fig 3 and Table 3 indicate that Producer's and User's accuracies varied with land-use and land-cover type. The Producer's accuracy for the pixel-based classification varied from 50.00% to 70.27%, while the Producer's accuracy for the object-based classification ranged from 91.89% to 97.06%. The User's accuracy for the pixel-based classification varied from 48.57% to 66.67%, while the User's accuracy for the object-based classification ranged from 90.91% to 100.00%.

The Producer's and User's accuracy of the classification result using object oriented approach are higher than those using a pixel based approach. This can be explained from two aspects of the two classification approaches.

a. From the characteristics of the two classification methods, in object oriented image analysis, all the image characteristics were considered. Partitioning an image into objects imitates the way humans conceptually organize the landscape to comprehend it. It uses image-objects as basic units instead of individual pixels thereby reduces computational classifier load by orders of magnitude, and at the same time enables the user to take advantage of more complex techniques (e.g. non-parametric). Image-objects exhibit useful features (e.g. shape, texture, context relations with other objects) that single pixels lack.

b. Properly performed segmentation creates good image objects that facilities the extraction from the image. This is achieved due to the edge detection technique in Object based classification method.

The overall accuracy of the pixel-based classification was 57.34%, while the overall accuracy of the object-based classification was 93.71% (Table 1). Comparisons of the result of the accuracy assessment shows that object oriented image analysis attain higher overall accuracy comparing with Pixel-based classification approach. Also higher individual producer's and user's accuracy for each classified class is shown by object base feature extraction.

This indicates that the object based classification approach is better than the pixel based approach in mapping urban greenery

5.0 CONCLUSIONS

Urban greenery is a key natural resource for a city; besides, vegetation has vast health and aesthetic significance for people. Plants are able to reduce many pollutants in the environment, and they create specific microclimates by decreasing wind, noise, and solar radiation. On the other hand, urban environmental effects on different aspects of plants' vital functions modify the state of vegetation vastly. These modifications touch individual physiological and morphological parameters, longevity, growth, and evolution, and increase the tolerance of urban plants to different pressures such as drought, cold or vermin. It is obvious that developing a system of monitoring urban greenery is an essential task for any city. This system is able to give information related to the current state of urban vegetation and forecast various situations. The Greenery results from our classification shows that while University of Nigeria, Enugu campus has abundant greenery around the staff quarters, most part of the Enugu urban have little or no greenery except for places very close to a river or stream. The object based classification gives a vector-like, accurate and aesthetic map than the pixel based method which mix up pixels belonging to different land uses.

In conclusion, the Object based classification presents an easier, faster, and cheaper way of producing Land-use and Land-cover maps for quick decision making. Though not as accurate as ground survey method, but it gives results that are very close to reality as edges are clearly defined unlike the Pixel based classification where the edges of the map objects are very hazy.

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