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- **COMPARATIVE STUDY OF PIXEL-BASED AND OBJECT-BASED IMAGE ANALYSIS IN LANDCOVER AND LANDUSE MAPPING OF ABA Main Township For Environmental Sustainability**

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Presentation outline

- **INTRODUCTION**
- **THEORITICAL FRAME WORK**
- **METHODOLOGY**
- **DATA ANALYSIS, RESULTS AND DISCUSSIONS**
- **SUMMARY,CONCLUSION AND RECOMMENDATIONS**
- **BIBLIOGRAPHICAL NOTES**

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INTRODUCTION

An important condition that will guarantee effective management of any nation's development is the ability of the nation to monitor and control environmental trends and her natural resources potential in both time and space.

Remote sensing, especially by Earth observation satellites complemented by Navigation and telecommunication satellites plays very important roles in generation and distribution of geoinformation in a timely manner and at the required scale and quality (Igbokwe, 2010).



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INTRODUCTION CONTD

- Remote Sensing information or data are acquired by means of photographic, mechanical, numerical or visual sensors located mainly on mobile platforms.
- The information so acquired is capable of being transformed into physical parameters that can contribute to the evaluation or characterization of the earth's surface or man's environment (Ndukwe, 2009).
- Remote sensing image analysis is a very important and challenging task however; a popular and commonly used approach to image analysis is **digital image classification**.
- The **purpose** of image classification is to **label the pixels in the image** with meaningful information of the real world.



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Introduction Contd.

- Through classification of digital remote sensing image, thematic maps bearing the information such as the land cover type; vegetation type, etc., can be obtained and analyzed. Typical method of classification of Remote Sensing imagery has been **pixel-based**.
- In the Pixel- based Image Analysis, the multispectral data are used to perform the classification and the spectral pattern present within the data in question for each pixel is used as the numerical basis for categorization.



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Introd Contd.

- Pixel-based approach is based on conventional statistical techniques(BINARY METHOD), such as supervised and unsupervised classification.
- In supervised classification the image is analyzed by pixel categorization process by specifying to the computer algorithm, numerical description of the various land cover types present in a scene.



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Introd Contd.

- Digital image classification techniques group pixels to represent land cover features. Land cover could be forested, urban, agricultural and other types of features.
- There are three main image classification techniques in Remote Sensing:
 - (1) Unsupervised image classification
 - (2) Supervised image classification
 - (3) Object-based image analysis
- 1 & 2 are PIXEL-BASED Classifications.



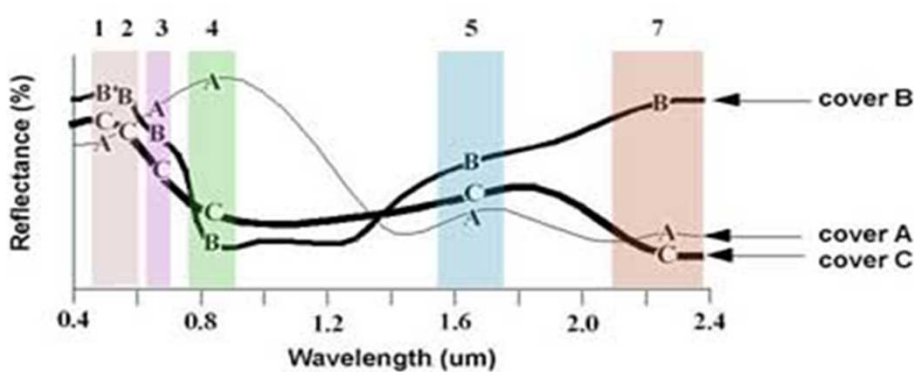
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SPECTRAL SIGNATURE OF LAND COVER CLASS



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- **Pixels are the smallest unit represented in an image. Image classification uses the reflectance statistics for individual pixels. Unsupervised and supervised image classification techniques are the two most common approaches.**

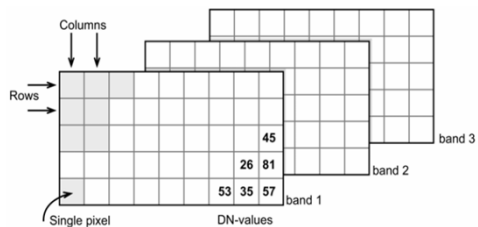


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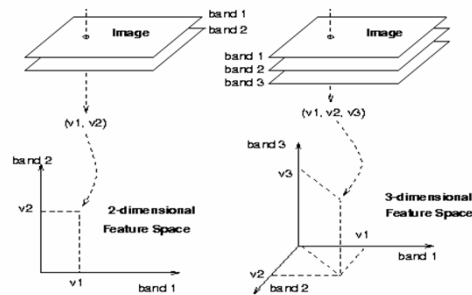
Spectral information in the image (Image Space)

- **A digital image is a 2D array of elements. In each element, the energy reflected or emitted from the corresponding area on the earth's surface is stored. The spatial arrangement of the measurements define the image or image space. Depending on the sensor, data are recorded in n bands(Jensen, 2001 in Goa, 2006).**



Feature Space

- In one pixel, the values in two bands can be regarded as components of a two dimensional vector, the feature vector. The following is the plotting of the values of a pixel in the feature space for a two and three band image.



UNSUPERVISED CLASSIFICATION

- Here the Pixels are grouped based on the reflectance properties of pixels(Features). These groupings are called "clusters". The user identifies the number of clusters to generate and which bands to use. With this information, the image classification software generates clusters. There are different image clustering algorithms such as K-means and ISODATA.
- The user manually identifies each cluster with land cover classes. It's often the case that multiple clusters represent a single land cover class. The user merges clusters into a land cover type. The unsupervised classification image classification technique is commonly used when no sample sites exist.



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SUPERVISED CLASSIFICATION

- The user selects representative samples for each land cover class in the digital image. These sample land cover classes are called "training sites". The image classification software uses the training sites to identify the land cover classes in the entire image (TRAINING STAGE).
- The classification of land cover is based on the spectral signature defined in the training set. The digital image classification software determines each class on what it resembles most in the training set. The common supervised classification algorithms are maximum likelihood and minimum-distance classification (CLASSIFICATION STAGE).
- Here the **MAXIMUM LIKELIHOOD Classifier** decision rule based on a normalized (**GAUSSIAN**) estimate of probability density function each class was used.



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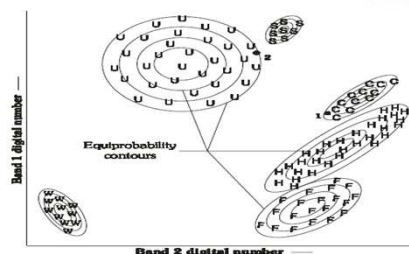


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SUPERVISED CLASSIFICATION CONTD.

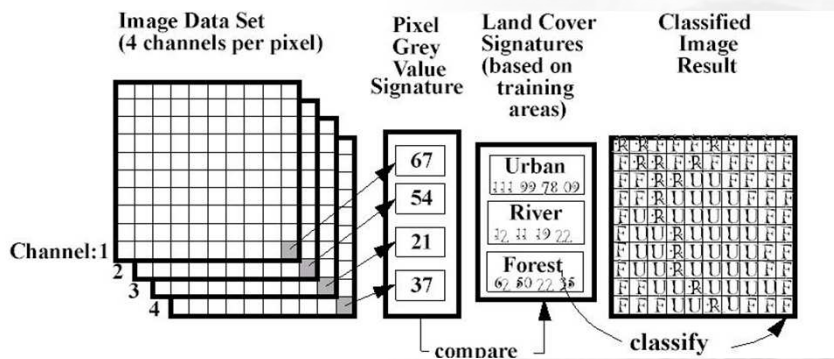
- After evaluating the probability in each category, the pixel would be assigned to the one with highest probability value or be labelled "unknown" if the probability values are all below a threshold set by the analyst.
- (Maximum likelihood Method, Jenson 2001 in Goa, 2006).



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SUPERVISED CLASSIFICATION STEPS



OBJECT-BASED IMAGE CLASSIFICATION

- Traditional pixel-based processing generates square classified pixels. Object-based image classification is very different in that it generates objects of different shape and scale.
- This process is called multi-resolution segmentation. Multiresolution segmentation produces homogenous image objects by grouping pixels.
- Objects are generated with different scales in an image simultaneously. These objects are more meaningful than the traditional pixel-based segmentation because they can be classified based on texture, context and geometry.



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Early Attempts at pixel-based classification

- Land cover map of Great Britain 1990 used Multi-temporal Landsat 5 Thematic Mapper data to produce a 25M spatial resolution pixel-based recording of land cover type (Area approximately 1.5 x 1.0 km in Agric. region of East Anglia) (Fuller, et al. 1994).
- **Draw backs of the pixel-based method:**
- Pixel's spatial extent may not match the extent of the land cover feature interest
- Problems of mixed classification is well known, whereby a pixel represents more than a single type of land cover often leading to misclassification (Fisher, 1997).
- Another problem is where object of interest is considerably larger than the pixel size leads to inappropriate classification because of the problem of within field variation (Agricultural field)



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Early Attempts at Object-Based Classification

- Developed as part of the classification of the Environment with Vector and Raster-Mapping (CLEVER-MAPPING) project (Dean and Smith, 2003) and used for the production of the 1997 Land cover Map of Jersey (Smith and Fuller, 2001) and Land cover Map 2000 (LCM 2000) of the UK, Fuller et al. 2002).
- **Strong points for Object-based Classification:**
- Removing the possibility of misclassifying individual pixels (can be more accurate than pixel-based method).
- By focusing on real-world objects, maps produced in this way may be more recognisable and directly usable by analysts (Benz et al. 2004).
- Objects-based information may be integrated with other spatial data in vector-based geographical information system (GIS) environment.



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OBJECT-BASED CONTD.

- **Segmentation is the main process in the object-based classification and its aim is to create meaningful objects.**
- **This means that an image object should ideally represent the shape of each object in question.**
- **This shape combined with further derivatives such as color and texture properties can be used to initially classify the image by classifying the generated image-objects**



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Different Segmentation Approaches in object-based classification

- **(A) Direct Method**
- **(i) Region Growing technique: Can be employed to group adjacent pixels with similar spectral values into individual objects(Goa et al. 2006).**
- **(ii) Edge Detection Technique: Can be used to identify discontinuities(object boundaries or edges) throughout the image, These boundaries can be used to build polygons for object-based classification(Carlaer et al. 2005).**
- **(B) Indirect Method**
- **Here, the imagery is supplemented with another spatial data, often, digital vector map data. The objects characterised by the vector polygons are assigned land cover values derived from the imagery. This is done by calculating the modal land cover class for each object.,**

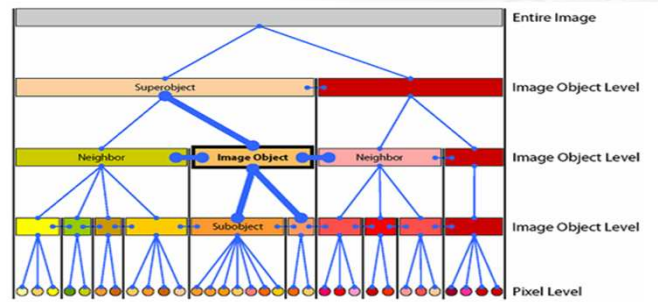




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Image - Object Hierarchy



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- In performing the segmentation of the Quickbird imagery of Aba different scales and other parameters were used. Based on these parameters, the segmentation process was performed.
- Using Nearest Neighbor as the classifier which is similar to supervised classification and training areas selected, the training areas are training objects; one sample object covers many typical pixel samples and their variation



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STATEMENT OF PROBLEM

- Classical algorithms of pixel-based image analysis are becoming less important for high resolution imagery classification.
- Alternatives to a pixel-based classification are being currently developed for instance the object-based approach that takes into account the form, textures and spectral information.
- The traditional pixel-based algorithm is based on binary theory.
- Based on this binary theory, one pixel is labeled to a class or is not assigned or remains unknown or not classified. For overlapping pixels, by the binary theory, such pixels will be labeled in one or two classes showing affinity



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MIXED- PIXEL PROBLEM OF TRADITIONAL PIXEL-BASED CLASSIFICATION

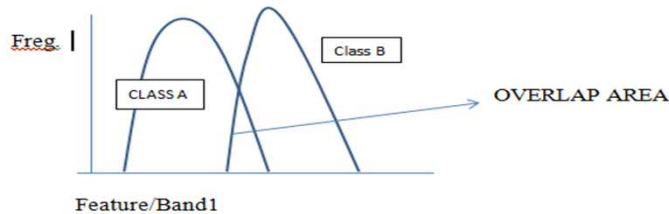


Figure 1.0 Different Land cover types having spectral pattern overlapped
(Source: Gao, 2003)



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- The traditional per pixel-based classification algorithm does not have the capability to solve the above problem because the image is classified according to the spectral information and the pixels in the overlapping region will be misclassified or incorrectly classified.
- Object-based image classification is believed to have a solution to the problems by combing spectral and spatial information in its analysis.
- Object-based image classification is based on the assumption that image objects provide a more appropriate scale to map environmental features at multiple spatial scales.
- The statement above is based on fuzzy theory, which assigns membership function of 1 or more (between 0 to 1) classes (Gao, 2003).



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STATEMENT OF PROBLEM CONTD.

- Object-based image classification typically consists of three main steps:
- (1) Image segmentation
- (2) Development of an image object hierarchy
- (3) Classification (Benz et al., 2004).
- Aba is one of the fastest growing towns in Nigeria and also the commercial nerve center of Abia State.
- **Despite the strategic location and importance of the town in the socio-economic development of Nigeria, no concerted effort has been made to document at regular intervals the land use and land cover changes for sustainability.**



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JUSTIFICATION FOR THE STUDY

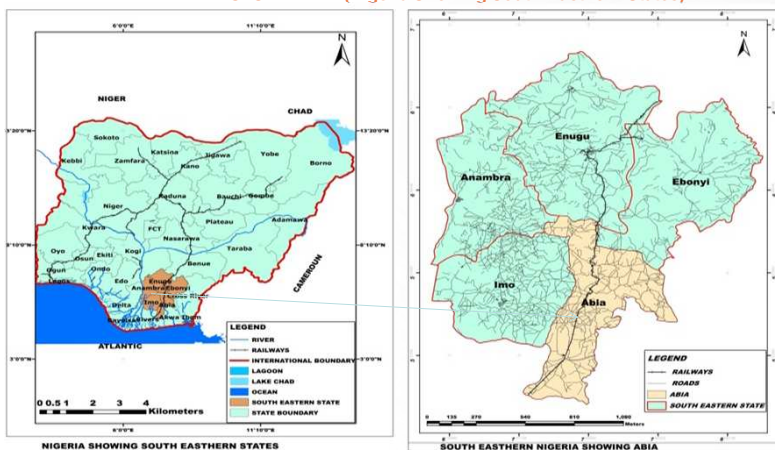
- This study, therefore, will add to the use of remote sensing and GIS in land use and land cover changes studies of Aba Main Township and also provide a guide for future physical development and sustainable planning of the town.



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THE STUDY AREA(Nigeria Showing South-Eastern States)

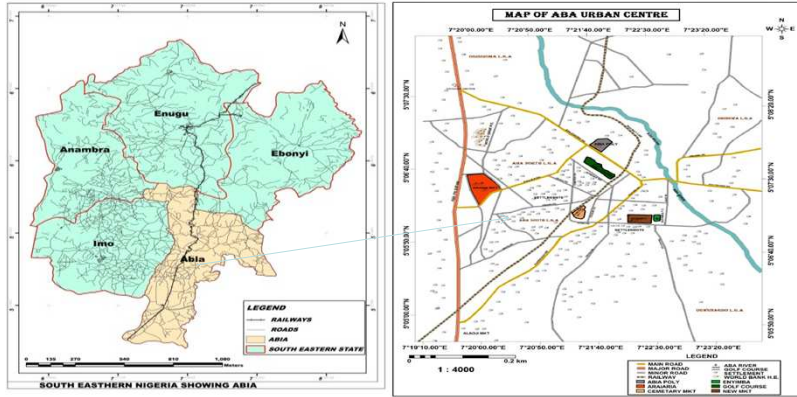




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ABIA STATE SHOWING ABA-TOWNSHIP



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STUDY AREA CONTD.

- This research area is Aba Main Township comprising Aba North, Aba South and part of Osisioma local Government Areas in Abia State of Nigeria.
- Aba is predominantly a commercial and industrial town, which owes its rapid growth to the functional transformation of pre-British villages into administrative headquarters of the various political units, which were created in Nigeria during the colonial period (Okoye, 2012).
- Okoye (2012), posited that Aba was simply a market village on the route from Bende to Bonny town which was a route for slave trade.
- Owing to the slave trade expedition and the centrality of the town, a military post was established in 1901 while a court was also established in 1904 for justice dispensation.





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STUDY AREA CONTD

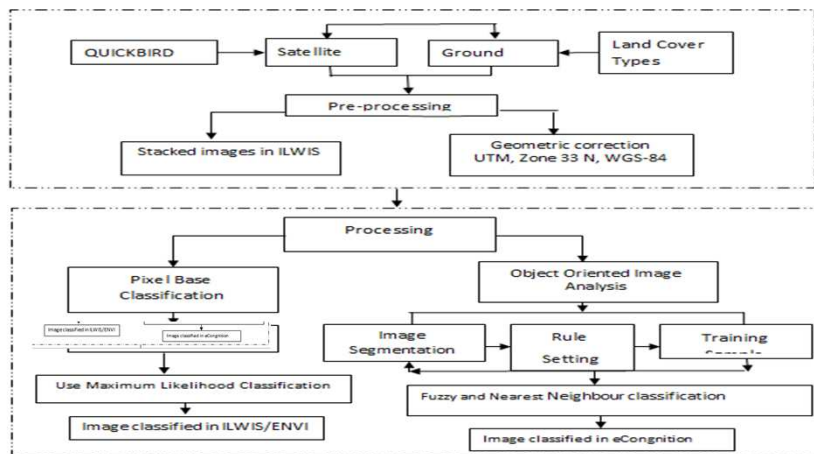
- Okoye (2012) noted further that the position of Aba as an urban center was strengthened by the fact the town served as the seat of administration for Ngwa District in all Igbo land then. This led then to the establishment of a hospital, post office, prisons and also emergence of housing needs due to population increase.
- Ogbonna (2008) in Okoye (2012) also buttressed that Aba assumed fully an urban status during the early 1970 when the then Imo state was created as one of the twelve states in Nigeria.
- Aba main town is in the South-eastern geo-political zone of Nigeria and is located between latitudes 05° 2' 30" N and 5° 08' 00" N of equator and longitudes 07° 20' 00" E and 07° 26' 00" E of Greenwich meridian. The town lies within the tropical rain forest zone of West Africa.



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METHODOLOGY

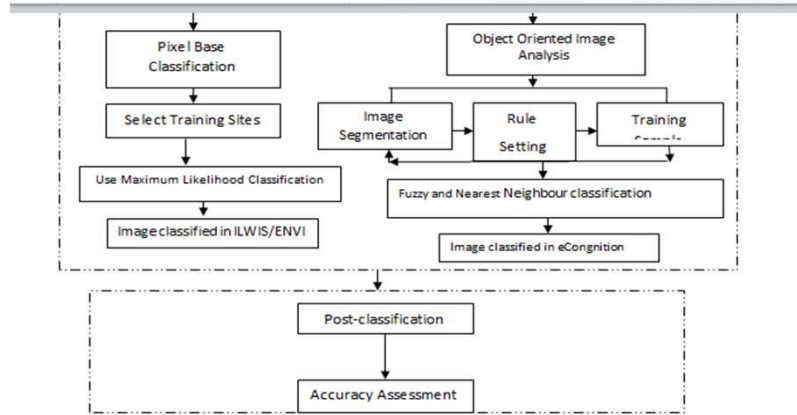




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METHODOLOGY CONTD.



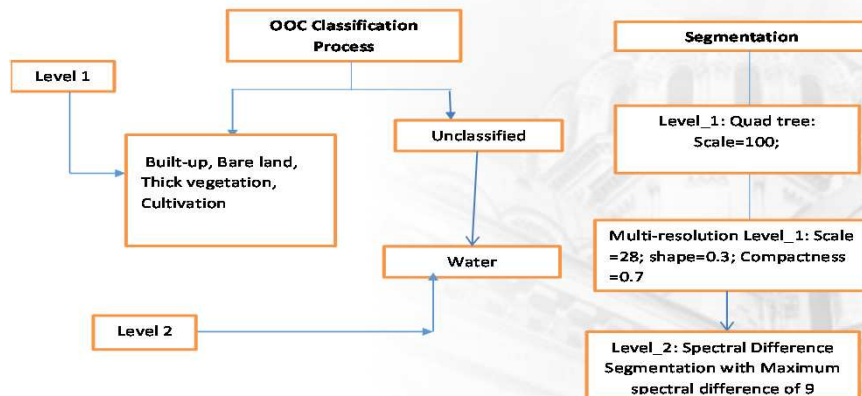
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METHODOLOGY CONTD. OBJECT-BASED CLASSIFICATION



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RESULTS

LEVELS	RULE SET	Features
LEVEL 1	Unclassified with brightness ≥ 130 and ≤ 140 at level_1: Built_Up_Area	Built_Up Area
	Unclassified with Rectangular fit $\Rightarrow 0.6$ and ≤ 0.8 at level_1: Built_up_Area	
	Unclassified with Red_band $\Rightarrow 70$ and ≤ 90 at level_1: Thick_Vegetation	Thick_Vegetation
	Unclassified with Red_band $\Rightarrow 90$ and ≤ 100 at level_1: Cultivated_Area	Cultivated_Area
	Unclassified with Brightness ≥ 110 and ≤ 130 at Level_1: Bare_Surfaces	Bare Surfaces
LEVEL 2	Nearest Neighbour classifier	Water
Tidy	Merge and tidy classes	



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DATA REQUIREMENTS AND SOURCES

- The datasets used this study consists of two types:
- **Primary Data:** This includes GPS data obtained using Garmin 76 x handheld GPS Receiver during field completion and Ground truthing exercise for image geo-referencing and different scene photographs of the study area captured with canon digital camera.
- **Secondary Data:** Administrative map of Abia State at the scale of 1:10000, Quickbird Satellite images of Aba of September, 2007 & 2012 (0.5m resolution).
- The Quickbird images of Aba was obtained from the Global Land Cover Facility (GLCF) through the Nigerian space agency (NASRDA) at Abuja.



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SYSTEM REQUIREMENTS

- These include all the hardware and software used

HARDWARE: The following hardware was used in the work:

- A Pentium V personal computer that has the following specifications;40 GB Hard Disk(HDD),256 MB Random Access Memory (RAM),1.6 Giga Hertz Speed(Microprocessor speed),Mouse and Keyboard,512 MB USB Flash Disk For data Storage and back up,500 G External hard Disk for data storage and back up, HP 500 Digital AO Plotter, HP Design Jet Scanner 4200 for Vector to Raster conversion, HP Laser/ Desk-Jet Printers, Garmin Handheld GPS 76 X for spatial data capture, etc.
- **SOFTWARE:**
- This includes :eCognition 8.8 professional software, AutoCAD 2010, ArcGIS 9.2, ILWIS software and Microsoft office 2010.



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- The stages shown in Figure 4 were adopted in the image processing, thematic image extraction/land use and land cover classifications were carried using pixel and object-based algorithms.
- For the pixel-based classification in ILWIS environment the Supervised Maximum likelihood classifier was used for the classification of 2007 and 2012 images while for object-based classification the Multi-resolution Minimum Distance to Mean classifier was used.
- Thereafter, Post classification processing and integration with GIS, overlay operation was undertaken to generate change statistics and comparative accuracy analysis of Pixel-based and object- based methods were equally done.



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PIXEL-BASED CLASSIFICATION USING QUICKBIRD IMAGERY

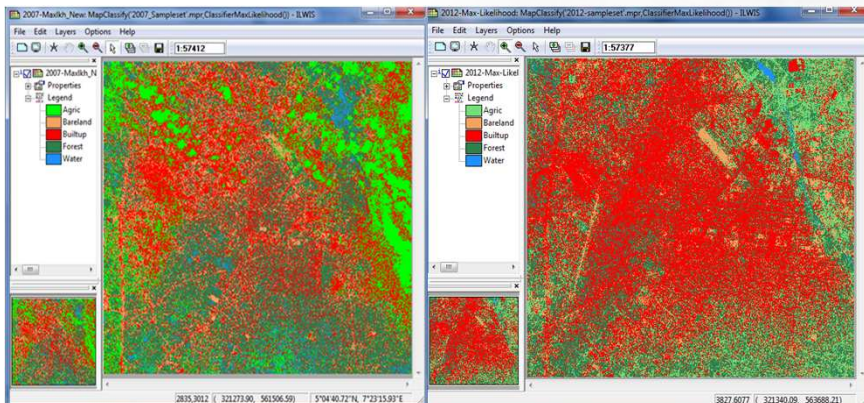
- The Maximum likelihood supervised classification algorithm is applied in pixel-based classification.
- Based on the ground truth data, five land use and land cover classes were identified.
- These are Built-up/Settlements, Thick forest, Cultivated Vegetation, Water body and Bare Surfaces.
- For ease of comparison for each method of classification, same training sites have been represented with the same color coding



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CLASSIFICATION RESULTS 2007 AND 2012 IMAGES (PIXEL-BASED)

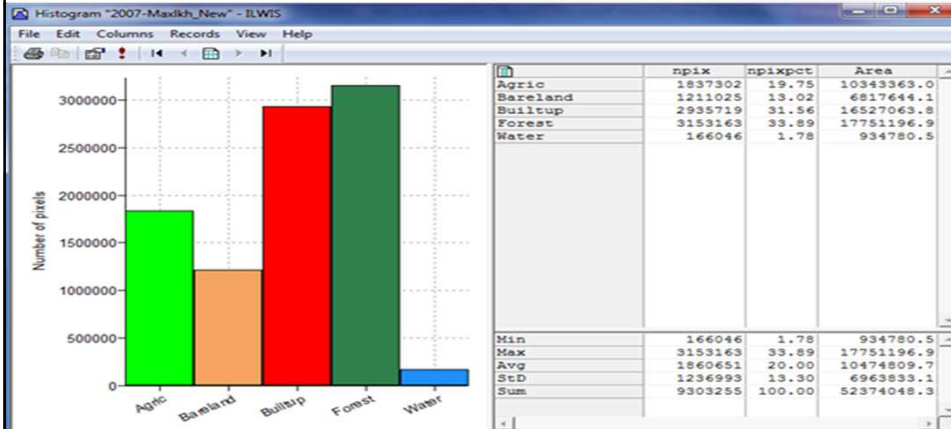




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CREATING HISTOGRAM FOR CLASSIFIED IMAGE 2007



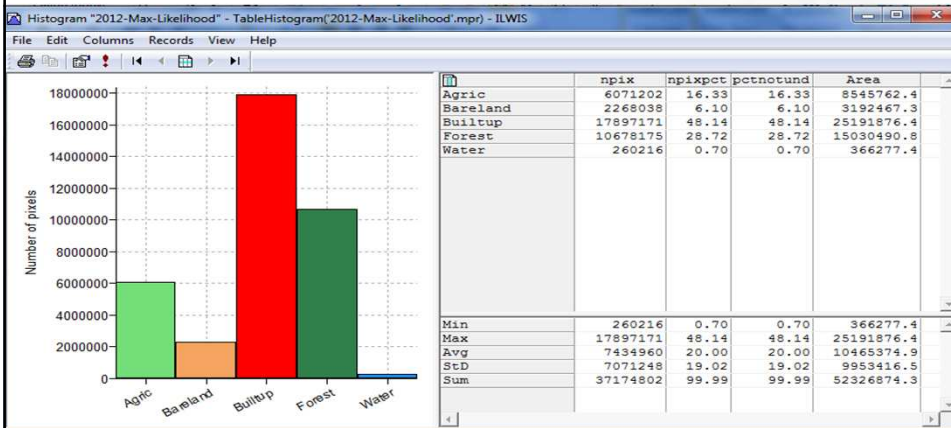
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CREATING HISTOGRAM FOR CLASSIFIED IMAGE 2012



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ACCURACY ASSESSMENT FOR 2007 IMAGERY

MatrixConfusion('C:\Aba Quickbird\Classified Image\2007-Cross-new.tbt,'2007-Maxlkh_New','200...')

File Edit View Help

Average Accuracy = 81.03 %
Average Reliability = 85.51 %
Overall Accuracy = 85.92 %

	Agric	Bareland	Builtup	Forest	Water	UNCLASSIFIED	ACCURACY
Agric	162	0	46	35	0	0	0.67
Bareland	0	989	242	0	0	0	0.80
Builtup	5	16	1630	3	4	0	0.98
Forest	6	39	59	541	188	0	0.65
Water	41	0	0	7	895	0	0.95
RELIABILITY	0.76	0.95	0.82	0.92	0.82		

Bareland



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ACCURACY ASSESSMENT FOR 2012 IMAGERY

MatrixConfusion('C:\Aba Quickbird\Classified Image\2012-Error-Matrix.tbt,'2012-Max-Likelihood'...')

File Edit View Help

Average Accuracy = 86.85 %
Average Reliability = 89.63 %
Overall Accuracy = 91.34 %

	Agric	Bareland	Builtup	Forest	Water	UNCLASSIFIED	ACCURACY
Agric	2951	247	239	887	144	0	0.66
Bareland	111	11203	419	0	0	0	0.95
Builtup	78	377	8262	28	98	0	0.93
Forest	261	0	454	5045	580	0	0.80
Water	10	0	0	34	14401	0	1.00
RELIABILITY	0.87	0.95	0.88	0.84	0.95		



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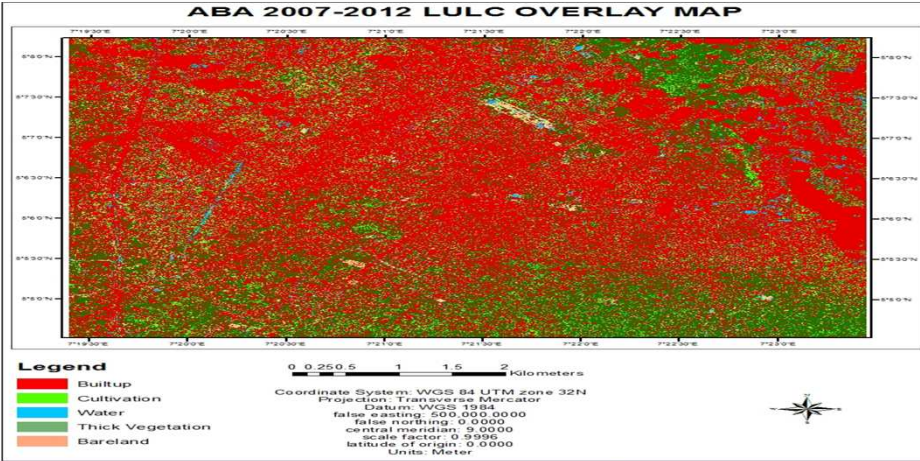




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OVERLAY RESULT OF ABA-MAIN 2007-2012 CHANGE MAP (PIXEL-BASED)



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ABA LULC 2007-2012 Change Table (Pixel-Based)

LULC	2007 (area m2)	2012 (area m2)	Changes (area m2)
<i>Built-up</i>	16527063.8	25191876.4	+8664812.6
<i>Cultivation (Agric.)</i>	10343363.0	8545762.4	-1797600.6
<i>Water</i>	934780.5	366277.4	-568503.1
<i>Thick Vegetation (Forest)</i>	17751196.9	15030490.8	-2720706.1
<i>Bare-land</i>	6817644.1	3192467.3	-3625176.8
TOTAL Classified	52374048.3	52326874.3	-47174.5 unclassified (mixed)

- While other land cover decreases, only Built-up land cover increased as a result of urban growth of Aba.

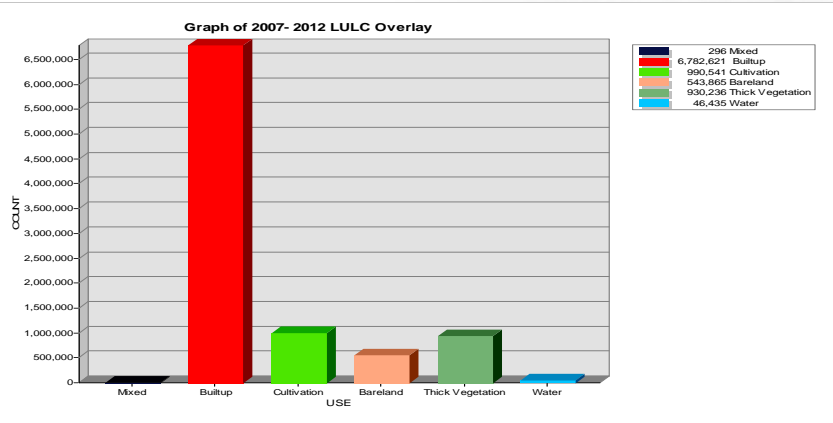




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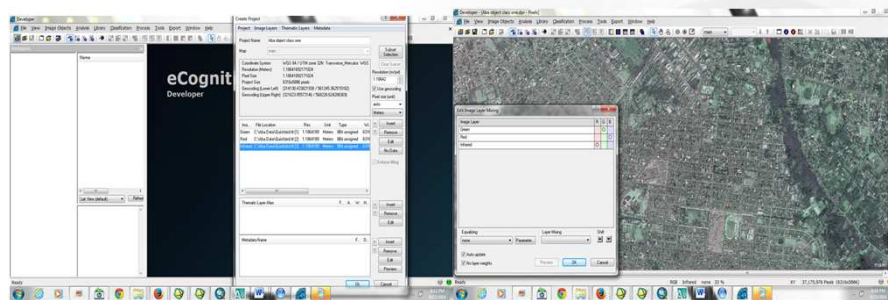
2007/2012 OVERLAY GRAPH



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OBJECT -BASED CLASSIFICATION OF 2007 AND 2012 IMAGERIES in e-Cognition

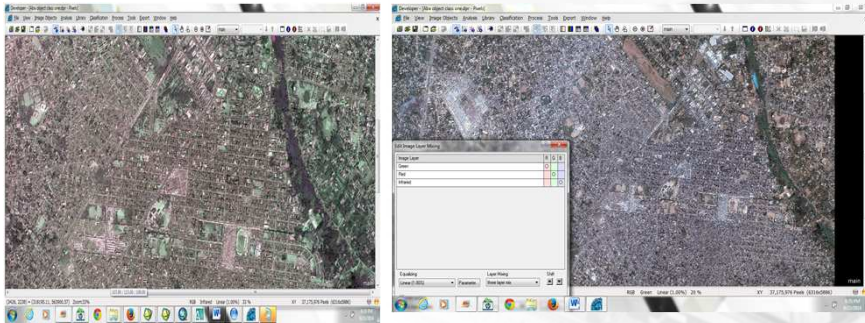




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Image Layer Mixing with 1% Linear Equalizing For imagery 2007 & 2012



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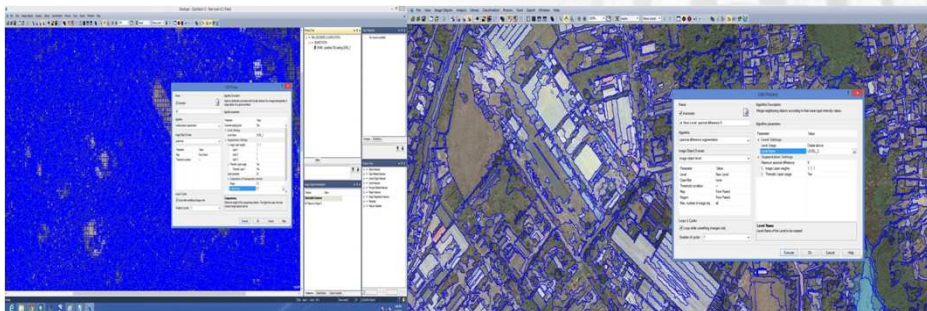


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MULTIRESOLUTION SEGMENTATION

The scale value of 28, shape value of 0.3 and Compactness value of 0.7 show how the rooftops and road network were segmented very well



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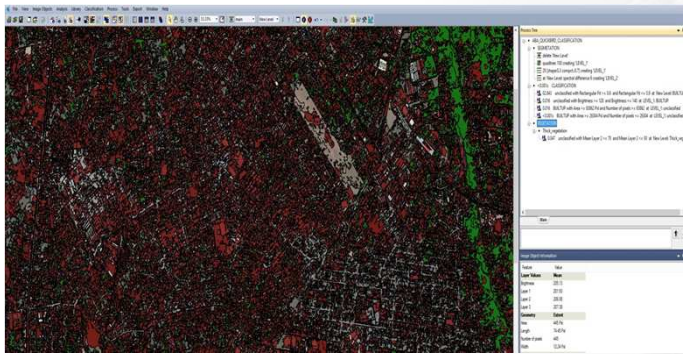


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DEVELOPING RULESET FOR EXTRACTING LULC CLASSES

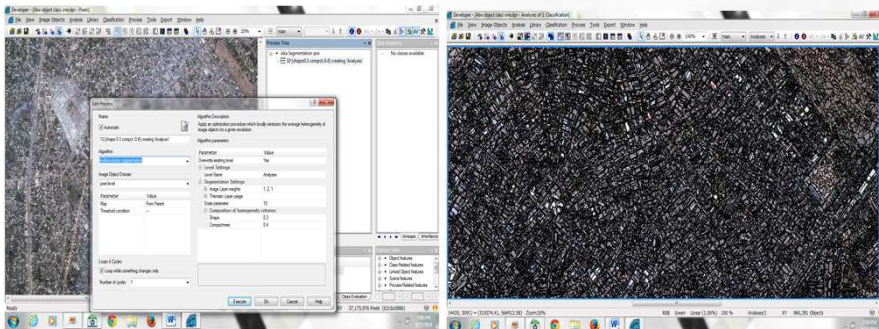
- Symbolizing object with Colour
- Extracting thick vegetation at level_1 using ruleset



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Result of Multi-resolution segmentation

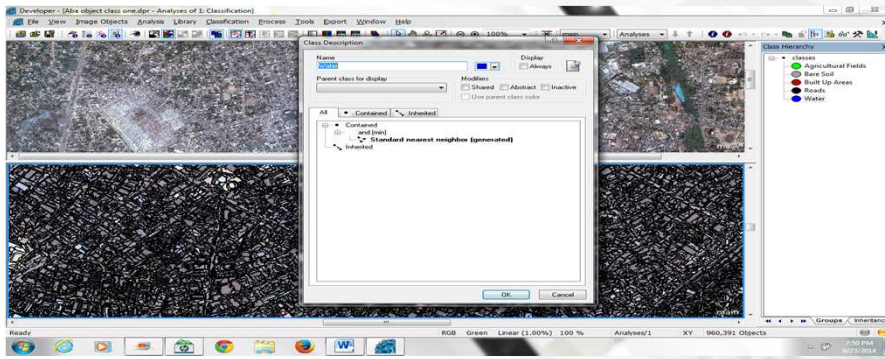




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FIG WORKING WEEK 2015
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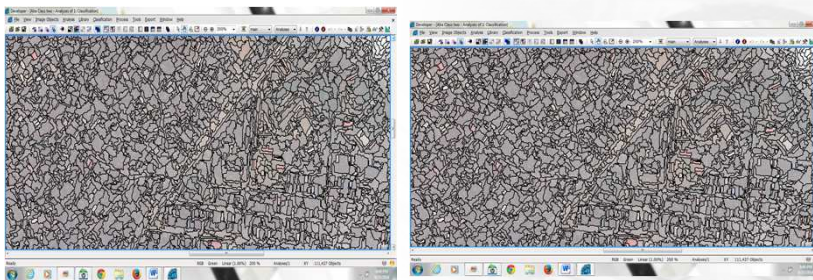
Defining class hierarchy and Inserting the Standard nearest Neighbor classifier



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Result of multi-resolution segmentation for 2012 & 2007 imagery



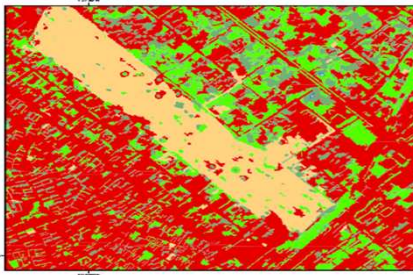


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OBJECT-BASED CLASSIFICATION RESULT 2007 & 2012

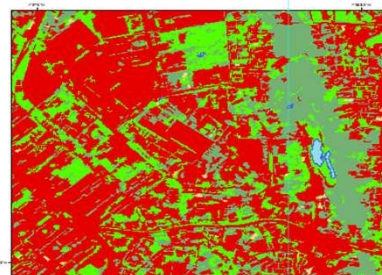
LULC MAP OF ABA 2007 (OBJECT-BASED)



Legend
OBJECT-BASED LULC
BARE LAND
BUILTUP
CULTIVATION
THICK VEGETATION
WATER

Coordinates System: WGS 84 UTM zone 32N
Projection: Transverse Mercator
Units: Meters
Scale: 1:50000
Scale factor: 0.0000
False meridian: 0.0000
Latitude of origin: 0.0000
Longitude of origin: 0.0000
Units: Meter

LULC MAP OF ABA 2012 (OBJECT-BASED)



Legend
OBJECT-BASED LULC
BARE LAND
BUILTUP
CULTIVATION
THICK VEGETATION
WATER

Coordinates System: WGS 84 UTM zone 32N
Projection: Transverse Mercator
Units: Meters
Scale: 1:50000
Scale factor: 0.0000
False meridian: 0.0000
Latitude of origin: 0.0000
Longitude of origin: 0.0000
Units: Meter



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Object Based Tabular analysis of change between 2007 and 2012 in ABA

• **Class results:**

LULC Type	2007 (Area)	2012 (Area)	LULC Change (2007 - 2012)	2007 (%) coverage	2012 (%) coverage	
1 Builtup	16499824	25099242	+8599418	31	48	+17
2 Forest (Thick Vegetation)	17752044	14622829	-3129215	33	28	-5
3 Bareland	6817702	3182542	-3635160	13	6.1	-6.9
4 Water	934680	364686	-569994	1.7	0.7	-1
5 Agric (Cultivation)	11257304	9057575	-2199729	21.3	17	-4.3
TOTAL	52326874	52326874		100	100	0



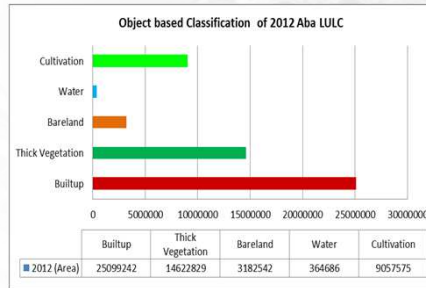
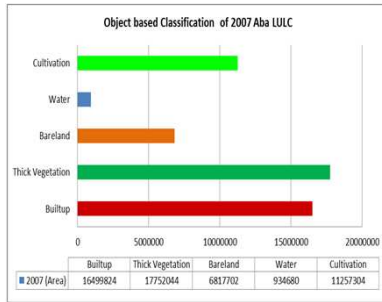


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HISTOGRAM OF CHANGES FOR LULC OF 2007 & 2008

- Histogram**



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ERROR MATRIX/ACCURACY ASSESSMENT FOR 2007 LULC

- Producer's accuracy = 99.93%**
- User's accuracy = 99.87%**
- Overall accuracy = 99.91%**

	Builtup	Thick vegetation	Bareland	Water	Cultivation	User's accuracy
Built-up	16425902	95	11314	0	704	99.93
Thick vegetation	19	17742998	190	3	7986	99.95
Bare land	11104	513	6805314	11	702	99.82
Water	16	87	15	934664	14	100.00
Cultivation	22	2504	711	8	1034220	99.69
Producer's accuracy	99.93	99.98	99.82	100.00	99.91	99.91



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ERROR MATRIX/ACCURACY ASSESSMENT FOR 2012 LULC

- *User's accuracy = 99.93%*
- *Producer's accuracy = 99.93%*
- *Overall accuracy = 99.93%*

	Built-up	Thick vegetation	Bare land	Water	Cultivation	User's accuracy
Built-up	25009928	321	1268	0	359	99.99
Thick vegetation	304	14601002	392	126	7002	99.95
Bare land	1148	562	3178247	0	2510	99.87
Water	0	282	0	364489	158	99.89
Cultivation	496	833	2560	0	8534383	99.95
Producer's accuracy	99.99	99.99	99.82	99.97	99.88	99.93



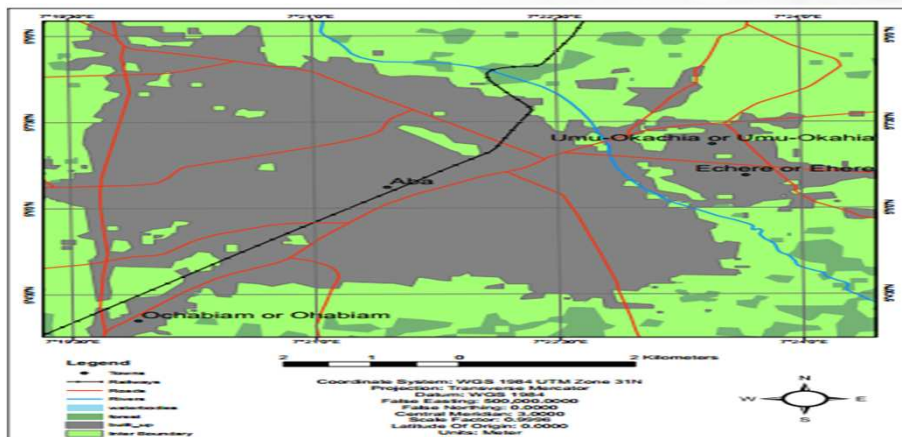
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LAND USE AND LAND COVER MAP OF ABA MAIN TOWN



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DISCUSSION ON THE CLASSIFICATION ACCURACIES

- From the results of the confusion matrixes shown in the tables above, the overall accuracy of the object-based classification was better than that of the Pixel-based classification.
- While the object-based classification from eCognition had an overall accuracy of 99.91% (the producer's and user's accuracies were 99.93% and 99.88% respectively for 2007 while the producer's and user's accuracy were 99.93% and 99.93 % for 2012 respectively), the pixel-based classification accuracies obtained with ILWIS software for 2007 were (overall accuracy 85.92%, average accuracy 81.03%) and 2012 were Average accuracy of 86.85% and overall accuracy of 91.34% respectively..
- Their overall kappa was 0.859 and 0.913 for 2007 and 2012 classified imageries (pixel-based) using ILWIS software while the kappa statistic for object based 2007 and 2012 were also 0.999 and 0.998 respectively..



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ANALYSIS OF CHANGE FOR LULC OF ABA (2007-2012)

- From the Pixel-based & Object-based Classifications 2007-2012

ILwis(pixel)	2007-2012	Object	2007-2012
Built-up	+ 16.54 increase		+ 17 increase
Forest	-5.13 decrease		5 decrease
Bare land	-6.092 decrease		-6 decrease
Water	-0.694 decrease		-1 decrease
Agric.	-3.42 Decrease		4,3 Decrease
unclassified	-1		none



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DISCUSSION CONTD

- The land cover classes classified using pixel-based in ILWIS, though, showed its inherent limitations of mixed pixel classification problems.
- In summary, the user's and producer's accuracies and kappa in eCognition results were on the average approximately 100% and 1 respectively
- This result also calls for further research especially on the integration of Pixel-based and object-based methods of classifications for optimal results.



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CONTD

- Hence, a conclusion is drawn that the classification accuracies obtained from the pixel-based classification and the object-based classification were distinctively different and significant, hence, elucidates existing literature on the preference of object-based method of classification over the pixel-based method (Goa, 2003, SEGE, 2011, Manandhar et al. 2009, Aplin et al. 2012).
- Recently, object-based image analysis has been applied frequently for remote sensing image classification, than pixel-based classification (Fuller et al. 2002; Blaschke, 2010).



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summary

- The application or use of spatial or contextual information from neighborhood or adjacent pixels remains a critical drawback to pixel-based image processing (Luo et al, 2011).
- Conversely, object-based methods allow integration of different object features, such as spectral values, shape and texture.
- The strength of the object-based method is derived from its ability to combine spectral information and spatial information in extracting earth surface features (Baatz et al, 2000, Definiens, 2009, Manakos, et al., 2000).
- State of Land use / Land Cover (LULC) changes a total five (5) LULC types were extracted in the study area for 2007 and 2012 built-up.



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Summary contd.

- In 2007 vegetation forest were the prevailing LULC type, contributing to about 70% of the study landscape, water body had about 15% contribution while bare surface contributed about 5%. In 2012, the number of built-up area increased astronomically with marked decrease in bare surface, vegetal surface and water.
- This is due to population increase caused by influx of people to Aba Main Township and the increased need for housing and shelter. The change results revealed a considerable reduction in farm land too, vegetation and forest from 2007 to 2012.



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FIG WORKING WEEK 2015
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summary

- The total vegetation / forest converted to built-up area amounts to about 25% of surface features which existed in 2012. Built-up increased at the rate of 5% annually for the period of 2007 to 2012.
- Similarly, bare lands decreased by 15% for the period under review. Water bodies also showed a marked decrease during the period of study (2007 – 2012).
- The change Matrix analysis show that as a whole, about (70%) of the land within the study landscape experienced LULC changes in one way or another between 2007 – 2012.



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CONCLUSION AND RECOMMENDATION

- The drawback for pixel-based image processing routines is the relatively unsophisticated use of spatial information. Object based approaches may offer a better alternative for many standard image processing tasks.
- The method of object-based classification is supported by rule-based classification.
- The rules can be defined based on the spectral statistics, spatial and pattern.
- It is recommended that further research is needed in developing rule-based data models that can be used to identify remote sensed data for more accurate classification



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Contd.

- The land use pattern and change dynamics of Aba urban showed marked and phenomenal increase in Built-up areas and water body while the vegetal surface decreased remarkably in both the pixel-based and object-based analysis.
- It is also observed that the object-based classification algorithm showed better accuracy results in eCognition software than that achieved ILWIS software. However, the limiting factor in the use of very robust software like eCognition is the high cost of acquiring and renewal of license.
- There is also need to investigate the efficacy of open source software like spring in object-based image classification especially for academic research work.



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- From the research findings, it is imperative that there is appreciable and astronomical increase in built-up areas due to commercial activities and high rate of influx of people to Aba urban area. This challenge is huge and massive to the planning authorities and other stakeholder environmental agencies.
- The increased population of the town occasioned by the commercial activities has given room to astronomical increase in solid waste generation in the town. Thus the government agency in charge of waste management is overwhelmed by the rate of waste generation in Aba.
- Therefore, there is need to implement all relevant town planning laws in the town to abate the ugly consequences of slump growth and also careful waste disposal system planning which should be based on good site and route selection amongst other considerations.



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BIBLIOGRAPHICAL NOTES

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- Bello Innocent(M.Sc.)
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- **THANKS FOR LISTENING**
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