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EXAMINING LAND USE/LAND COVER CHANGE INVENTORY OF UYO CAPITAL CITY IN AKWA IBOM STATE, NIGERIA.

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ABSTRACT

This study represents an attempt to understand the trend in the expansion of Uyo urban centre, Akwa Ibom State. The objective of the study included; taking inventory of the land use/cover of the study area; assessment of the trend, rate, and nature of urban expansion in the study area over the periods 1986/2003 and 2003/2008. In order to achieve these objectives, remotely sensed data of LandSat TM 1986, LandSat TM 2003, and NigeriaSat 2008 of the study area were used. The minimum distance supervised classification algorithm and post classification change detection techniques in GIS were carried out on the remotely sensed data. The study revealed that between 1986 and 2003 built-up area increased from 149.09km^2 to 172.21km^2 at the rate of 1.36km^2 per annum; and between 2003 and 2008 built-up area increased to 207.10km^2 at the rate of 6.98km^2 per annum. Based on these findings, the study recommended that urban planning should not be limited to analogue master plans, but should be a dynamic and modifiable system which would make modifications speedy and more functional. More so, Local Planning Authorities should restrict

development in strategic areas within the heart of the town in order to maintain some green belts within the capital city. This, apart from moderating the urban temperature, also enhances the urban character of the capital city.

Keywords: *Land Use, Land Cover, Urbanisation, Inventory, Uyo.*

INTRODUCTION

Urbanization is a topical issue and its study has aroused interest from a wide variety of experts, ranging from ecologists, urban planners, civil engineers, sociologists, administrators, policy makers, to the common man. This is because of the myriad of activities and processes that take place in the urban ecosystems every day. Urban expansion takes place either in radial direction around a core or linearly along the highways. This dispersed development along highways, or surrounding the city and in rural countryside is often referred to as a sprawl (Theobald, 2001).

Urban expansion is always evident in an increase in the built-up area. In 1976, one third of the world population lived in cities and 30 years later (2006), this rose to one-half of the humankind, and by the target year for the Millennium Development Goals (MDGs), cities in the world are estimated to grow to two-thirds or 6 billion people by 2050 (UN-Habitat 2006). For most developing countries, cities and towns appear to be growing beyond the control of planners, beyond management capacities and beyond available resources (Agbola and Olurin 2003).

Uyo, being the urban centre under study was initially a small village with a dispersed settlement pattern typical of the area and later became a Local Government Headquarters, in Cross River state. With the creation of Akwa Ibom state on 23rd September 1987, Uyo then assumed the status of a State Capital and has remained the State Capital till date. Ever since, the basic push and pull factors called transformation forces, have increasingly been manifesting in Uyo over the years. Agbola (2006) classified these transformation forces into three major processes. They are; natural increase in the population, rural urban migration, and city annexation into the surrounding rural areas. The third class is the real expansion process and generally speaking, it is accented by the following phenomena:

First, some people prefer to move away from the city centre, where they cannot readily acquire vast parcels of land, to the outskirts where they acquire parcels

of land vast enough for highly affluent and massive residential developments. Second, currently, every average man naturally has a quest for property ownership and since it is relatively cheaper to acquire and develop a land in a surrounding rural area than in the centre of the city, coupled with the fact that the regulations and permits requirements for building in such areas are less stringent, many residential developments are likely to spring up beyond the peripheries of the city. Third, due to the general high demand for land, some people venture into buying land in good geographic locations outside the City Centre, clearing and fencing it round and then reselling it for profit. This also is a catalyst for the development of commercial and industrial buildings in such areas.

Geographical Information System (GIS) and Remote Sensing are powerful tools to derive accurate and timely information on the spatial distribution of land use/land cover changes over large areas. These powerful tools have been combined to detect and control urban encroachment in a way, which is easier and faster than the traditional methods of surveying the urban environment.

Although urbanization has traditionally been associated with a higher quality of life for urban dwellers as opposed to rural dwellers, a number of ills plague cities in the developing world. Such ills include depletion of the green belts within existing urban settlements, as a result of internal growth; and encroachment upon surrounding areas suitable for agricultural land use, as a result of outward growth. These have direct impacts on food supply, and are a serious threat, if it is not visualized for proper policy making.

Another significant point is that urban expansion, in most cases is unplanned and often results in inadequate infrastructural facilities to service the expanding urban settlements. In most cases, existing infrastructural facilities are overstretched to service the expanding urban settlements. The dynamism that subsists in urban land use makes it necessary for urban planners to employ a dynamic and pragmatic approach in urban planning.

Uyo being the State Capital and the core of Akwa Ibom State is not different from other cities of the developing world in terms of rapid urban growth. It is therefore likely that this rapid growth results in overstretching of infrastructure to service the expanding urban centre, and difficulty in proper urban planning, as earlier mentioned. This therefore necessitates this research which is intended to probe into the trend and pattern of the expansion in Uyo urban centre.

There are varying definitions of urbanization by different authors. However within the context of this work, urbanization is the physical growth of urban areas as a result of rural migration and even suburban concentration into cities, particularly the very large ones. Urbanization is closely linked to modernization, industrialization, and the sociological process of rationalization. The term urbanization can represent the level of urban relative to overall population; or the rate at which the urban proportion is increasing.

Urbanization is an outcome of natural and socio- economic factors and their utilization by man in time and space (Khalid, Meraj, Ramze and Gomaa, 2012). Urbanization is not merely a modern phenomenon, but a rapid and historic transformation of human social roots on a global scale, whereby predominantly village culture is being rapidly replaced by predominantly urban culture. Urbanization is not about simply increasing the number of urban residents or expanding the areas of cities. More importantly, it is about a complete change from rural to urban style in terms of industry structure, employment, living environment and social security (Li Keqiang, 2003).

Urbanization could be formal or informal. The formal city is the one composed of areas equipped with infrastructure in which public investments are concentrated, while the informal city is characterized as the region where growth is disordered and unplanned, and where the lack of infrastructure and the socio-environmental differences are alarming.

Burchell (2003) defines sprawl as low density occupation; leap frog development characterized by unlimited expanses. According to Burchell (2003), urban sprawl is described by the dispersion of urban occupation into rural areas, which is characterized primarily by the low population density of these areas, which spreads beyond the consolidated city center. This agrees with the description by Theobald (2001) that urban sprawl is a dispersed development outside of compact urban and village centres along highways and in rural countryside. Sprawl refers to any form of development that has negative consequences such as the loss of agricultural land, open space, and ecologically sensitive ecosystems. Also, sometimes sprawl is equated with radial spread of town or city. In simpler words, as population increases in an area or city, the boundary of the city expands to accommodate the growth; this expansion is considered as sprawl (Theobald, 2001).

It can therefore be inferred from the definitions of urbanization and sprawl that urban sprawl is an integral part of urbanization but not synonymous with

urbanization. While sprawl is just an outward quantitative growth of a city, urbanization goes beyond outward quantitative growth to qualitative change of the rural areas so encroached upon. More so, urbanization takes place not only on the fringes of a city, but also in some pockets of undeveloped areas within the city core.

Urbanization and urban sprawl are closely related to land use/land cover change except that particular emphasis is placed on the urban land. In analyzing urbanization, every vegetative land cover can be conveniently merged into agricultural land use without any prejudice to the urban land use analysis.

OBJECTIVE OF THE STUDY

The objective of the study included; taking inventory of the land use/cover of the study area; assessment of the trend, rate, and nature of urban expansion in the study area over the periods 1986/2003 and 2003/2008.

THE STUDY AREA

Uyo Local Government Area is located in the central part of Akwa Ibom State. It lies within latitudes 4º50̍N and 5º7'N and longitudes 7º45'E and 8º05'E. It is bounded on the north by Ikono, Ibiono Ibom and Itu Local Government Areas, on the South by Ibesikpo Asutan, Nsit Ibom, Etinan and Mkpat Enin Local Governments, on the East by Uruan Local Government Area and on the West by Abak Local Government Area. It covers a total landmass of about 155.856 square kilometers (Okon, 2008). The limit of the capital city however exceeds some of the boundaries of Uyo Local Government Area, and covers approximately 314.65 square kilometers.

The area lies in the humid tropics which are characterized by two distinct seasons: dry and wet seasons. The dry season starts from November to March while the wet season lasts from April to October. The dry season is influenced by the North-Eastern Trade Winds known as the Tropical continental (CT) which originates from the Sahara desert. The wet season, on the other hand, is influenced by the movement of the rain-bearing Tropical Maritime Airmass (MT) which comes from the Atlantic Ocean. During the rainy season, a period of intense sunshine may be recorded in August.

The area is located within the equatorial rain forest belt which is often evergreen in nature, and is characterized by tall trees and tree shrubs with thick ground cover. This vegetation type is fast disappearing as it is constantly being cleared

for road construction, building of houses and other land requirements of urbanization. In fact, more than 70% of vegetation has disappeared while the remaining 30% is found in small areas especially at the periphery of the city (Okon, 2008).

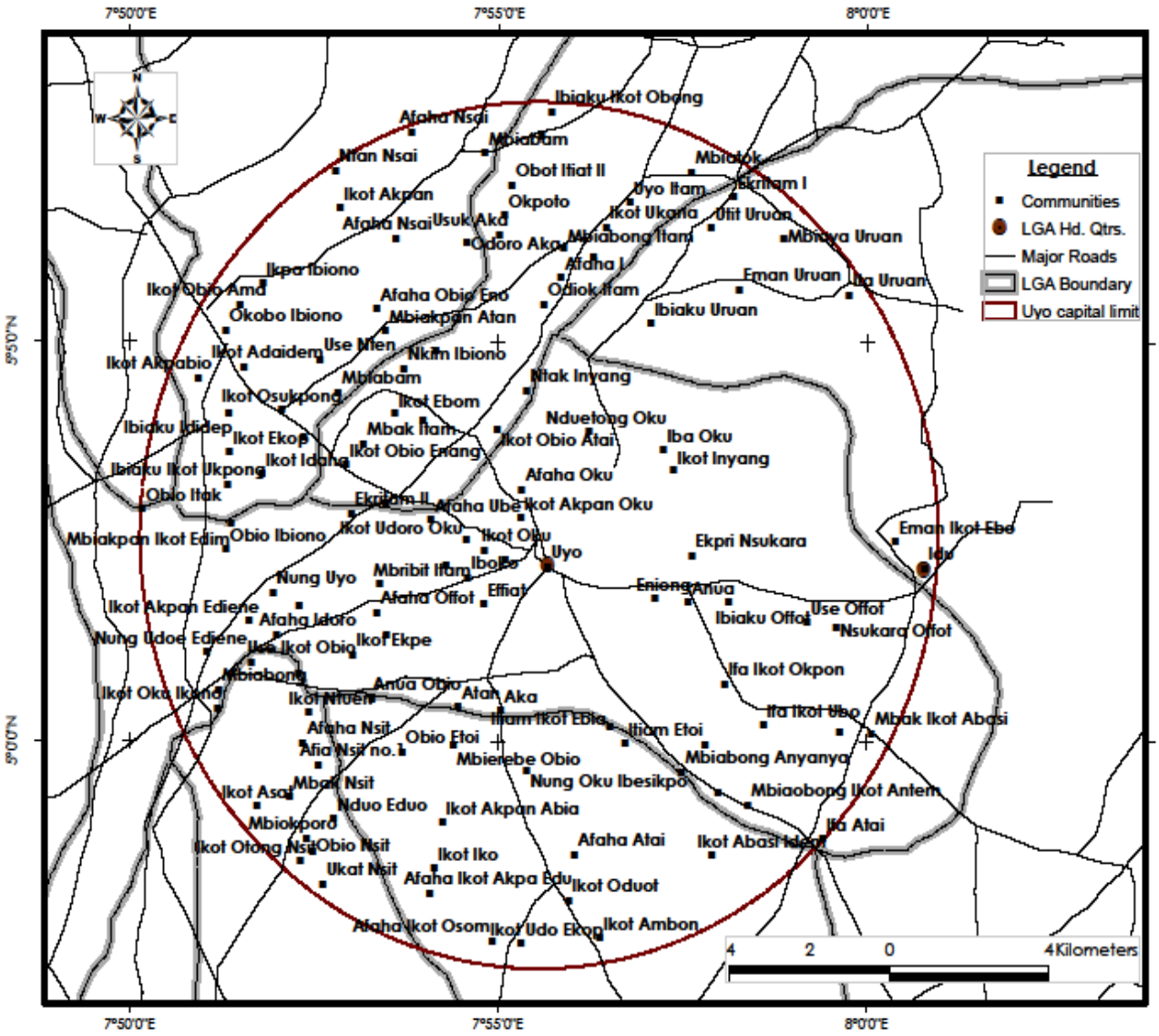

Figure 1: Communities within the Study Area

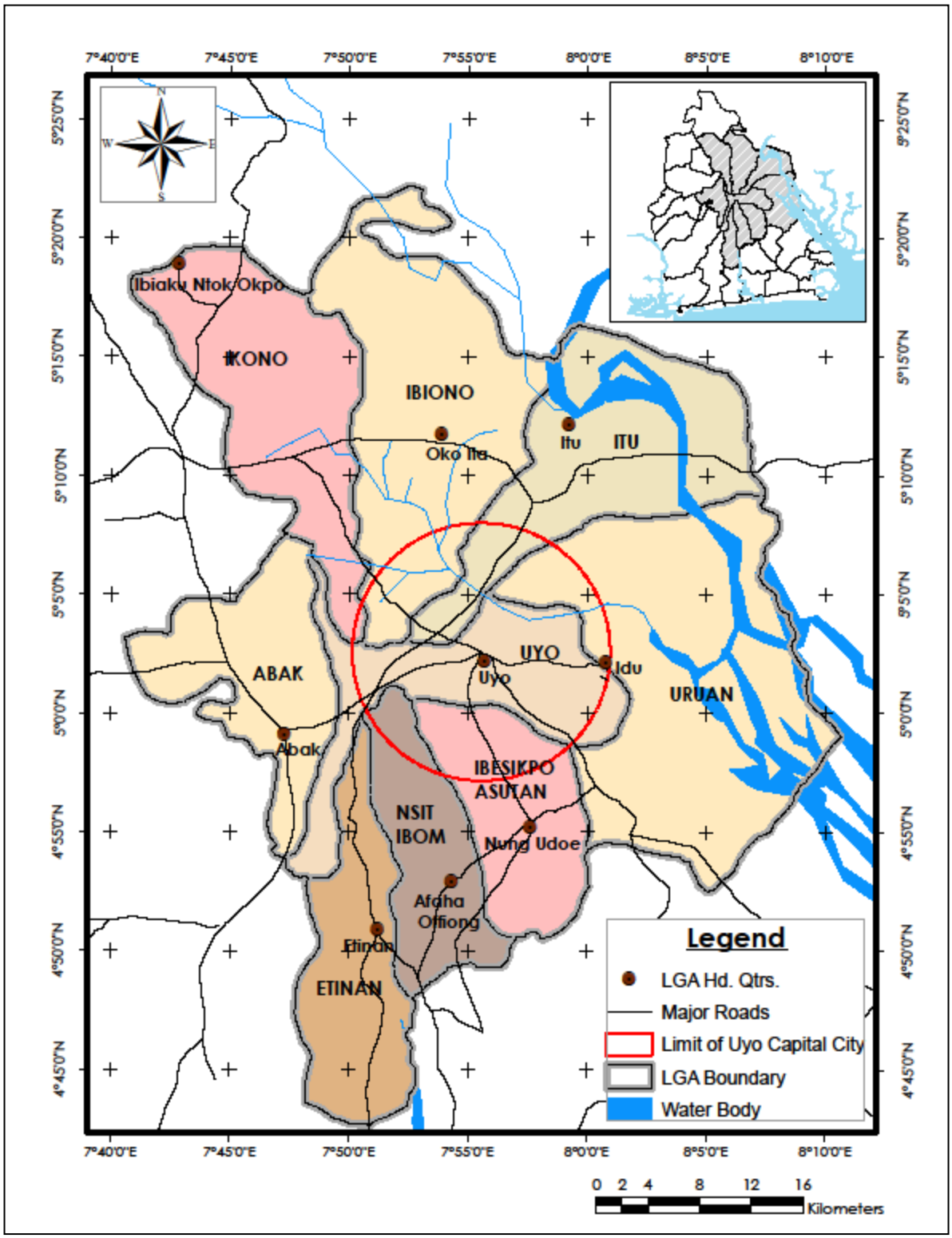

Figure 2: Study Area with Surrounding LGA's

DATA AND METHOD

Data Acquisition

a. Landsat TM and ETM+ images captured December, 1986 and January, 2003 were acquired from United States Geological Survey (USGS). Each had a spatial resolution of 28.5m^2. NigerSat image of 2008 was also acquired from the National Centre for Remote Sensing (NCRS), Jos. The Nigersat image has a spatial resolution of 32m^2. 1986 was selected as the base year and since the study is on trend analysis, more than two time periods were required, hence the choice of 2003 and 2008 images in addition. Data availability also influenced the choice of images.

b. Existing land use map of the area was also acquired from Cross River Basin Development Authority (CRBDA). This was used as ancillary data for training sets and accuracy assessment of the 1986 classified image.

c. A digital database of buildings in Uyo as of 2006 acquired from Akwa Ibom Water Company was used as an ancillary data for training sets for built-up area of the 2008 imagery.

Methods of Analysis

Image Processing

All image interpretation processes were carried out using Erdas Imagine 9.2 software, while point-by-point change detection was completed using the Spatial Analyst extension within ArcGIS 9.2. Erdas Imagine was chosen due to its capabilities in image analyses, while ArcGIS was chosen due to its flexibility in spatial data analyses.

Image Enhancement

The imageries were acquired in bands and so there was need for layer stacking to integrate the imageries. In order to create subset images of the study area, area of interest (AOI) tools were applied to the images. Since the images were captured during the dry seasons of their respective years, distortions due to weather and season were not considered as the images were cloud-free. The spectral enhancement method that was used was change of band combination to have true colours, and the band combination was 5,4,3(RGB).

Image Interpretation

Supervised classification techniques were applied to derive meaningful classes from the images. First, training sites for each land use class were defined, after which signatures were extracted. The classification technique was based on minimum-distance-to-means classifier. Minimum distance to mean classifier is preferred because, despite its simplicity, it actually performs quite well. Besides, it is reasonably fast and can employ a maximum distance threshold which allows for any pixels that are unlike any of the given class to be left unclassified. The outcome of the above analysis is the Land Use/Cover status of the study area.

For accuracy assessment of land use/cover maps generated from the 1986 and 2003 satellite imageries, the classified images were compared with the land use and vegetation map published by the CRBDA in 1987. For accuracy assessment of the land use/cover map generated from the 2008 satellite imagery, the classified image was compared with ground truth data and a digital database of buildings in Uyo.

Change Detection

Change detection is the concept of identifying contrasts or discrepancies in the state of an object or phenomenon by observing it at different times (Singh, 1989). This is only possible if multi-temporal datasets are used. In this study, three study years – 1986, 2003 and 2008 – were considered.

To achieve this objective, two forms of spatial analysis were undertaken. They are areal calculation of the land use/cover for each year and post-classification change detection. The former involves comparison of the LUC statistics derived from the classified images, while the latter is an area-specific change detection procedure (point-by-point).

Areal Calculation of land Use/Cover

Areas of the different land use classes were derived from the attribute table that was generated alongside the land use maps. These areas in hectares and percentage change measured against each land use class were presented in a table. To determine the trend of change, observed change was divided by the sum of changes and multiplied by 100.

(Trend) percentage change = (observed change x 100)/sum of change.

To obtain annual rate of change, the area changed is divided by the number of study years.
(Rate) annual rate of Change = area change/number of study years.

Land Use/Cover Change Matrix (Point-by-Point Change Detection)

The classified images of the study area for 1986 and 2003 were reclassified using the reclassify function of the Spatial Analyst Tool. This was done in order to collapse the numerous classes of the classified images, on display in the table of content of the ArcGIS software, into the four classes that were predetermined in the classification scheme. To carry out the change detection, image minus was done using the mathematical function of the Spatial Analyst extension of ArcGIS, the 2003 reclassified image being input value 1 and 1986 reclassified image, input value 2. This same process was repeated using 2008 reclassified image as input value 1 and 2003 reclassified image as input value 2.
To generate the land use/cover change matrices from the change images, the following computation was carried out.
X^2 = 28.5m x 28.5m (resolution of image or pixel size).

$$\text{Area of land use/cover in km}^2 = \frac{X^2 \text{ x number of pixels (number of counts)}}{1{,}000{,}000}$$

Land Use/Cover Map Production

After all the images were classified, reclassified and change detection carried out, the reclassified images were composed in the ArcGIS 9.2 software to produce the final land use/cover maps and inventories. The cartographic quality of maps informed the choice of ArcGIS 9.2 software in the maps production.

PRESENTATION OF RESULTS AND DISCUSSION OF FINDINGS

Land Use/Cover Inventory

Satellite images were used to create land use maps for the study region in 1986, 2003, and 2008. Figures 3, 4, and 5 show the interpretations, respectively. In this segment, the image analysis and change detection results are discussed. Table 1 shows the summary statistics for land use/cover transition between 1986 and 2003, while Table 2 shows the summary statistics for 2003 and 2008.

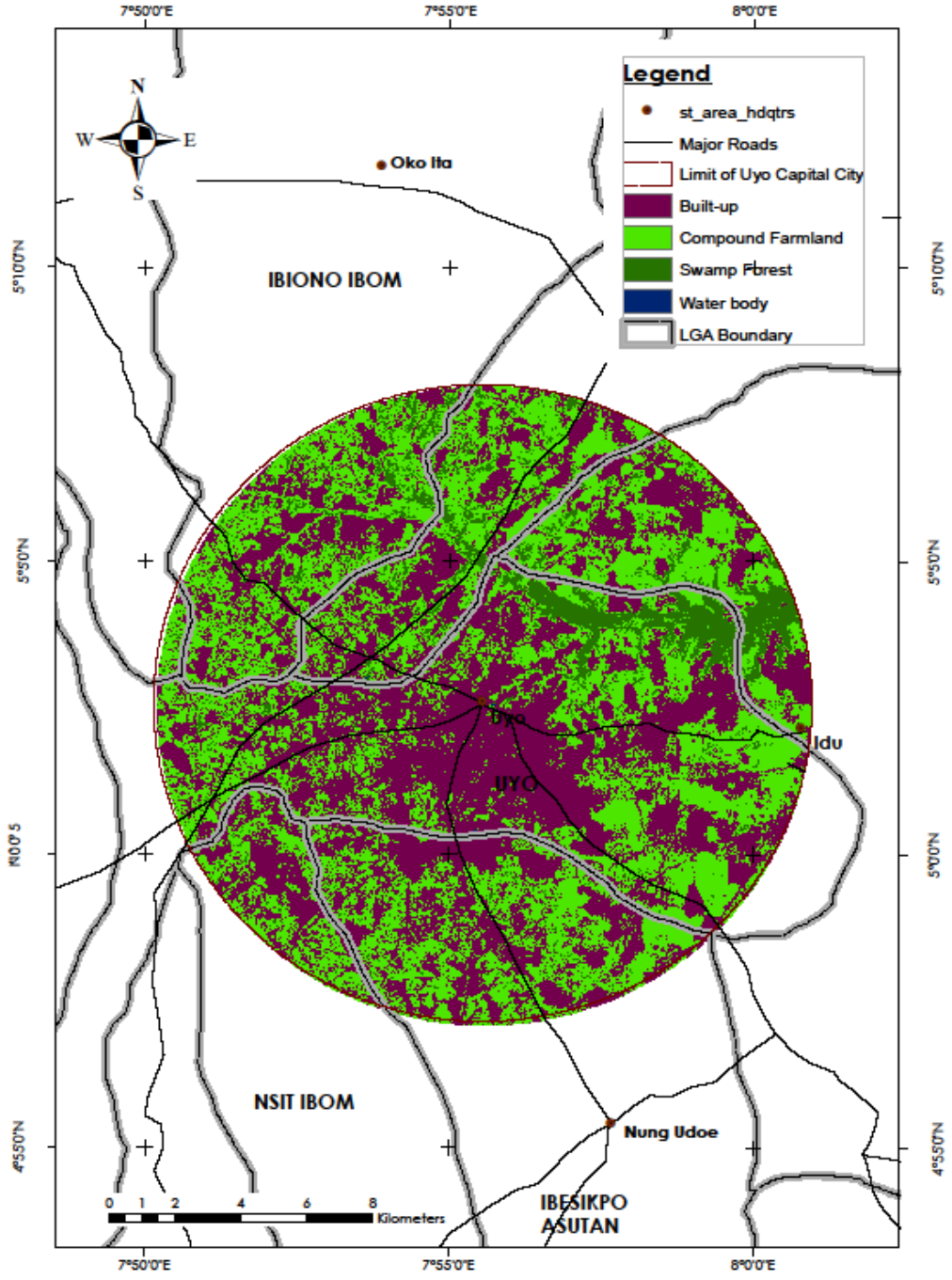

Figure 4.1: Land Use/Cover of Study Area for 1986

Figure 3: Land use/cover of Study Area for 1986

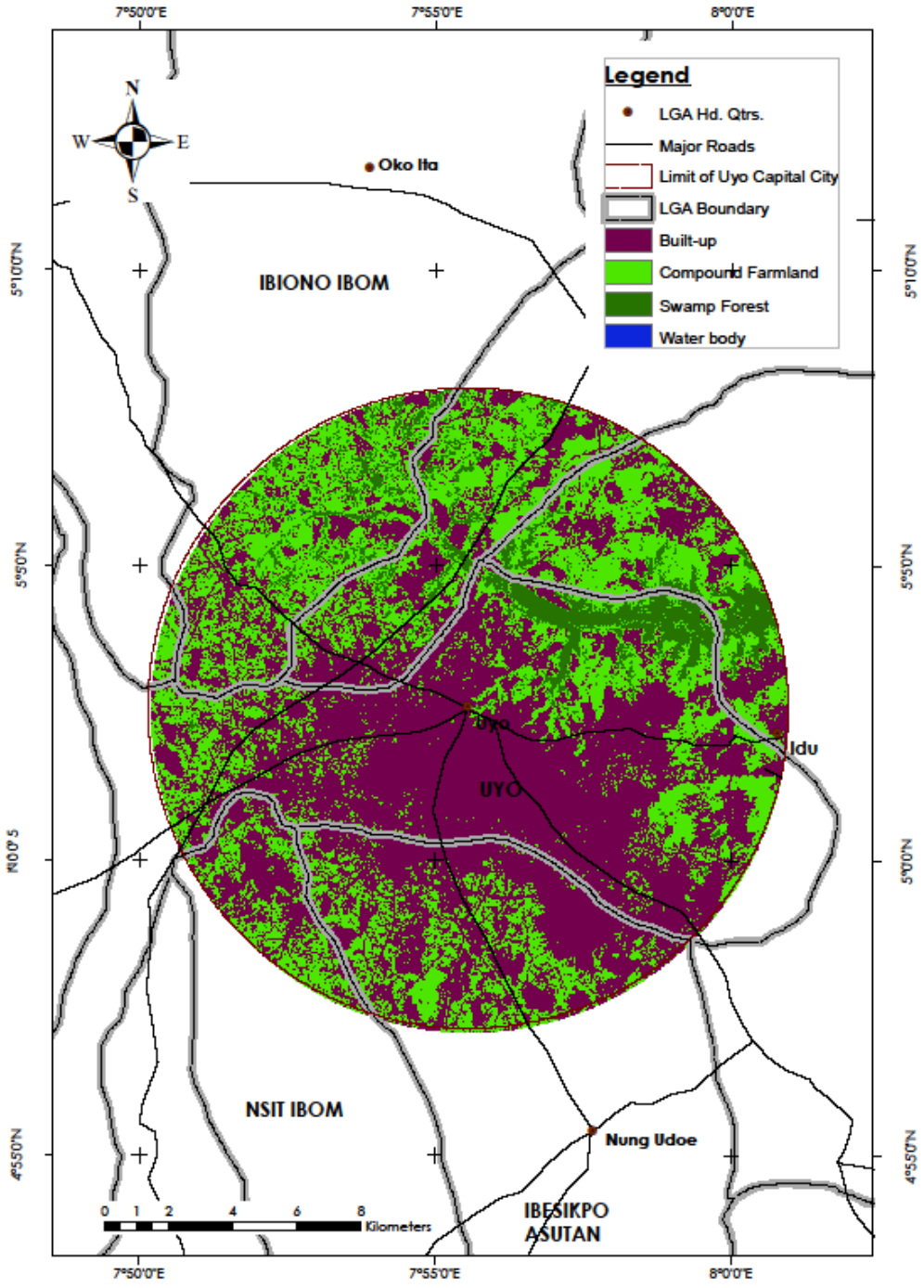

Figure 4.2: Land Use/Cover of Study Area for 2003

Figure 4: Land Use/Cover of Study Area for 2003

Table 1: Land Use/Cover Change Summary Statistics for 1986 and 2003

S/N	Classes	1986 (km^2)	2003 (km^2)	Change (km^2)	Change (%)	Change/yr (km^2)
1	Water Body	0.035	0.035	-0.000	0.000	0.000
2	Swamp Forest	22.89	23.07	0.18	0.394	0.011
3	Compound Farmland	142.64	119.35	-23.30	50.008	-1.37
4	Built-up	149.09	172.21	23.13	49.614	1.36
	Total	**314.65**	**314.65**	**46.59**	**100**	

Source: Image processing by Author

From the statistics presented in Table 1 above, it is clear that there is only a negligible reduction in the area of water body during the 17 year period. Swamp forest increased by 0.18km^2 over the period, and this change represents 0.394% of the total land use change. The yearly rate of increase in swamp forest area is 0.11km^2. Compound farmland reduced appreciably by 23.30km^2 over the 17year period, and this represents 50.008% of the total land use change. This reduction took place at the rate of 1.37km^2 per year. An upsurge of 23.12km^2 occurred in the built-up area at 1.36km^2 per year. This represents 49.614% of the total change in land use/cover of the study area.

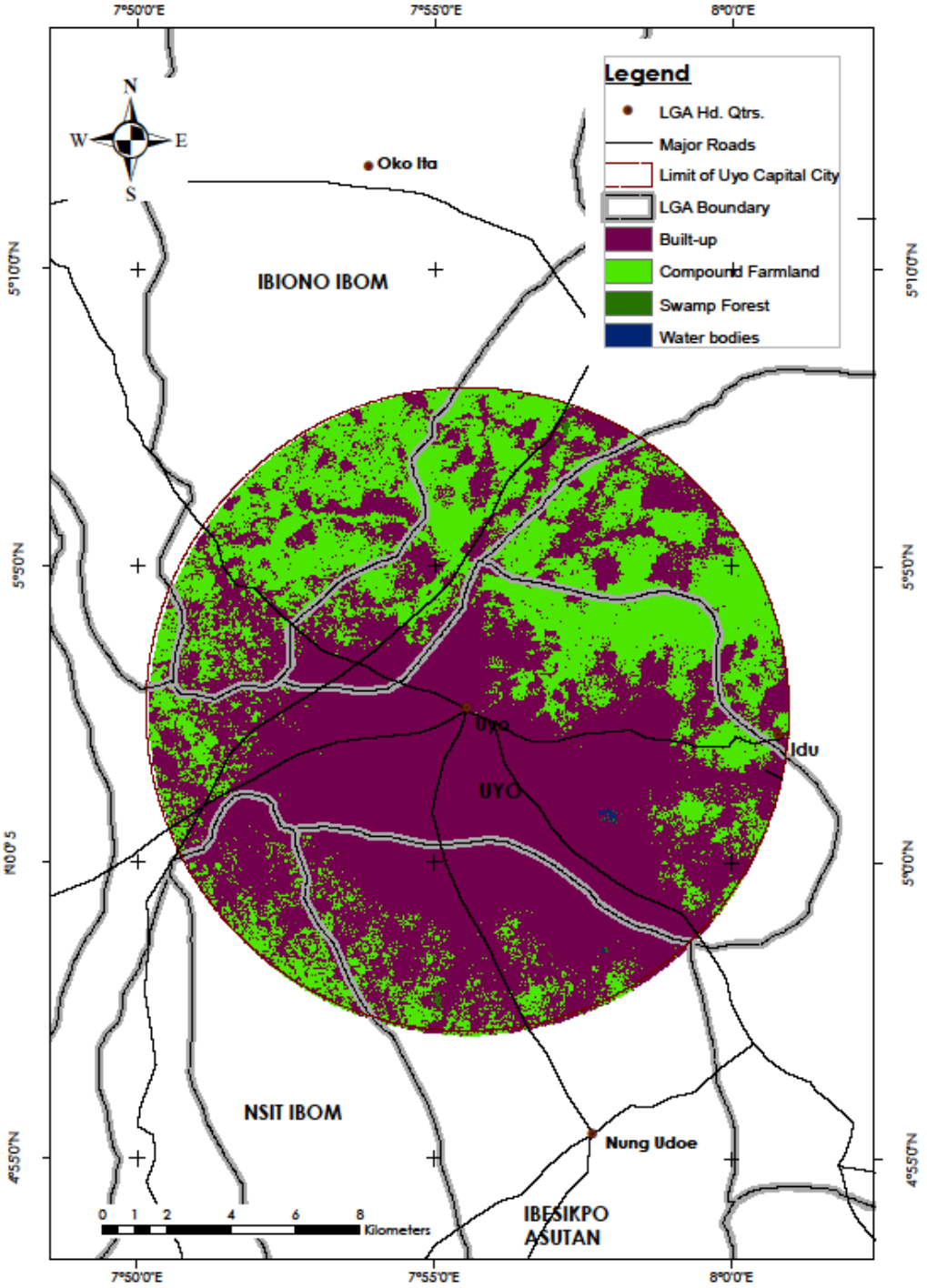

Figure 4.3: Land Use/Cover of Study Area for 2008

Figure 5: Land Use/Cover of Study Area for 2008

Table 2: Land Use/Cover Change Summary Statistics for 2003 and 2008

S/N	Classes	2003 (km^2)	2008 (km^2)	Change (km^2)	Change (%)	Change/yr (km^2)
1	Water Body	0.035	0.035	0.000	0.000	0.000
2	Swamp Forest	23.07	0.42	-22.65	32.454	-0.05
3	Compound Farmland	119.34	107.10	-12.24	17.546	-2.45
4	Built-up	172.21	207.10	34.89	50.000	6.98
	Total	**314.65**	**314.65**	**69.79**	**100**	

Source: Image processing by Author

From the statistics presented in Table 2 it is revealed that the area of water body remained unchanged throughout the 5 year period. There was a landslide reduction in the swamp forest by 22.65km^2, representing 32.454% of the total change. The annual rate of the said reduction was 4.53km^2 per year. Compound farmland reduced by 12.24km^2 over the period at an annual rate of 2.45km^2/year. This change represents 17.546% of the total change. Built-up area increased very rapidly at the rate of 6.98km^2/year. The total increase in the built-up area over the 5year period was 34.89km^2 and this represents 50% of the total land use/cover change over the study period.

Point-by-Point Change Detection

In capturing both the pattern and direction of the land use /cover change, each land use/cover type was analyzed individually as summarized in the land use/cover change matrix in Table 3. Figures 6 and 7 highlight the direction of change between land use/cover classes.

Table 3: Land Use/Cover Change Matrix (Km^2) for 1986 and 2003

1986 Land Use (from)	**Built-up**	2003 Land Use (to) **Compound Farmland**	**Swamp Forest**	**Water Body**
Built-up	No Change	55.27	0.00	0.00
Compound Farmland	74.62	No Change	0.00	0.00
Swamp Forest	3.67	0.00	No Change	0.0
Water Body	0.00	0.00	0.00	No Change

Source: Researcher's Analysis (2014)

a) Built-up: The land use change matrix in Table 3 shows that about 55.27km^2 of the built-up area was lost to compound farmland. Figure 4 shows that this direction of land use/cover change was completely absent in the core of the capital city and common around the fringes of the capital city. This suggests migration towards the city centre as a result of state creation. However this loss was compensated for by a much greater gain of 74.62km^2 from compound farmland and 3.67km^2 from swamp forest. This culminated in an ultimate gain of about 23.02km^2 in built-up area. The areal gain was evenly distributed across the entire capital city but was more intense around communities such as Mbiabong Anyanya, Mbiabong Ikot Antem, Ifa Atai, Ifa Ikot Okpon, Use Offot, and Nsukara Offot.

b) Compound Farmland: This represents areas largely used for continuous cultivation of crops. There always subsists some level of contiguity between this land use class and built-up areas, hence the tendency of areal exchange between the two land use classes. From the land use change matrix, it is clear that compound farmland encroached on 55.27km^2 of the built-up area, mostly at the fringe of Ikpa Ravine area, Ibiono area, parts of Itu, Utit Uruan and Mbiaya Uruan. However, appreciable reduction from the compound farmland to built-up area occurred.

c) Swamp Forest: Table 3 indicates as slight loss from Swamp forest to built-up area within the study area. This shows that between 1986 and 2003 there was little or no disturbance of the swamp forest.

d) Water Body: The land use change matrix shown in Table 3 shows that this land use category was stable.

Table 4: Land Use/Cover Change Matrix (Km^2) for 2003 and 2008

2003 Land Use (from)	2008 Land Use (to) Built-up	Compound Farmland	Swamp Forest	Water Body
Built-up	No Change	29.96	0.00	0.00
Compound Farmland	87.51	No Change	0.00	0.00
Swamp Forest	22.65	0.00	No Change	0.0
Water Body	0.00	0.00	0.00	No Change

Source: Researcher's Analysis (2014)

a. Built-up: Between 2003 and 2008 there was a significant gain in the built-up area and this gain was from both compound farmland and swamp forest - 87.51km^2 from compound farmland and 22.65km^2 from swamp forest. This is likely due to increased

population. At the same time, there was a loss from the built-up area to compound farmland by 29.96km^2 and it is likely to be occasioned by some buildings being overgrown with weed in mostly the suburban fringes.

b. Compound Farmland: There was no marked areal exchange between compound farmland and other land use classes except built-up area. 87.51km^2 was lost to built-up area. This pattern of land use change was predominant within the nucleus of the capital city and the northern part of Ibesikpo Asutan Local Government Area, where both the concentration of roads and population density are highest.

c. Swamp Forest: The study area experienced a reduction in swamp forest over the five year period. The land use/change matrix in Table 4 reveals that 22.65km^2 of the swamp forest area was converted to built-up area.

d. Water Body: The land use change matrix shown in Table 4 shows that this land use category remained stable.

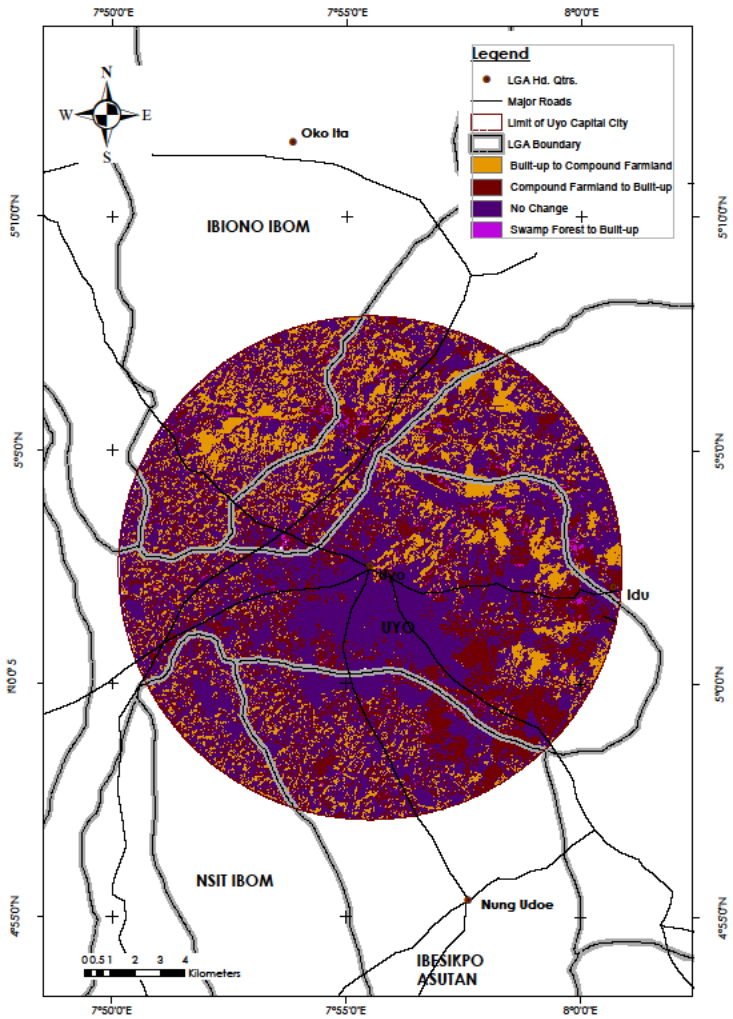

Figure 4.4: Land Use/Cover Change Pattern of Study Area (1986 -2003)

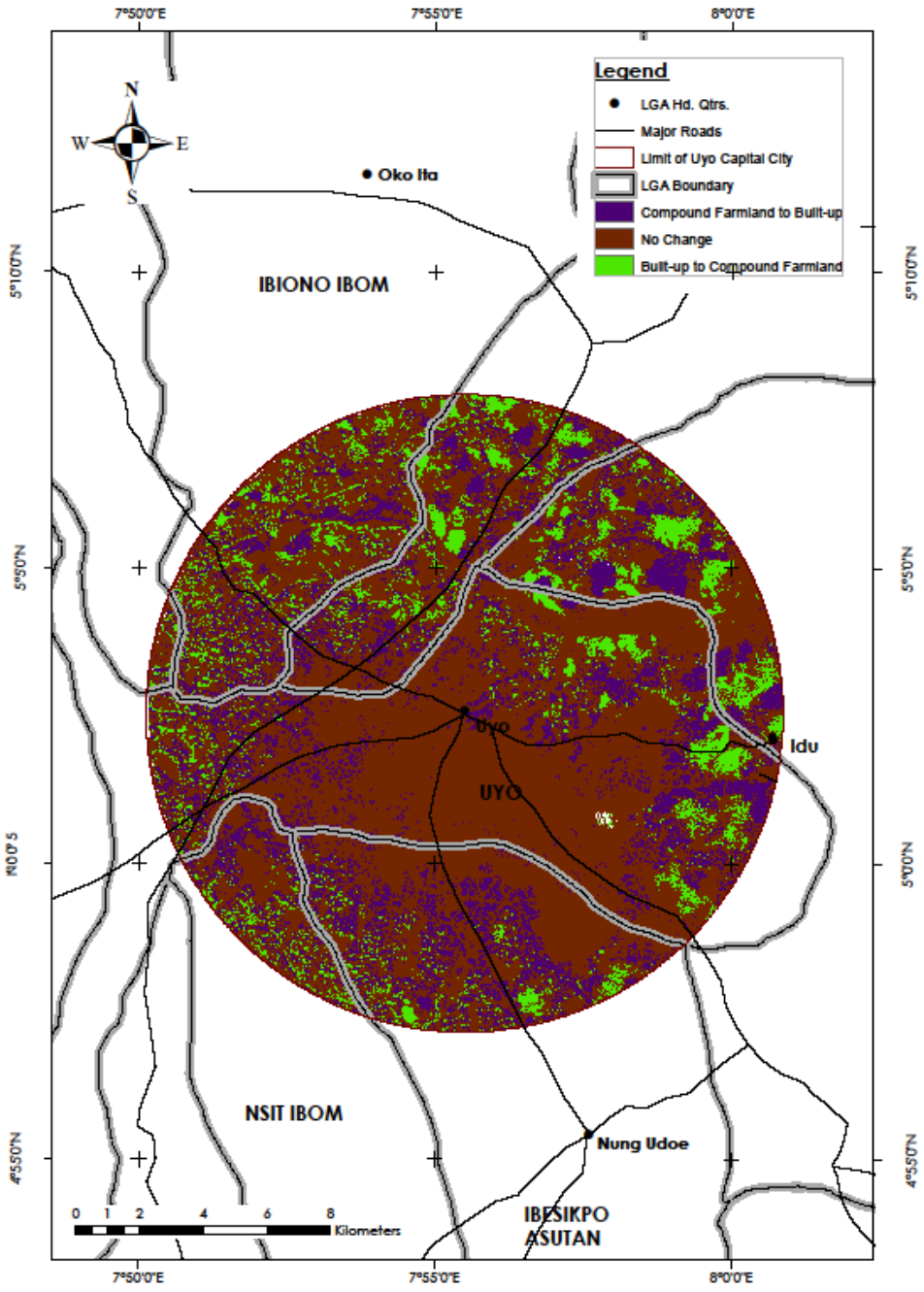

Figure 4.5: Land Use/Cover Change Pattern of Study Area (2003 -2008)

Figure 7: Land Use/Cover Change of Study Area between 2003 and 2008

Discussion of Findings

The study has revealed a consistent trend in the land use of the study area over the study period. In each of the study year, the built-up area constituted the

highest percentage of the study area. In 1986, built-up area constituted 47.38% of the study area, followed by compound farmland which constituted 45.38%, swamp forest constituted only 7.28% of the study area, and water body constituted 0.01% of the study area which is the least. In 2003, the percentage of the study area that was urbanized increased to 54.73%, while compound farmland reduced to 37.93% and swamp forest experienced little or no change while water body remained stable. In 2008, built-up area covered 65.82% of the entire capital city, compound farmland covered 34.04% of the total area, while swamp forest area reduced drastically and water body still remained stable.

The study has revealed that between 1986 and 2003 the expansion of Uyo urban was at a relatively slow pace of 1.36km^2 per year. This is likely due to the fact that in 1986, Uyo was still a Local Government Headquarters in Cross River State and between 1987 when Uyo became a capital city, and 2003, its development and urbanization was still at the infancy state. Between 2003 and 2008, the rate of urbanization increased to 6.98km^2 per year.

CONCLUSION

This study has demonstrated the usefulness of Geographic Information System techniques in urban studies. It has confirmed that pattern of expansion and analyses of spatial and temporal changes can be done cost effectively with the help of spatial and temporal technology along with collateral data such as demographic data, base maps, digital elevation model (DEM), etc. The study has also demonstrated that with remotely sensed data and collateral data, phenomena that are responsible for land use pattern and change as well as the significance of their effects, can be probed into. The study further confirms that if the trend and pattern of urban expansion over a period of time can be detected, future expansion can be predicted. The findings of this study have provided proper insight of the land use pattern in the area as well as providing useful information for future planning.

Recommendation

Based on the findings of the study, the following recommendations are made:

I. Local planning authorities should carry out regular land use inventory to keep abreast of the land use dynamics – if possible on a yearly basis.

II. Urban planning should not just be limited to analogue master plans; but should be a dynamic or modifiable system. This makes it easy to modify the master plan whenever the need arises without unnecessary repetition and data redundancy.

III. Government has a vital role to play in directing the trend of expansion of the study area since anthropogenic factors have more significant effects on the urban growth pattern. This could entail creating a satellite town or socio-economic opportunities in a suburban area in order to redirect the urban growth trend. If for instance, Ikono Local Government, Ibiono Ibom Local Government or Itu Local Government is targeted, much pressure would be reduced from the Ibesikpo and Uruan axes.

IV. Local Planning Authorities should restrict development in strategic areas within the heart of the town in order to maintain some green belts within the capital city. This, apart from moderating the urban temperature, also enhances the urban character of the capital city.

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