LAND USE LAND COVER CHANGE PREDICTION OF IBADAN METROPOLIS

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ABSTRACT

This study examines theapplications of Geographic Information System (GIS) and Remote Sensing in mapping Land Use Land Cover in Ibadan city between 1984 and 2011 so as to assess the changes that have taken place between these periods. The study utilized Lands at images of 1984 and 2011, with ground resolution of 28.5m.The images were enhanced using histogram equalization to improve the images, which were classified with hard classifier called parallelepiped classification method. To predict land use land cover change of the area in the next 27 years, CA_Markov chain analysis, a land cover prediction procedure was introduced as well as Land Consumption Rate (L.C.R) and Land Absorption Coefficient (L.A.C) to quantify the changes. The result of this study shows that the built-up area increased moderately by 21.52%towards the suburbs withinthe study periods, and this may likely be the trend between2011 and 2038 as projected.

Keywords: Remote Sensing, GIS,Land Use Land Cover, Land Consumption Rate and Land Absorption Coefficient,

INTRODUCTION

Attempt has been made to document the growth of Ibadan city in the past but that was carried out using conventional surveying techniques. In recent times, the dynamics of Land use Land cover and particularly settlement expansion in the area requires a more powerful and sophisticated system such as remote sensing and geographic information system (GIS), which provides a general coverage of large areas than the method employed in the past.The aim of this study is to produce a land use land cover map of Ibadan city and its environs at different epochs in order to detect the changes that have occurred particularly between the built-up and vegetation areas and subsequently predict likely changes that might take place in the same area over a given period. To achieve this, efforts were made to generate data on land consumption rate and land absorption coefficient for the evaluation of socio – economic implications of predicted changes.

Information abouttheearth and our environment can be extracted from imagery obtained by various sensors carried in aircraft and satellites(Paul and Charles, 2002). This has been very useful tovarious relevant authorities in ensuring sustainable development. Remotely sensed data have been applied in many fields like forestry, geology, agriculture, conservation and planning etc. (Paul et al, 2002).The role of planning agencies, for example, is becoming increasingly more complex and is extending to a wider range of activities. Consequently, there is an increased need for these agencies to have timely, accurate and cost-effective sources of data of various forms. Several of these data are well served by visual and digital image interpretation. A key example is land use land cover mapping(Lillesand, Kiefer and Chipman, 2008).

Land cover pattern of a region is an outcome of natural and socioeconomic factors and their utilization by man in time and space. Studies have shown that there remain only few landscapes on the Earth that is still in their natural state. Man's activities on earth have had a deep effect on the natural environment thus resulting into anobservable pattern in the land use/land cover over time. According to Kamagata*et al*, (2006) in Hula (2010), vegetation cover on the surface of the earth likewise population has never in the history of humankind remained static and as a result it is always and constantly changing from one type to another. Annabel(1993), stated that the world environment is being degraded as a result of unsustainable exploitation of natural resources and environmentally unsound agricultural practices.

Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental variations. The development in the concept of vegetation mapping has greatly improved research on land use land cover changes thus providing an accurate evaluation of vegetationThe advent of air – and space – borne remote sensing has made it possible to acquire pre- and post- project land use land cover data in a consistence manner (Peter and Ademola, 1999).

In situations of rapid and often unrecorded land use change, viewing the earth from space provides objective information of human utilization of the earth. Remote Sensing and Geographic Information System (GIS) are now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the analyses of Earth - system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity (Wilkie and Finn, 1996). Therefore, an attempt was made in this study to map out the status of land use land cover of Ibadan city and its surroundings between 1984-2011 with a view to detecting the land consumption rate and the changes that have taken place particularly in the built-up and vegetated areas so as to predict possible changes that might take place in the next 27years using both Geographic Information System and Remote Sensing tools.

MATERIALS AND METHODS

The study was carried out in Ibadan city and its environs, comprising eleven Local Government Areas, which include,among others, Ibadan North, North-West, Ibadan South-West, Ibadan North-East and Ibadan South-East Local Government Areas. It is located within longitude 3.8^0E and3.9^0E, latitude 7.3^0N and 7.4^0.N. The study area has an aerial extent of about $195km^2$

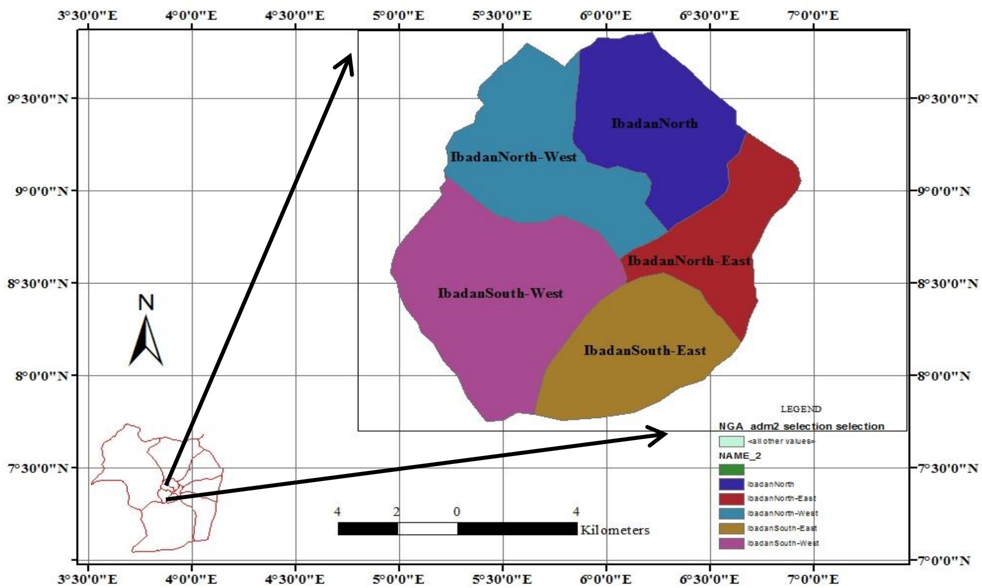

Fig 1: Map showing the study area

To assess and predict the future land use land cover of the study area, Remote Sensing and GIS techniques have been used. Three land cover types have been identified for this research:

Table I: Land Cover Types

Built-up land	All residential, commercial and industrial areas, settlement and infrastructures
vegetation	Trees, shrub land, natural and semi-natural vegetation.
Water body	Rivers, dam, ponds and canals

Data Acquired and Sources

For the purpose of this study, Landsat satellite images of Ibadan were acquired for 1984 and 2011. All were obtained from Global Land Cover Facility (GLCF), an Earth Science Data Interface. On the images, a notable feature such as Eleyele dam can be observed.

It is also important to state that the Ibadan core city was carved out using the local government boundary map derived from Nigerian Administrative map obtained from the internet. These were brought to Universal Transverse Mercator projection in zone 31N – Datum WGS84 and the pixel size is 28.5 meters. The band combination used for this study is 4,3, and 2 (RGB). GPS base maps of the study area were used for the purpose of groundtruthing.

Software Used

According to Bayes (2011);Kritsana*et al*, (2013) and Kufogbe and Amatekpor (1999), the software used in this study are:

(1) ERDAS Imagine 9.1–this was used for displaying and subsequent processing of the images.

(2) IdrisiSelva 17.0 – this was also used for image processing and analysis

(3) ArcGIS 10.1 –to compliment the display and processing of the data, ArcGIS 10.1 was used for the carving out of Ibadan city from the whole Oyo State imagery using both the administrative and local government maps.

Development of a Classification Scheme

Based on the prior knowledge of the study area and reconnaissance survey with additional information from previous research in the study area, a classification scheme was developed for the study area.

Table 2: Land use land cover classification scheme

CODE	**LAND USE/LAND COVER CATEGORIES**
1	Built-up Land
2	Vegetation
3	Water Body

Methods of Data Analysis

Four main methods of data analysis were adopted in this study.

(i) Calculation of the Area in hectares of the resulting land use/land cover types for each study year and subsequently comparing the results.

(ii) Markov Chain and Cellular Automata Analysis for predicting change

(iii) Land Consumption Rate and Land Absorption Coefficient.

The comparison of the land use land cover statistics assisted in identifying the percentage change, trend and rate of change between 1984 and 2011.

In achieving this, the first task was to develop a table showing the area in hectares and the percentage change for each of the years measured against each land use land cover type. Percentage change to determine the trend of change can then be calculated by dividing observed change by sum of changes multiplied by 100:

$$\text{(Trend)percentage change} = \frac{\text{observed change}}{\text{sum of changes}} x\ 100 \qquad (1)$$

Going by the second method (Markov Chain Analysis and Cellular Automata Analysis), is one in which the future state of a system can be modeled purely on the basis of the immediate preceding state. Markovian chain analysis will describe land use change from one period to another and use this as the basis to project future changes.CA_MARKOV is a combined Cellular Automata / Markov Chain / Multi-Criteria/Multi-Objective Land Allocation (MOLA) land cover prediction procedure that add an element of spatial contiguity as well as knowledge of the likely spatial distribution of transitions to Markov chain analysis. This will ensure that land use change occurs proximate to existing like land use classes, and not wholly random (IdrisiSelvaManual,17.0version).

The Land consumption rate formula is given below as

$$\text{L.C.R} = \frac{\text{A}}{\text{P}} \qquad (2)$$

A = areal extent of the city in hectare;P = population.

$$\text{L.A.C} = \frac{\text{A2} - \text{A1}}{\text{P2} - \text{P1}} \qquad (3)$$

A_1 and A_2 are the areal extents (in hectares) for the early and later years, and P_1 and P_2 are population figure for the early and later years respectively (Yeates and Garner, 1976)

L.C.R = A measure of compactness which indicates a progressive spatial expansion of a city.

L.A.C = A measure of change in consumption of new urban land by each unit increase in urban population

The population figures used in this study were estimated from the 1991/2006 population figures of Ibadan Local Governments respectively using the recommended National Population Commission (N.P.C) 2.8% growth rate as obtained from the 1991/2006 censuses (National Population Commission, 2006).

Land Use Land Cover Distribution

The land use land cover distribution for each study year as derived from the maps (figures 2–4) is presentedin the table 3 below:

Table 3: Land use Land Cover Distribution (1984 and 2011)

	1984		**2011**	
LANDUSE/LAND COVER CATEGORIES	**AREA (Ha.)**	**AREA (%)**	**AREA (Ha.)**	**AREA (%)**
BUILT UP LAND	7669.833075	38.73	11931.724	60.25
VEGETATION	12031.290675	60.75	7810.79	39.45
WATER BODY	104.13045	0.52	62.74	0.30
TOTAL	19805.254	100	19805.254	100

The figures presented in table (3) above represent the static area of each land use land cover category for each study year.

Built-up in 1984 occupies the least class with just 38.73% of the total built up land for the study years. This may not be unconnected to the fact that Ibadan has long been regarded as one of the cities in the world with highest slums and with few industries. The increase in built- up area from 38.73% to 60.25% in 1984 and 2011 respectively may be as a result of urban rural-urban drift and renewal policy of government of the State in recent times. The table equally reveals that the vegetated area has been reducedand the water body being encroached.

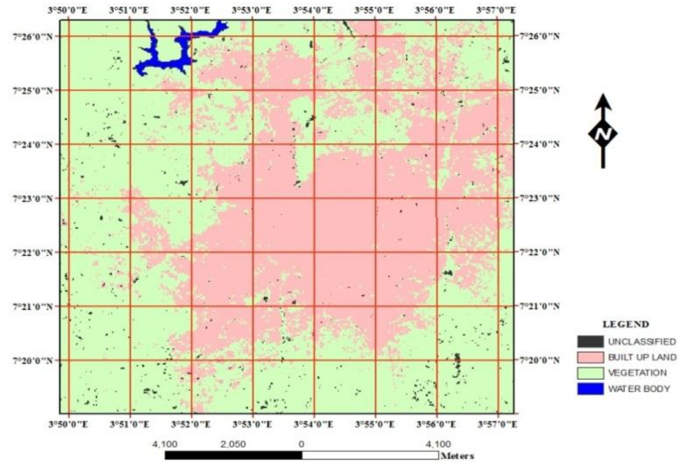

Figure 2: Map of Ibadan City in 1984 Derived from Landsat image of 1984

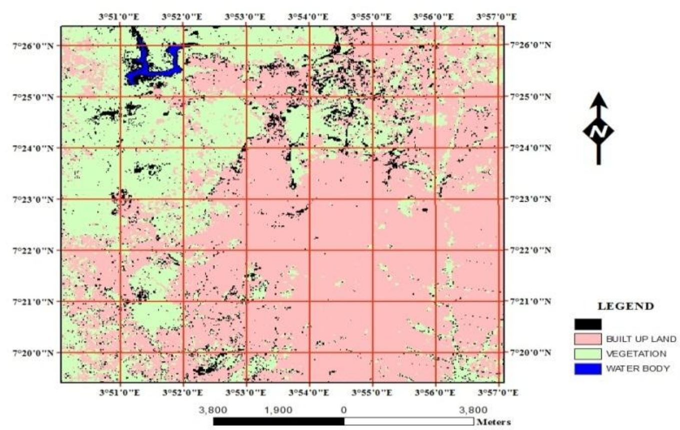

Figure 3: Map of Ibadan City Derived from Landsat image of 2011

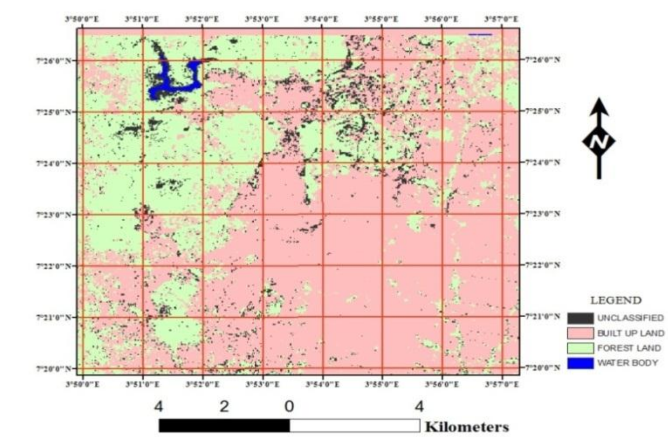

Figure 4: Projected Land cover Map of Ibadan City in 2038.

Table 4: Land Consumption Rate and Absorption Coefficient

YEAR	LAND CONSUMPTION RAT	YEAR	LAND ABSORPTION COEFFICIENT
1984	0.021	1984/2011	0.0054
2011	0.013		

Table 5: Population figure of Ibadan Core City in 1984 and 2011

YEAR	POPULATION FIGURE
1986	945093.254
2011	1,479,018.2

The population figures used was estimated from the population census figures using the recommended National Population Commission (NPC) 2.8% growth rate as obtained from the 1991 and 2006 census (National Population Commission on the 2006 census).

Table 6: land Use Land Cover Change: Trend. and Rate

	1984 - 2011		**2011– 2038**	
LANDUSE/LAND COVER CATEGORIES	**AREA (Ha.)**	**PERCE TAGE CHANGE**	**AREA (Ha.)**	**PERCENT AGE CHA NGE**

BUILT-UP LAND	333.916	1.68	773.25	3.9
VEGETATION	-302.644	-1.53	-765.23	-0.9
WATER BODY	-31.272	-0.15	-8.02	-0.02

From table6, there seems to be anincrease in built up area but a reduction in vegetation between 1984 and 2011. This may not be unconnected to the change in urban renewal policies of recent administrations which have discouraged concentration of people within the city by providing infrastructural facilities in the fringes. Some city dwellers have moved to the fringes as their illegal buildings have been demolished. Subsequently, built-up land increased from 38% 1984 to 60.25%in 2011, while vegetated land decreased from 60% in 1984 to 39.45% in 2011. Many projects have been embarked on by State and Local Governments after the creation of some of the local government areas especially Ibadan North-West which was created in 1990 and South-East in 1991. And this attracted a lot of people to the area thus contributing to the physical expansion of the city.

Nature and Location of Change in Land Use Land Cover

In terms of location of change, the emphasis is on built-up land. Figures 2, 3 and 4 show this change between 1984, 2011 and 2038. The observation here is that there seem to be a growth away from the city center following the concentric theory of city growth by Christaller (1933). From the maps derived from the Landsat images, it is observedthat growth tilts towards the south-western part of the city and the Eleyele dam area in the north-west. Furthermore, the derived statistics show gradualrate in the spatial expansion of the city between 1984 and 2011. For the projected change as shown in Table 8, the built-up land seems to have increased and this therefore suggests that more vegetation might disappear by 2038.

For the 3 by 3 matrix table presented above, the rows represent the older land cover categories (1984) and the column represents the newer categories (2011). Although this matrix can be used as a direct input for specification of the prior probabilities in maximum likelihood classification of the remotely sensed imagery, it was however used in predicting land use land cover of 2038.

As seen from the table 7,while the built up land has a 0.5718 probability (higher probability) of remaining built up land and a 0.4253 probability (lower probability) of changing to vegetation in 2038, the vegetated area has a higher probability (0.6300) of changing to built-up land than remaining a vegetated land with a probability of 0.3667, though the difference is small. Water body which is the last class has a 0.0168 probability of remaining as water body and a 0.4341probability of changing to built-up land.

Table 7: Transition Probability Matrix

CLASSES	BUILT-UP LAND	VEGETAT	WATER BODY
BUILT-UP LAND	0.5718	0.4253	0.0029
VEGETATION	0.6300	0.3667	0.0033
WATER BODY	0.4341	0.5491	0.0168

Table 8: Land Use Land Cover Projection for 2038

LAND USE LAND COVER CLASSES	BUIL-UP LAND	VEGETATION	WATER BODY
AREA IN HECTARES	12704.974	7045.56	54.72
AREA IN PERCENTAGE	64.15	35.57	0.28

The table 8 above shows the statistic of land use land cover projection for 2038. Comparing the percentage representations of table 8 and that of table 3, there exist disparities in the observed distribution. This suggests changes in the classes between 1984 and 2038.Vegetationcover has been steady in reduction throughout the study periods and this may likely bethe trend between 2011 and 2038 as projected. It will pay off, therefore, if the State can uphold this moderate degeneration in vegetation cover so as to reduce the negative effect of deforestation.

Again, the water body is shrinking and there is a probability of it being covered with buildings if development is not monitored or controlled. It is therefore suggested that while people should be encouraged to build towards the suburbsto reduce compactness in the city by creating pulling factors,which are capable of pushing them away from the city Centre, activities of man in the fringes should properly be monitored.

CONCLUSION

This study demonstrates the ability of GIS and Remote Sensing in capturing spatial data. Attempt was made to capture as accurate as possible three land use land cover classes as they change through time. The three classes were distinctly produced for each study year but with more emphasis on built-up land as it is one that affects the other classes. In achieving this, Land Consumption Rate and Land Absorption Coefficient were introduced into the research work. An attempt was also made at generating estimated population figures for the study years using the recommended National Population Commission 2.8% growth rate.

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