2013

The Dynamic of land Cover Change in Abuja City, Federal Capital territory, Nigeria

Lays S Usman

Usman S.L, 2013 8: 14-24
http:www.journalhome.com/cjes
ISSN: 1597-5827

The Dynamics of Land Cover in Abuja City, Federal Capital Territory, Nigeria.

USMAN, Salihu Lay
Department of Geography, Nasarawa State University Keffi, Nigeria
E-mail:*usmanansirlay@gmail.com*

Abstract
The Federal Capital City of Abuja, Nigeria, is one of the World's fastest growing citiesexperiencing rapid urbanization. This work aimed at assessing the dynamic of Abuja city's land cover, Federal Capital Territory Abuja Nigeria. The following objectives were to: identify the characteristics and the spatial distribution of the urban land cover, and estimate the dynamics in the Land cover over a period of 25 years. The data used were Landsat TM and ETM$^+$ images (path and row 189/54 respectively) with a 30m spatial resolutions; for the periods 1986,1990,2001,2006 and 2011; and sourced from glovis and glcf NASA. The satellite images selected for the land cover classification were bands 543. Artificial Neural Network algorithm was used for the urban Land cover classification. Land cover categories was analyzed by regression techniques. The results of the analysis showed that the built up area was more prominent in the urbanized areas with 207% change from 1986 to 2011. There is inverse relationship between vegetation and built-up area and direct relationship also exist between the built-up and the years. The study concluded that the green vegetation area has weaken the effects on urban heat island, while, built-up area has the capability of strengthening the effects of urban heat island in the Abuja city. Owing to the constraints posed by availability and quality of data; to study the dynamics of city land cover; satellite based sensors with very high spatial resolution were recommended to enable highly detailed land use/cover, and ecological characterization of the urban environment of the city.

Keywords: Artificial Neural Network, cross-tabulation matrix and urban land cover.

Introduction

Over the past one hundred years, cities have been transformed from small, isolated population centers to large, interconnected urban economic, physical, and cultural features of the landscape has changed (Xian, 2007). The major factors contributing to these differences are the land use and land cover transformations (Lilly and Monsingh, 2009). These land use changes often include replacements of natural surfaces with highly reflective parking lots, concrete masses, asphalt roads, and other surfaces that affect the thermal environment in cities. There is a great concern about the impacts of human activities such as rapid urbanization on the environment, especially as it relates to local climate system (Lin *et al*., 2002).

Urbanization is an extreme case of land cover or land use (LCLU) change. Although only 1.2% of the earth's surface is at the moment urban, it contains half of the population, with a tendency of increasing spatial cover and density. It is estimated that in the year 2025, 60% of the world's population will live in cities (UNFP, 1999); while 69% by the year 2050 (Geospatial world, 2012). Perhaps cities are the most dramatic expressions of the transformation of natural environments by the hand of humans. However, in primitive societies the degree of transformation is minimal and the character of the settlement is quite different from that of modern urbanized places (Gluch and Ridd, 2007). Spatial distributions and patterns of urban land use and land cover (LULC) often affect socioeconomic, environmental (Gillies*et al*., 2003) and climatic conditions (Arnfield, 2003; Kalnay and Cai, 2003; Voogt and Oke, 2003). In view of these, there is need in elucidating the complex interactions and Abuja city morphology, which is of great concern (Hall *et al.,* 1992; Sellers *et al.,* 1997). Land-use and land-cover (LULC) pattern is regarded as an important determinant of ecosystem functioning, and can be considered as the representative of landscape pattern in an *in situ* area (Bain and Brush, 2004).

It is widely recognized that the spatial pattern of a landscape affects ecological processes (Wu and Loucks, 1995). Similarly, tremendous urban expansion with high inflow of population from the local or distant places and dynamic urban changes processes in their morphology, expansion of built up surface and conversion of productive lands in and around Abuja city, affects natural and human

systems at all geographic scales. Deteriorating conditions of the city crowding, housing shortages and lack of infrastructure, as well as increasing urban expansion on fertile lands highlights much attention for sustainable and effective management and planning of the area. The complexity of urban morphology in contemporary cities and the great variety of urban materials and land cover types introduce significant challenges to urban remote sensing analysis (Gluch and Ridd, 2007). Abuja is the capital city of Nigeria and one of the fastest growing cities in the world since early 1990s; leading to a large removal of portion of the green areas and converted to different land uses which could result to environmental problems such urban floods, urban heat island effects. It has a variety of land use types that strongly reflect the processes and the patterns of urban development in recent time. These differences could mainly due to the changes of natural surfaces with highly reflective parking lots, concrete masses, asphalt roads amongst others.

Research is needed to assess the spatio-temporal dynamics of the area, which holds great potential for characterization of the urban landscapes and for planning and development (Weng, 2003).

Not much has been done in term of urban growth and configuration in the city of Abuja. This study explored the capability of GIS and Remote Sensing in quantifyingand detecting morphological/ spatialdynamics of the urban area over a period of twenty five years. In view of these, this paper is aimed at assessing the dynamics of Abuja city's landuse /landcover. The objectives of this study are to:

- identify the spatial distribution of the urban land cover;
- estimate the dynamics in the Land cover over a period of 25 years; and
- The implications of the patterns of thechange of the land cover.

Study Area

The study covers the Municipal area of Abuja city, Nigeria (Figure 1).The Federal Capital Territory covers a total land area of approximately 8,000sqkm. However, the Capital City has a land area of about 250sq.km. It falls within latitudes 38′N and 10′N and longitudes 02′E and 39′E.

Figure 1 shows the administrative boundary of the FCT and the six area councils. The FCT is bordered in the north by Kaduna State, South-east by Nasarawa State, in the south-west by Kogi State and in the west by Niger State. The Federal Capital City (FCC), Abuja was chosen as the target area for this study. The high rate of urbanization, concentration of secondary and tertiary economic activities, large number of vehicle population and fuel consumption, artificial surfaces and low vegetation cover are some of the main characteristics of this area.

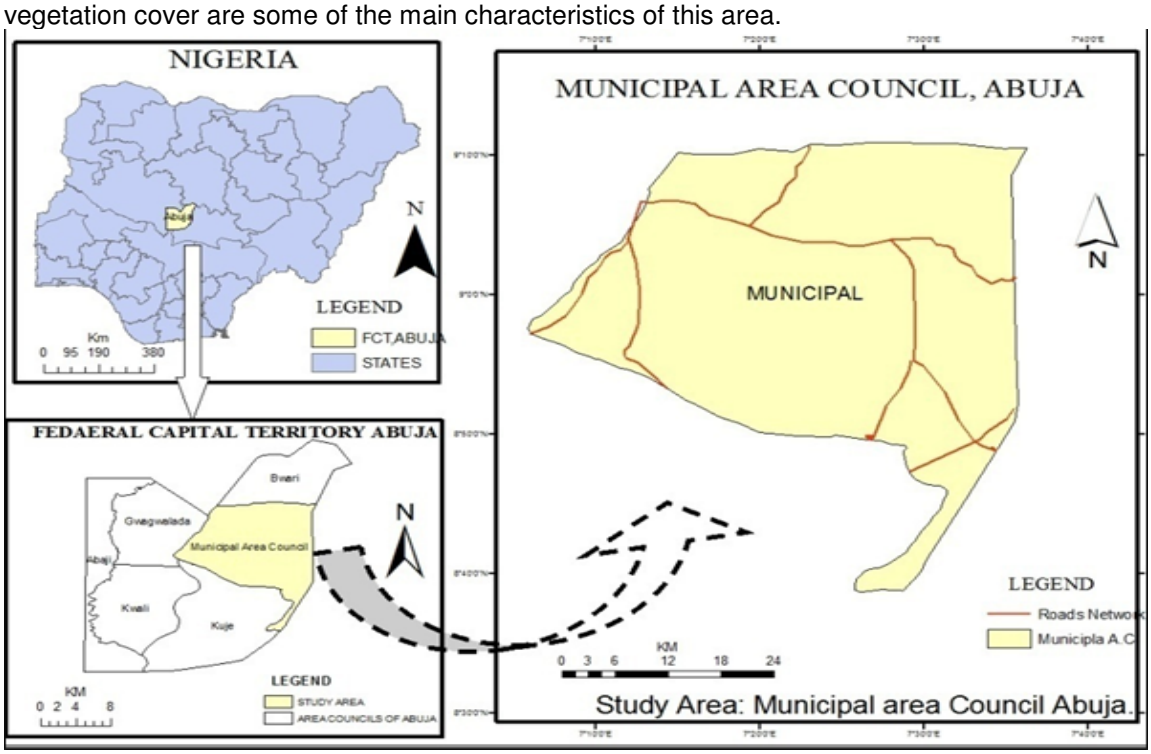

Figure 1: Abuja showing the study area Source: *Author's study 2012*

The defining feature of its landscape is the built up which is the most human activity in the City; intermixed with these are the roadnetworks, bare surface, parks and garden. Like most of Nigerian urban centers, residential land use dominates all other land use activities (Onokerhoraye 1994). These reflect the processes and patterns of urban development in the past two decades (Lay 2006).

The FCT enjoys a warm, humid tropical climate; hence its major climatic conditions have regimes that are traditionally different from those of the southern and northern part of the country. Thus relative humidity is not as high as in the far north (Balogun, 1972) with 23% and 35% minimum and maximum relative humidity respectively. Temperature is consistently high in the city centre throughout the year. The mean air temperature is within the range of 28.1 and 34.7 as minimum (Abuja Development,

1995). The annual total rainfall ranges from 1100mm to 1600mm; and itsets in from around the middle of March through October. The end of the season is characterized by frequent occurrences of squall lines. The wind is largely governed by the Inter-Tropical Convergent Zone (ITCZ). There is a brief interlude of Harmattan occasioned by the North-East Trade Wind, with main feature of dust haze, intensified coldness and dryness (Lay, 2006).The area falls within the tropicalferruginous soils.

Materials and methods

Images and tools employed in the study

Five Scenes of land sat TM and ETM+ images (path and row 189/54 respectively), dated 1986,1990,2001,2006 and 2011 were used to identify the spatial distribution characteristics of land use/land cover classes in the city of Abuja. The bands 5, 4 and 3 were used for land cover classification. Band 5- have higher reflectivity of urban building which could be strengthen building information and extraction of the built-up land in the urban area; band 4 has high reflectivity of vegetation and band 3 has the capability of reflecting bared surface most.

The other data used in this research were the satellite imageries data specifically Landsat TM/ ETM^+ for25 years period. The Landsat TM/ETM^+ images used in this research were obtained in the same seasons (8^{th} January1986; 12^{th} February1990; 27^{th} December 2001; 09^{th} December 2006; 23^{rd} December 2011) and all were used, (see Table 1). Land sat 7 (ETM^+) has eight spectral bands with one panchromatic band; it crosses equator at approximately 10:30 am local time.

Table 1: Data types and sources

DATA	SOURCE	FUNCTION	RESOLUTION	YEAR
LANDSAT TM and ETM^+ (1986-2011)	Global Land Cover Data Facility (GLCF)- http://glcf.umiacs.umd.edu	Land cover classification (Bands 342).	28.8m, 30m, spatial resolution	1986 TM and 1990, 2001, 2006 and 2011 ETM^+
Topographic map	OSGOF	Terrain model	1:50,000	-

In order to store, analyze and display information, software from ESRI and Clark Lab. were employed. Hence, both ArcGIS 9.3, IDRISI selva 9.0 software were used to extract and classified the urban land cover of the study area.Dynamics, patterns and trends in a multi-temporal approach, Microsoft office (MS Excel) were employed also for tabulations and graphical representations presentation, and analyses.

Image Pre-processing, Georeference and Geometric correction

The landsat-TM images of the year's 1986, 1990, 2001, 2006 and 2011 were further registered on the ETM+ image with a resultant root mean square Error (RMSE) of 0.22 pixels, so that both TM/ETM+ imageries would be on same spatial resolution and covered the same area. All these imageries were adjusted to a common spatial resolution of 30 m, using nearest neighbor resampling technique to merge and obtain a detailed land use/cover classification for the analysis.

In order to prepare the multi-temporal satellite images for accurate change analysis and detection, the Landsat images were pre-processed using standard procedures including geo-referencing and geometric correction. The projected coordinate system UTM WGS_86 (zone 32N) was used as the coordinate system. Subsets of Landsat satellite images were rectified with UTM projection Zone 32, using first order polynomial method and nearest neighbor image re-sampling algorithm. A total of 20 Ground Control Points (GCPs) were used to register the ETM^+ image subset with the rectification error less than 1 pixel. Subsequently, Landsat TM and ETM^+ images were registered to the already registered ETM^+ images through image-to-image registration techniques with rectification error of less than 0.5 pixels. In performing this image pre-processing, IDRISI selva Version 9, was used.

Data processing

The land cover classes used in this research were defined based on the Anderson's level 1 classification system.After the images were goeoreferenced and geometrically rectified, image clipping was performed, using spatial analyst tool on a sub-scene from the full image on the basis of a frame covering the municipality. These preprocessing tasks allowed us to export the satellite images to the IDRISI for classification and extracting land cover information. Anderson land cover maps for 2001 as reference classeswere adopted. More than 200 Training samples were generated as signatures for each Landsat imagery.

Supervised classification was performed on the same image with random training sample using on screen digitizer on the standard menu of the software, here 6-layers (ROI)/ land cover types with their id were created. The image processing icon was further selected for signature development; signatures were extracted from the id (1-6) layers by given each layer signature files name (identified Land cover type).Todetermine a signature for each band, the landsat spectral bands 543 were assigned to a particular class. Furthermore, a pixel must exhibit reflectance within this reflectance range for every band considered to be classified. Finally, hard Classifier as a supervised classification technique in IDRISI, specifically Multi-Layer Pereceptron (*MLP*) was used as a classifier to produce the land cover maps. To complete this classification, an Artificial Neural Network (ANN) model, specifically the multilayer-perceptron (MLP) with feed forward network with the back-propagation learning algorithm, was employed. And as a subpixel image classifier to estimate urban land use land cover types for each year.

For the Abuja city, five maps of land-use categories illustrating the method for the years 1986, 1990, 2001, 2006 and 2011 were generated.The classification was achieved with identified three input layers of trained network option of independent variable images. The input specifications were the six vectors (classes) or categories, wherein each pixel represents one of six categories identified in the study area: *Built-up area, road network, Water body, Forest, Orchard/park, and Bare surface*. 500 average training pixels per class were selected for the image classification, automatic training parameters was used here with a dynamics learning rate. A pixel centered in a matrix format which has multiple opportunities to be added to the hidden layer and ultimately assigned to one of the six land cover class. The network topology used are (3x2x6) matrix, that is 3- input layer node, 2- hidden layers and 6- output layers; hence the output options is a hard classification figures 2 to 6.The classifier was set to perform confusion matrix analysis. The final land cover maps produced using these procedures enabled spatio-temporal change analysis and pattern through change maps and spatial metrics.

For this study, the land cover classification accuracy assessment was based on 500 stratified random sampling points, comparison between each classified images, and comparison with a Google Earth Imageries and existing land cover maps. After accuracy assessment, all images were vectorized into polygons. These polygon coverage were then pre-processed.On the running statistics of MLP, that total training pixels are 2424, while the actual total testing pixels are 2426; notes that 2 -pixel were hidden layers. Iteration accuracy is 74.73%; the training RMS is 0.249, testing RMS is 0.251. The average accuracy of classification and the Kappa coefficients were determined to be 86.3% and 0.846 for 1986; 87% and 0.851 for 1990; 81.5% and 0.820 for 2001; 84.9% and 0.816 for 2006 and 90.1% and 0.882 for 2011 respectively. It was observed that the standard overall accuracy for land use/cover maps is set between 85% (Ronald *et al.,* 2012 and 90% (Lins and Kleckner 1996). The proportion correct and the standard Kappa index of agreement (Congalton, 1991; Congalton and Green 2009; Ronald *et al.,* 2012) have been the most commonly reported parameters for accuracy assessment for a classified land use/cover map.

Land cover Change analysis

In order to monitor the urban land use change and development in the City, a change detection analysis was performed to determine the nature, extent and rate of change over time and space. Post classification comparison sometimes referred to as delta classification, was adopted. It involves independently produced spectral classification results from each end of the time interval of interest, followed by a pixel-by-pixel or segment-to-segment comparison to detect changes in cover type (Falahatkar, *et al.,* 2011). The principal advantage of post classification comparison lies in the fact that the two dates of imagery are separately classified; thereby minimizing the problem of radiometric calibration between dates (Coppin *et al.,* 2004).

A post-classification comparison technique using the 'CROSSTAB' module in IDRIS, (Di Eugenio and Glass 2004) was employed to detect the changes in the urban land cover from 1986 to 2011. The process of cross-tabulating of the two images produced a statistical table's and was further used to calculate the extent of change of one landcover class to another from 1986 to 1990; 1996 to 2001; 2006 to 2011. After cross-tabulation matrix for each time interval were created, and then follow by the change analysis in terms of size and rate/intensity, in order to extract three types of information.

At the first level, the total change in each time interval was analysed to examine how the size and annual rate of change vary across time intervals; hence, this is called the "interval level". After the annual change intensity for each time interval were calculated, the observed change rates were compared to a uniform rate that could exist if the annual changes were stationary across all intervals. At the second level, which is call "category level", here each category to measure how the size and intensity of both gross losses and gross gains varies across space are examine. After the intensity of gross losses and gross gains for each category were calculated, moreover; comparison was made between the observed intensities with a uniform intensity of annual change that would exist if the change within each interval were distributed uniformly over the entire study area.

Finally, landcover dynamic that occurred in the study area was quantified represented through series of statistical techniques and charts. The land cover dynamic of the area was estimated in hectares, for the period of 25 years. The comparison of the land cover statistics assisted in identifying the rate, pattern and percentage of changes between 1986 and 2011. This is relevant in identifying the characteristics and the spatial distribution of the urban land cover; also in estimating the dynamics in Land cover type over a period of 25 years.

In achieving the pattern of the land cover change, a table was developed showing the area in hectares and percentage change for each year (1986, 1990, 2001, 2006 and 2011) measured against the land cover type. The percentage changes was determined by dividing observed change by total sum of changes and multiply by 100 see equation (1).

$$\text{(Pattern/trend) } \Delta\% = \frac{\Delta_0}{\Delta_s} x\ \% \qquad (1)$$

Where $\Delta\%$ is the Percentage change, Δ_0 is the Observed change and Δ_s is the Sum of change; in number of pixels.

Also in determining the annual rate of change, the observed change in land cover was divided by the number of years of study 1986-2011 (25years):

$$\frac{\text{Change between 1986 and 2011}}{25} \qquad (2)$$

Results and Discussion

Land Cover change

Using the approaches adopted in the methodology, land cover maps were generated for all the five years Figures (2, 3, 4, 5 and 6) and area estimates in hectares and change statistics were computed. Individual class area and change statistics for the five periods were summarized in Tables 2. In the

study periods covered, the major land cover classes identified includes Built-up, water body, Road, forest Light forest and bare surface. Among all the land cover types identified, and in the five periods, forest and built-up surfaces constituted the predominant type of land cover with an approximate area of 93% in their spatial extent in the region. Light forest, barren and wetland, roads and water body accounted for 7 % of the total area of the region representing the small proportion of the land cover classification Table 2.

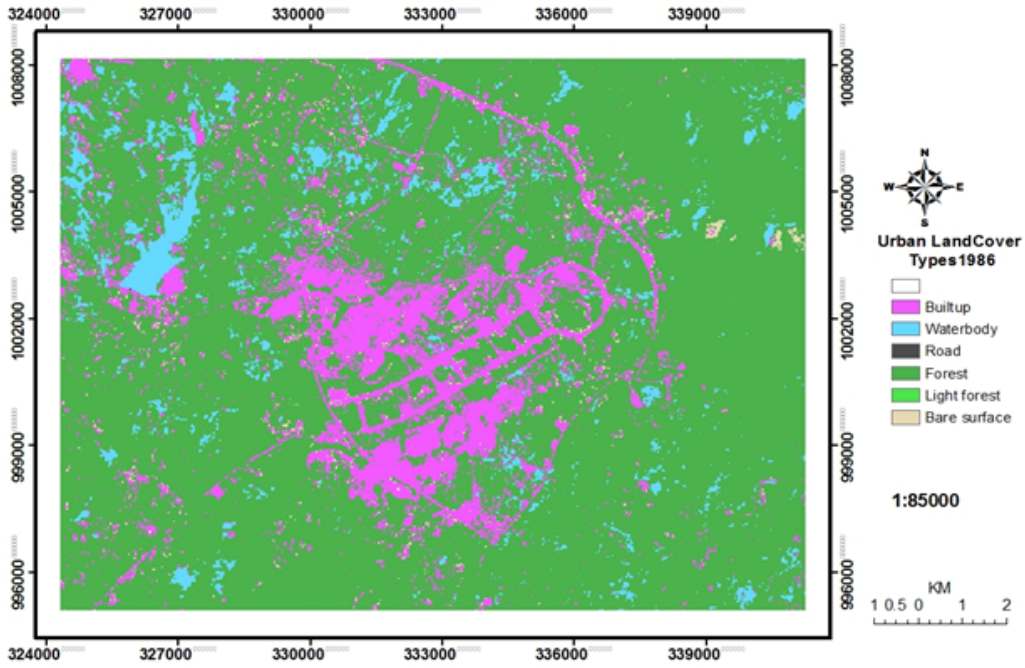

Figure 2: Land cover of Abuja City of 08, January 1986

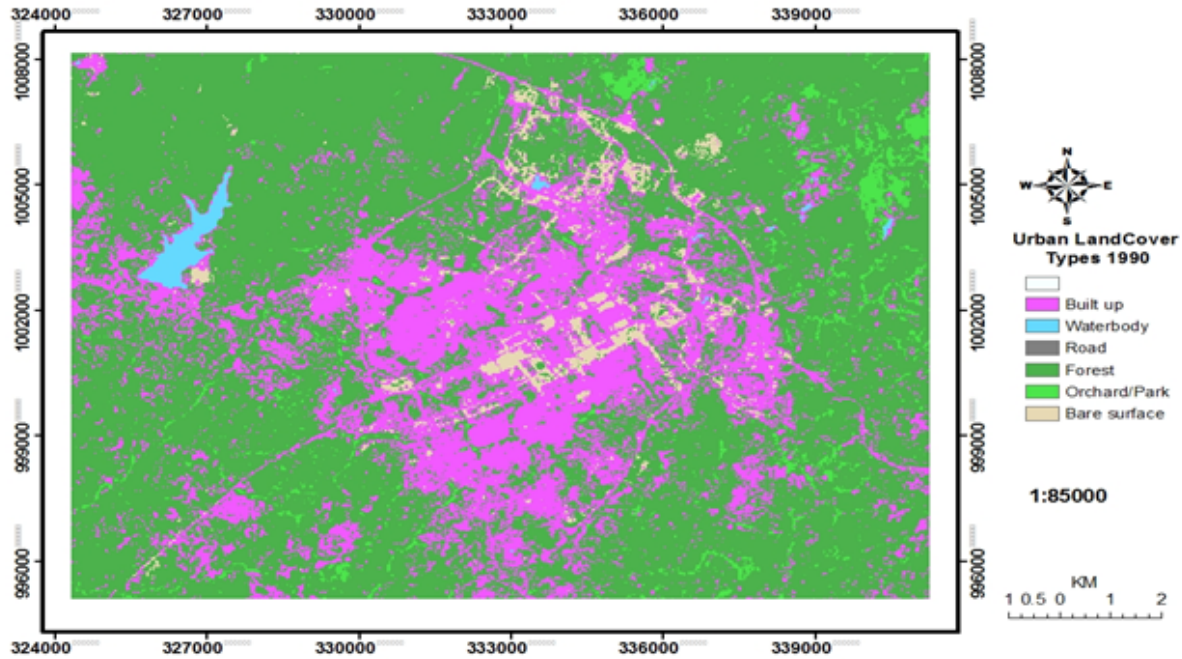

Figure 3: Land cover of Abuja City in 12, Febuary,1990

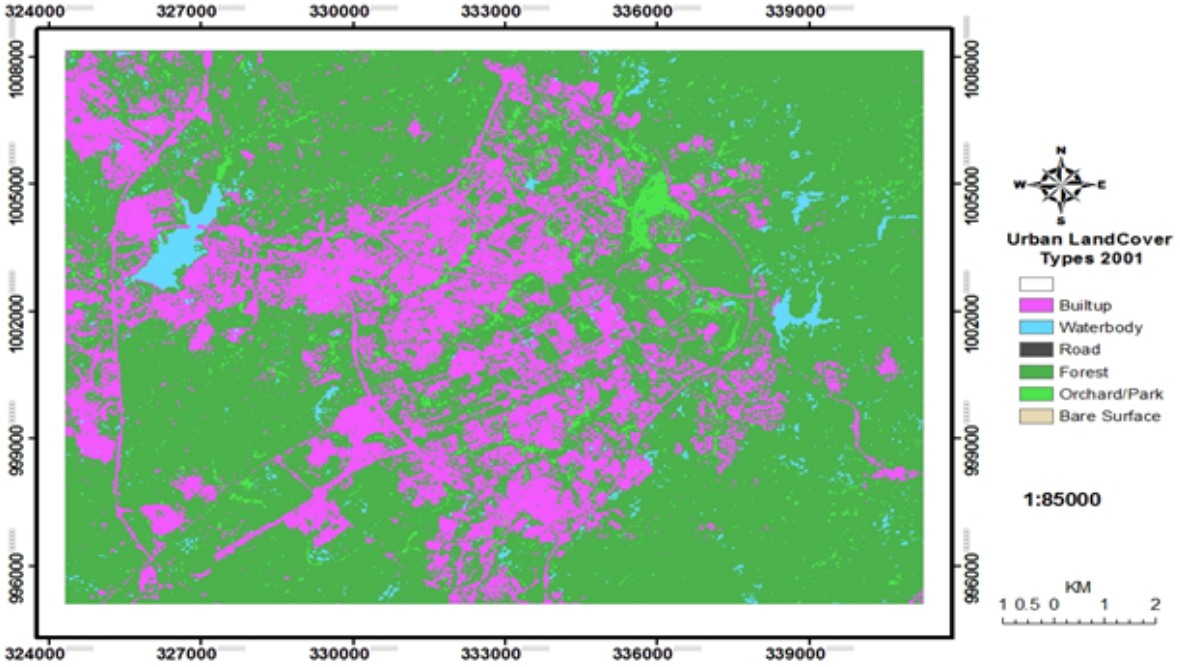

Figure 4: Land cover of Abuja City in 27,December,2001

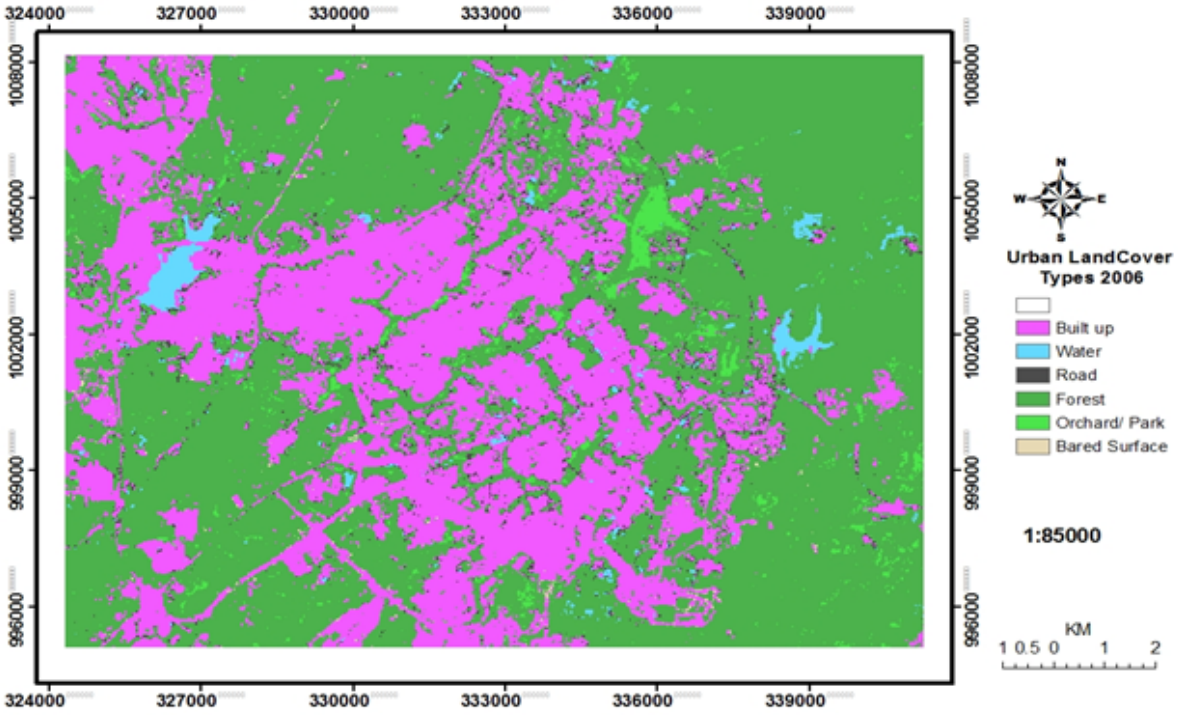

Figure 5 : Land cover of Abuja City of 09,December,2006

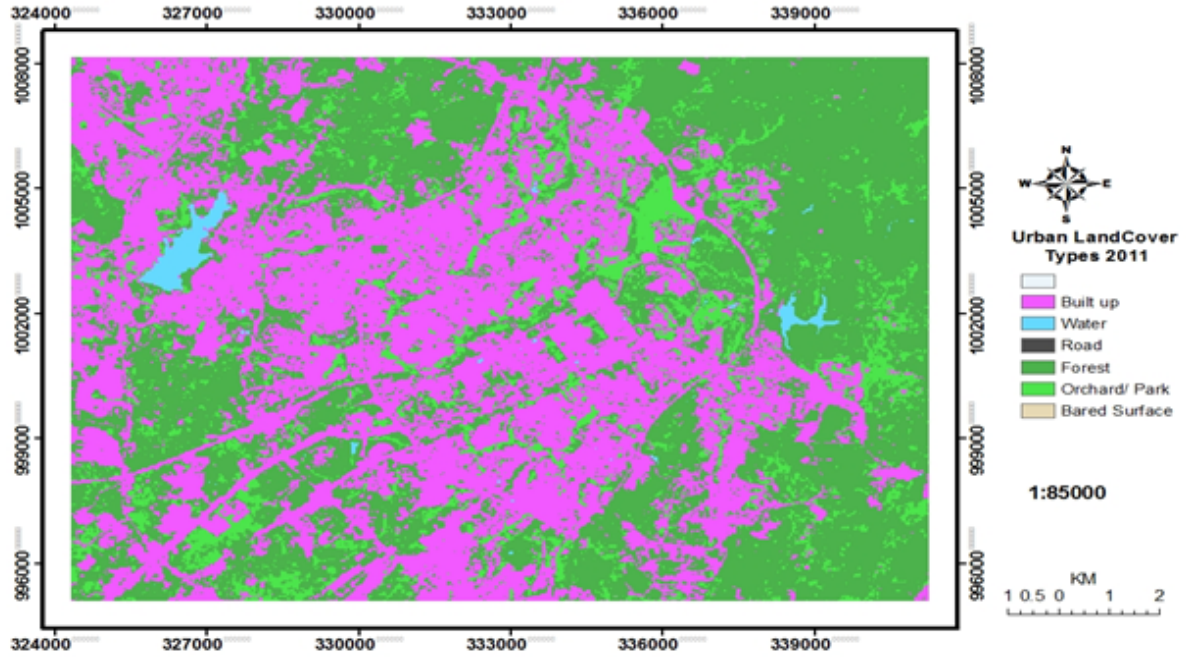

Figure 6: Land cover of Abuja City o 23,December,2011

Table 2: Area statistics and Percentage of the cover units in 1986-2011

	1986		1990		2001		2006		2011	
Land Cover type	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**
Builtup	3064.14	14	5707.35	25.74	5321.16	24.0	7354.53	33.17	9396.45	42.38
Waterbody	1082.07	5	162.90	0.73	483.30	2.2	329.04	1.48	195.75	0.88
Road	0.09	0	4.14	0.02	0.00	0.0	462.24	2.08	0	0.00
Forest	17803.89	80	15022.35	67.76	15756.12	71.1	13547.16	61.10	10186.29	45.95
Light forest	0.00	0	637.29	2.87	610.02	2.8	408.87	1.84	2392.11	10.79
Bare surface	220.41	1	636.57	2.87	0.00	0.0	68.76	0.31	0	0.00
Total	**22170.60**	**100**	**22170.60**	**100**	**22170.60**	**100.0**	**22170.6**	**100.00**	**22170.6**	**100.00**

Landcover Distribution

From the classified raster data, urban class was extracted and converted to vector representation for computation of precise area in hectares. About 207% increase in built up area from 1986 to 2011 manifested from the temporal analysis,that leads to a sharp decline of 82% area of the water bodies in the Abuja city. This mostly could be attributed to intense urbanization process. The rapid development of urban sprawl has many potentially, detrimental effect on the city; these include the loss of valuable agricultural and eco-sensitive (e.g. forest) land, enhance energy consumption and green house gas emission from increasing private vehicle use which will results to urban discomfort. Evidence of urban dynamic was attested in the loss of green area of about 2782 ha (16%) from 1986 to 1990, by 734 ha (5%) from 1990 to 2001, by 2209 ha (14%) from 2001 to 2006 and by 3361 ha (24%) from 2006 to 2011. From 1986 to 2011 in area extent of 7618ha (43%) decrease in vegetation

wereobservedand increasedin light forest area by 275% from 1990 to 2011. Further more, urbanization hasled to sharp decline in number of water bodies. Temporal analyses indicate the decline of 55% during 1986 to 2001, 69.6% during 1986 to 2006 and 81.9% of water bodies 1986 - 2011 within the city. This was correlated with increase in the built up area. Figure 7 showed clearly the distribution and spatio-temporal pattern of the urban land use in the study area; there is inverse relationship between green area and the years. Also there exist a direct relation between the built-up area and the period.

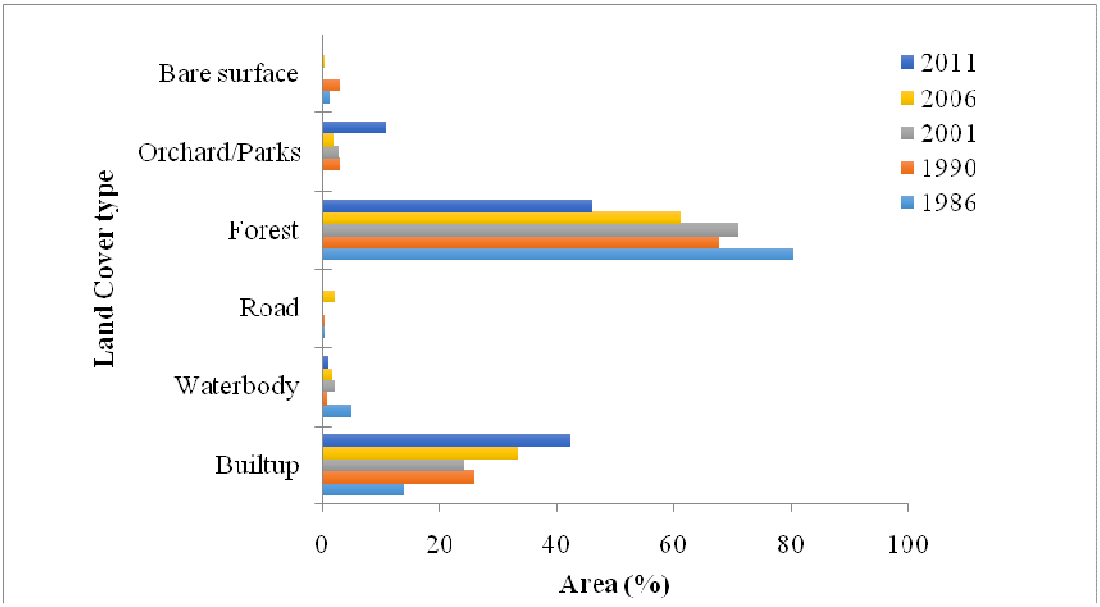

Figure 7: Distributions of land cover dynamics for 1986-2011

Land cover Pattern and Distribution

Light forest (Orchard and Parks) were considered to be the urban vegetal cover table 2, it is drastically increasing from 0% in 1986 to 59% in 2011. These changes could be as a result of Abuja City's urban renewal and the establishment of Department of Parks and Garden in 2004. They were responsible for the maintenance and creation of parks and garden within the city all seasons. Urban green area has direct and indirect effects on local and regional air quality by altering the urban atmosphere. Furthermore, thereare four main ways in which urban trees affect air quality namely: Temperature reduction and other microclimate effects, removal of air pollutants, emission of volatile organic compounds and tree maintenance emission, energy effects on buildings (Manawadu and Nirosha 2008). Though, Abuja is the administrative city of Nigeria, it has been observed that some green areas such as playground, urban forests and trees along the roads do obscure the detection of road network from the satellite imageries e.g. land sat ETM^{+} Figures 4,5,6. This problem can easily be resolved by spatial resolution of the imagery.On the other hand the Western and the Southern parts of the city indicated a relatively fair coverage of vegetation. These designatesthe present of many playground (IBB golf course, Millennium parks and others).

The distribution pattern of the urbanized area has been changed from a dot pattern in 1986 to a chain/areal pattern in 2011, with a result of gradually formed and increased infrastructure of the current urban system in the Abuja City during the study period. A comparison between land use/cover maps derived from images of 1986 and 2011 revealed dramatic expansion of the urbanized area. Temporal analysis showed a linear growth of 206% in the built up area from 1986 to 2011 and decline of 81.6% in the number of water bodies with a 29% decrease in vegetation. The tremendous urban expansion indicates a high influx of population from the local or distant places into the city. Perhaps cities are the most dramatic expressions of the transformation of natural environments by the hand of humans. Deteriorating conditions of urban crowding, housing shortages and lack of proper infrastructure, as well as increasing urban expansion on land highlights much attention for sand fills on the water body. Hence sustainable and effective management and planning of urban areas is require. Similarly during 2001 to 2011, the increase in built up pixels was 76.59% while vegetation

and water bodies decline by 42.79 and 59.5% respectively. Analysis of water bodies indicate sharp decline of 81% in the Municipal area attributed to intense urbanization process, manifested from 206% increase in builtup area from 1986 to 2011. Significant variations in the portion of the water bodies could be attributed to land filled for urban developments. This urban expansion has negative effects on the ecology of the Abuja-city, in a number of ways: eliminating and disintegrating native habitats, modifying local climate conditions and spawning anthropogenic pollutants. Wu and Loucks, (1995) recognized that the spatial pattern of a landscape affects ecological processes.

Conclusion and Recommendations

In the past twenty five years the city of Abuja is experirncing an immensed expansion. Like any other growing city, it was observed that the pressure were mostly on the natural resources as manifested from the temporal analysis and was attributed to intense urbanization process. There is inverse relationship between green area and the years; also there exist a direct relation between the built-up area and the period. In order to monitor urban land use change and development of a City, there is a need for change detection analysis so as to determine the nature, extent and rate of land cover change over time and space. The results quantified the land cover change patterns in the municipal area and demonstrated the prospective of remote sensing and GIS; using a multi-temporal Landsat data to provide an accurate, economical means to map and analyze changes in the land cover. A spatio-temporal framework can be used as inputs to land use type for management and policy decisions with regard to varied themes that has link with space such as urbanization, water management, deforestation, land degradation and so on.

Owing to the constraints posed by availability and quality of data; to study the dynamics of land cover; satellite based sensors with very high spatial resolution were recommended to enable highly detailed land use/cover, ecological characterization of urban and suburban regions of potential used to urban research. Urban areas are one of the most difficult areas to categorize with remote sensed imagery alone. They are complex, dynamic and growing rapidly (Pezzoli 1998). There is need for improvement in satellite images spatial resolution increases, whenever the objective calls for detail urban study and dividing each of the V-I-S groups into sub-categories. However, to account for the micro-level study of the land use land cover with a detailed urban growth model, the classification process required further refinement with other techniques such as support vector machine, fuzzy-Art-map, spectral mixture analysis for estimations and assessments of uncertainty and standard errors along with high spatial resolution data would be needed. The gapsthat were needed to be filled in this study area were the effect of urban growth on the environment/ dynamics of impervious surface and flooding. Finally, it is probably that more detailed information in respect to the relationships between LST and urban structures using high spatial resolution satellites imageries, readily available on temporal extents could give better answer to some unexplained questions on urban climatology. Therefore, this subject is open for further research especially on the effect of land cover on LST or urban flooding of the city.

References

Abuja Hand book-yellow pages (1998).Ministry of Federal Capita Territory Abuja. Nigeria Int'l. Biography centre Marina Lagos, Nigeria.

Arnfield J. 2003. Two decades of urban climate research: a review of turbulence, exchanges of energy and water, and the urban heat island. *International Journal of Climatology* **23**:1-26.

Balogun, C. (1972). The variability of rain fall in Nigeria. Journal of Sci. Vol.6, No.1 87-91

Bain, D.J., and Brush G.S. (2004). Placing the pieces: Reconstructing the original property mosaic in a warrant and patent watershed, *Landscape Ecology*, **19(8)**:843–856.

Congalton, R.G. (1991). A review of assessing the accuracy of classifications of remotely sensed data. *Remote Sens. Environ.* **37**, 35–46.

Congalton, R.G.and Green, K. (2009). Assessing the accuracy of remotely sensed data: Principles and practices, 2nd ed.; CRC Press: Boca Raton, FL, USA.

Coppin, P., Jonckheere, I., Nackaerts, K., Muys, B. and Lambin, E. (2004). Digital change detection methods in ecosystem monitoring: a review, *International Journal of Remote Sensing***25**:1565-96.

Falahatkar, S., Hosseini, S. M. and Soffianian A. R. (2011). The relationship between land cover changes and spatial-temporal dynamics of land surface temperature,*Indian Journal of Science and Technology***4 (2**) : 0974- 6846.

Geospatial World Magazine (2012). Geospatial Industry and Sustainable World Economy p21. **02**: 09: 2277-3134.

Gillies R. R., Carlson T.N., Cui J., Kustas W.P., and Humes K. S. (2003). A verification of the 'triangle' method for obtaining surface soil water content and energy fluxes from remote measurements of the Normalized Difference vegetation Index (NDVI) and surface radiant temperature. *Journal of remote Sensing***18**: 3145-3166.

Glunch, R.M. and Ridd, M.K. (2007). The V-I-S model: Quantifying the Urban Environment; (Weng Q. and Quattrochi D.A. 2007). Urban Remote Sensing (Eds.) taylor and Francis Group, CRC press, NY.

Hall, F. G., K. F. Huemmrich, S. J. Goetz, P. J. Sellers, and J. E. Nickeson, (1992). Satellite remotesensing of surface energy balance: Success failures, and unresolved issues in FIFE, *J. Geophys. Res.*, **97**, 19,061– 19,089.

Kalnay, E. and Cai, M., (2003). Impact of urbanization and land use on climate change. Nature, **423**, 528–531.

Lay, U.S. (2006). Analysis of Selected Weather elements in Federal Capital City, Abuja Nigeria. B,Sc, project submitted to the department of Geography and Planning Unijos. Nigeria.

Lins, K.S. and Kleckner R.L. (1996). Land cover mapping: An overview and history of theconcepts. In *Gap Analysis: A Landscape Approach to Biodiversity Planning*; Scott, J.M., Tear, T.H., Davis, F. (Eds). ASPRS: Bethesda, MD, USA, pp. 57–65.

Lilly, R. A. and Monsingh, D. D. (2009). Analysis of Land Surface Temperature and Land Use/Land Cover Types Using Remote Sensing Imagery. *The seventh International Conference on Urban Climate,* Yokohama, Japan.

Lin W., Huang J., Shi R., Zong W. and Shi B. (2002). Quantitative Analysis of Urban Thermal Environmental Effect with TM+ Data.*International Conference on Land Surface Radiation and Energy Budget.*

Manawadu L. and L. Nirosha. (2008). Identifying Surface Temperature Pattern of the City of Colombo. *Engineer,* **05**, 133-140, the Institution of Engineers, Sri Lanka.

Onokerhoraye A.G. (1994). Population growth and provision of Social Service in Nigeria. Kraft Books Ltd, Ibadan, Nigeria.

Pezzoli, K. (1998). Human Settlements and Planning for Ecological Sustainability: the case study of Mexico City, Cambrige, MA MIT Press.

Ronald C. E., Ria S. E. and Yuji M. (2012). Prioritizing Areas for Rehabilitation by Monitoring Change in Barangay-Based Vegetation Cover. *International Journal of Geo-Information* **1**, 46-68.

Sellers, P. J., Mintz Y., Sud Y. C. and Dalcher A. (1997). A Simple Biosphere Model (Sib) for Use within General Circulation Models', *J. Atmos. Sci.* **43**, 505–531.

UNPF (1999). The state of world population. United Nations Population Fund, United Nations Publications, NY.

Voogt, J. A., and Oke, T. R. (2003). Thermal remote sensing of urban climate. *Remote Sensing of Environment,***86**, 370– 384.

Weng, Q. (2003). Fractal analysis of satellite-detected urban heat island effect. *Photogrammetric Engineering and Remote Sensing*, **69**, 555– 566.

Wu, J. and Loucks, O.L. (1995). From balance of nature to hierarchical patch dynamics: Aparadigm shift in ecology. *Quarterly Review of Biology*.70, 439-466.

Xian G. (2007). Assessing Urban Growth with subpixel impervious Surface coverage, Weng Q. and Quattrochi (Eds): Urban Remote Sensing, CRC- Taylor and Francis, NY.