

SPATIAL TEMPORAL CHANGES OF WETLANDS IN ILORIN, KWARA STATE, NIGERIA

Ajibade, L.T., Mustapha, T. A. and Ajewole, D. O.

Department of Geography & Env'tal Mgt.,

Faculty of Social Sciences,

University of Ilorin, Nigeria.

Corresponding Author's email: edabijalt2001@yahoo.com



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ABSTRACT

This study was designed to map and generate the multi-temporal inventory of land use/land cover in order to evaluate the spatial-temporal wetlands changes within Ilorin metropolis between 1986 and 2006. The study made use of data generated from land sat coupled with field work. Supervised classification was carried out to identify five land use/land cover type which are built-up area, wetlands, forest, grass land, water bodies with particular emphasis on wetlands. Erdas Imagin was used for the classification of landuses and Arc GIS 9.3b was used to convert the raster outputs from the exported Erdas Imagin and to compliment the processing and display the final output. Area analysis was used for change detection analysis. Result of the study showed that wetlands continue to experience reduction in areal extent due to the various anthropogenic activities of man especially urbanization and urban farming on wetlands. There was reduction of 226.8194sq.hectares between 1986-2000; 49.8774sq.hectares 2000-2006 and 276.6968 sq hectares 1986-2006. The annual rate of change was reduction of 16.2014sq hectares, 8.3129 sq hectares and 46.1161 sq hectares for 1986-2000, 2000-2006 and 1986-2006 respectively. This shows that wetlands recorded only loss in terms of areal extent during the period under investigation. Suggestion was made to protect wetlands ecosystem from extinction by demarcating it from other land use.

Keywords: Wetlands, Wetland changes, Wetlands encroachment, Remote sensing, GIS.

Introduction

Studies have shown that there remains only few landscapes on the earth that still exist in their natural state. Due to anthropogenic activities, the earth's surface is being significantly altered and man's presence on

the earth and his use of land has had a profound effect upon the natural environment, thus resulting into an observable pattern in the land use/land cover over time (Lambin, Geist and Lepers, 2003;

Jiang, Yang, Nicholas, and Wang, 2004; Asthana and Asthana, 2005; Zubair, 2008; Long Wu, Wang, and Dong, 2008).

According to Turner (1990), wetland ecosystems account for about six per cent of the global land area and are considered by many authorities to be among the most threatened of all environmental resources. Both the physical extent of wetlands and their quality (in terms of species diversity, etc.) have declined greatly over the past years. Most of the physical losses have been due to the conversion of wetlands to other land uses, such as residential and agricultural.

In Nigeria, anthropogenic threats and biogeophysical factors such as population pressure, urbanization, mining, pollution, crop production, overgrazing, logging and dam construction have greatly affected wetlands. Unsustainable use of wetlands and river basins could result in higher frequency and severity of flooding, drought and pollution, posing heavy economic and social losses (International Training of Trainers on Wetland Management, 2009).

Wetlands serve as protection to enable ecosystems survive and provide reliable benefit to community (Oyebande et.al. 2003). Wetland inspection through the analysis of their status is not only necessary but essential for the implementation of sustainable use and management. Although, information on wetlands cover only exist at national levels, there is need to embark upon mapping of wetland at local government level since information on change and conversion is lacking except for a few cases. The interest therefore is in the monitoring of wetland areas and particularly wetland areas considered to be of vital importance (Winter, 1988).

The widespread depilation of wetlands in Ilorin, Kwara State a striking example remained unprotected. Thus, the Asa river basin wetlands are presently experiencing a lot of physical changes. Due to the increasing

population pressure, increasing and urgent demand for food, high cost of land and the almost unavailability and unaffordable cost of land in Ilorin Metropolis, urban agricultural activities and other developmental processes are competing for land, especially wetlands around Maraba, Kulende, Oloje and unity areas of Ilorin, Kwara State.

In the Asa River Basin Wetlands, there has being changes in the functional role being played by the changed wetland due to influx of population and the rapid urbanization, plus their various socio-economic activities and the need to provide food for the people at low cost. Presently, more and more wetlands are being taken over for other purposes.

The information on the current status of wetland resources in Ilorin is not well known and documented hence this paper investigated this using some geo-spatial techniques. To achieve this, digital maps which relate the feature to any given geographical location have strong usual impacts. Thus they are essential for monitoring and quantifying change over time scale, and assist in decision making. This study aims at evaluating the spatial temporal wetland changes in Asa River Basin Area of Ilorin. To achieve this, the following objectives were pursued:

1. To map and generate the inventory of wetlands within the study area during the period of 1986, 2000 and 2006.
2. To evaluate the spatio-temporal wetland changes within the study area over a specific period.

Study Area

Ilorin, the capital city of Kwara State Nigeria is the study area. The city which lies between latitudes 8° 24' and 8° 36' North and between longitudes 4° 10' and 4° 36' East has a humid tropical climate which is characterized by wet and dry seasons. Rainy season in the region begins towards the end of March and ends

around October with two peak periods in June and September. Temperature in the city is uniformly high throughout the year and open air insolation can be very uncomfortable during the dry season (Oyegun, 1983). Ilorin is underlain by pre- Cambrian basement complex rock. The elevation on the western side varies from 273m to 333m above sea level while on the Eastern side it varies from 273m to 364m. The Landscape of Ilorin is relatively flat, and is mainly drained by two large rivers, the rivers Asa and Oyun which flow in a South – North direction forming the dividing boundary between eastern western

part (Ajibade and Ojedola,2004). The Asa tributary Rivers such as Aluko, Alalubosa, Okun, Osere, Agba and Atikeke form the four drainage basins. The basins range in size between 5.8sqkm and 17.1sqkm. Two of the basins (Okun and Aluko) are located on the western part of River Asa, while the other two (Agba and Alalubosa) can be found on the eastern part of the river. Land use pattern in the basins can be classified into built-up (paved) area, forest covered, farms and fallow area, area covered by grassland and bare surface area (Jimoh and Iroye, 2010)

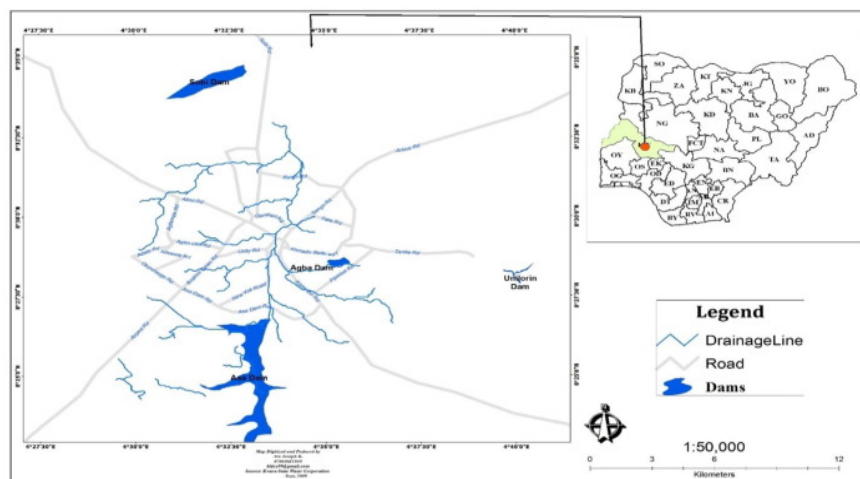


Figure 1: Map of Ilorin showing the Study Area . Inset: Map of Nigeria showing the 36 States.

Source : Kwara State Ministry of Lands and Housing, 2010

Conceptual framework

The analysis of land use change is embedded within the broader discourse on global environmental change, a variety of theoretical approaches which are called “man-environment” theories. More balanced theoretical frame-works for the study of nature-society relationship are offered by ecologically sensitive approaches known as "human ecology" or "cultural ecology" (Briassoulis, 2000). These approaches draw upon ecology and systems theories to provide comprehensive descriptions of the complex

interactions between people and their bio-physical environment (Butzer, 1990).

According to Tivy and O’Hare (1988) the main advantages of the systems approach in geography are: (a) that it provides a conceptual framework or model by which the component parts of the earth’s, and the links between them, can more easily be studied; (b) that the mutual interaction of components throughout a particular system can be more easily illustrated and analyzed; (c) that humans can be studied as integral components of any system, be it physical or

human; and (d) that interactions can be studied at any scale.

An ecological system or ecosystem is a set of interacting, interdependent living (organic or biotic) and non-living (inorganic or abiotic) components or sub-systems. According to Tivy and O'Hare (1988), it is a neat, concise term originally coined to convey the idea of a group of organisms and the place or habitat (i.e. home) they occupy, and the way the two are linked together to form a working or functioning unit. All ecosystems display certain common processes and features which result from the fact that they are, within given limits, self-regulating systems. An ecosystem can regulate itself in two ways – as a result either of the interactions between one system and another, or of the interactions within a system. According to Tivy and O'Hare (1988), humans are now the most powerful agents of change in the ecosystem. Their impact can be accidental or deliberate, direct or indirect. In some instances their activities have altered the volume, composition and structure of the organic components and, consequently, the nature of the physical habitat. In others, they have so modified the physical environment as to bring about changes in organic matter. Any change in the composition and structure of one will inevitably have repercussions on that of the other. Human impact on ecosystem components is greatest in those which are deliberately managed in order to maximize the output of a particular product. In this respect, the effect is most marked in crop production. Land use change research has evolved out of global efforts to identify, predict and manage ecologically damaging land use changes such as deforestation. Indeed, the international global environmental change research community has chosen land use/cover change as a major area of research not only because it provides broad scale data on changing carbon storage and sequestration by plants, but also because it provides an entry into

understanding the human dimensions of environmental change (Turner et al., 1995; Lambin et al., 2003). Political and cultural ecology, intensification theory, economic theories and other concepts have informed LULC research associated with the International Geosphere-Biosphere Programme (IGBP).

The early interests of social scientists in explanation and ecologists in prediction are evidently convergent in the spatially explicit model. Ecologists have provided strong motivation with their focus on the landscape as a biogeographic unit of analysis subject to fragmentation processes. On their part, social scientists have filled the explanation gaps on the human side of the equation. Now, social scientists and ecologists are even found to publish jointly on the topic (Turner et al., 1996). The spatially explicit model is increasingly used to predict landscape change and is often evaluated both in terms of conventional inference on variable coefficients and goodness-of-fit and with respect to ability to predict actual landscape change (Nelson and Hellerstein, 1997; Mertens and Lambin, 2000).

MATERIALS AND METHODS

Methods of Data Collection

This study made use of remote sensing techniques. In this study, three multi-date Landsat satellite imagery of Ilorin were procured for the years 1986, 2000 and 2006. 1986 and 2000 images were obtained from the Global Land Cover Facility (GLCF) and 2006 Image from the office of Surveyor General of Kwara State (Table 1). The unequal interval of year used was taken care of by the equation for calculating annual rate of change in the data analysis since it considered the starting year and the ending year.

This involved the use of archival remotely sensed data and topographic maps to generate multi-temporal, as well as spatial

states of wetlands. Firstly, the aerial photograph was scanned to convert them into digital format which was then opened within the Arc-view environment as image data. There-after, the scanned image was geo-rectified using Universal Transverse Mercator (UTM) projection with Clarke 1880 spheroid for proper projection and to make it registered with the satellite images (Spot and Landsat) as planimetrically accurate data source. On the other hand, the satellites images were opened directly within the Arc-view software environment. A hierarchical classification

scheme which takes into consideration the characteristics of the multi-source and multi-date remotely sensed data, and the physical and human setting (from field observation) of the study area was then developed. In addition, the classification scheme considered the degree of details required for this study, as well as the clarity in defining each landuse/landcover category. The classification scheme used for this study is presented thus: Built-up Area, Wetlands, Forest, Grass land, Water bodies.

Table 1: Data Characteristics

S/n	Data type	Date of production	Scale	Source
1	Landsat image	2006-11-03	30m TM	Office of Surveyor General State
2	Landsat image	2000-11-17	30m TM	Global Land Cover Facility
3	Landsat image	1986-11-07	30m TM	GLCF

Methods of Data Analysis

The analyses that were carried out include the following:

- (i) The mapping of the study area at different times (1986, 2000 and 2006) was done within the Arcview software as stated earlier. Analyses in form of areal extent were derived from the Attribute Table section of the Arc-view software.
- (ii) The area analysis was used in this study. This involved the analysis which highlights the trend and rate of the land use/land cover changes over the period under investigation. The percentage change was calculated using the equation:

$$\text{Percentage Change} = (\text{OC} / \text{ASC}) \times 100$$

Where OC is the observed change; and ASC is the absolute sum of change.

The annual rate of change is calculated using the equation:

$$\text{Annual Rate of Change} = \text{OC} / (Y_2 - Y_1)$$

Where OC is the observed change; Y_1 is the starting year; and Y_2 is the ending year.

Data Analysis and Presentation

Multi-Temporal Inventory of

Landuse/Landcover (1986, 2000 and 2006)

The areal extent of landuse/landcover for the years under investigation are presented in Table 2, while figure 2, 3 and 4 shows the spatial distribution of the landuse/landcover of the study area in 1986, 2000 and 2006 respectively.

Table 2: Landuse/Landcover (Area Extent) for 1986, 2000 and 2006 in the Study Area

LAND USE CLASSIFICATION CATEGORIES	1986		2000		2006	
	Area (sq. hectare)	Area (%)	Area (sq. hectare)	Area (%)	Area (sq. hectare)	Area (%)
Built-up Area	9833.7231	6.6286	14543.225	9.8032	19286.8956	13.0009
Grass Cover with Scattered Trees	113328.183	76.3911	109370.939	73.7239	107870.887	72.7128
Forest	20293.0405	13.6789	19860.3216	13.3872	16761.2214	11.2983
Wetland	3363.0351	2.2669	3136.2149	2.1140	3086.3379	2.0804
Water Bodies	1533.9816	1.0340	1441.262	0.9715	1346.621	0.9077
TOTAL	148351.9633	100	148351.9625	100	148351.9629	100

Source: GIS Analysis of Interpreted Remotely Sensed data (2013)

As shown in Table 2, the entire study area covered 148351.9633 sq. km. During the three periods investigated, built-up area recorded 9833.7231 sq. hectares. (6.6286%), 14543.225sq. km (9.8032%) and 19286.8956 sq. km (13.0009%) in 1986, 2000 and 2006 respectively. In 1986 2000 and 2006, Grass cover with scattered trees covered 113328.183 sq. km (76.3911%), 109370.939sq. km (73.7239%) and 107870.887sq. km (72.7128%) respectively. On the other hand, forest recorded 20293.0405 sq hectares (13.6789%), 19860.3216 sq. hectares (13.3872%), 16761.2214 sq. hectares (11.2983%) in 1986, 2000 and 2006 respectively while water bodies recorded

1533.9816 sq hectares (1.0340 %), 1441.262 sq. hectares (0.9715 %), and 1346.621sq. hectares (0.9077 %) respectively in 1986, 2000 and 2006.

Multi-Temporal Inventory of Wetlands and Cultivation (1986, 2000 and 2006)

In line with the objectives of the study, emphasis is given here to the areal extent of wetlands over the three periods (1986, 2000 and 2006). As shown in Table 2, wetlands covered 3363.0351 sq. km in 1986, representing 2.2669 % of the total study area; while in 2000, it covered 3136.2149 sq. km (2.1140%) and 3086.3379 sq. km (0.9077%) in 2006.

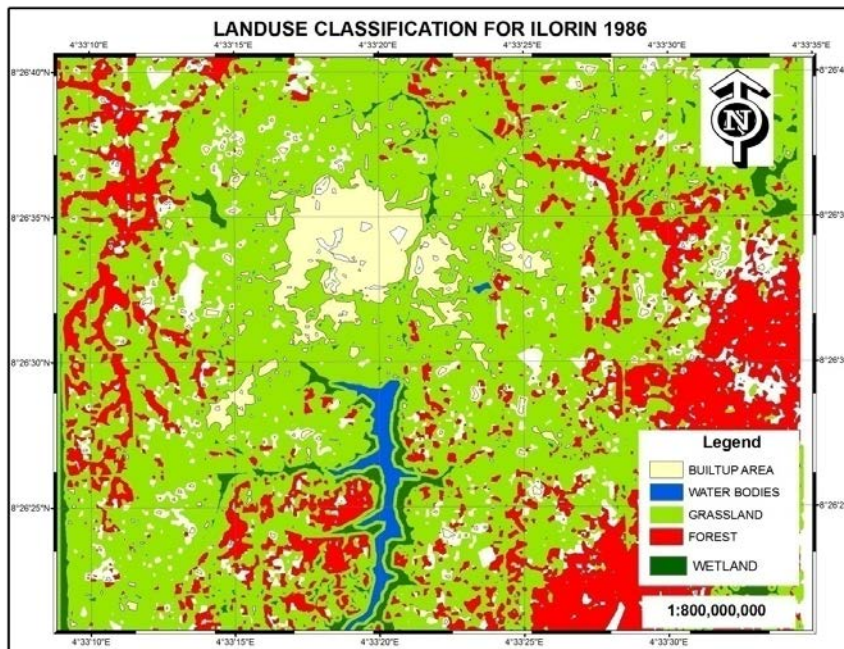


Figure 2: Landuse/Landcover Distribution of the Study Area in 1986

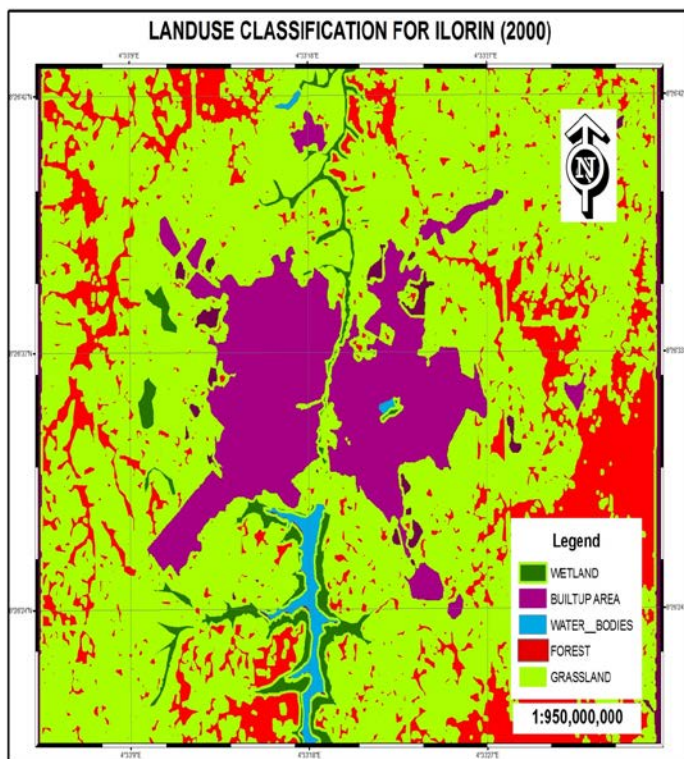


Figure 3: Landuse/Landcover Distribution of the Study Area in 2000

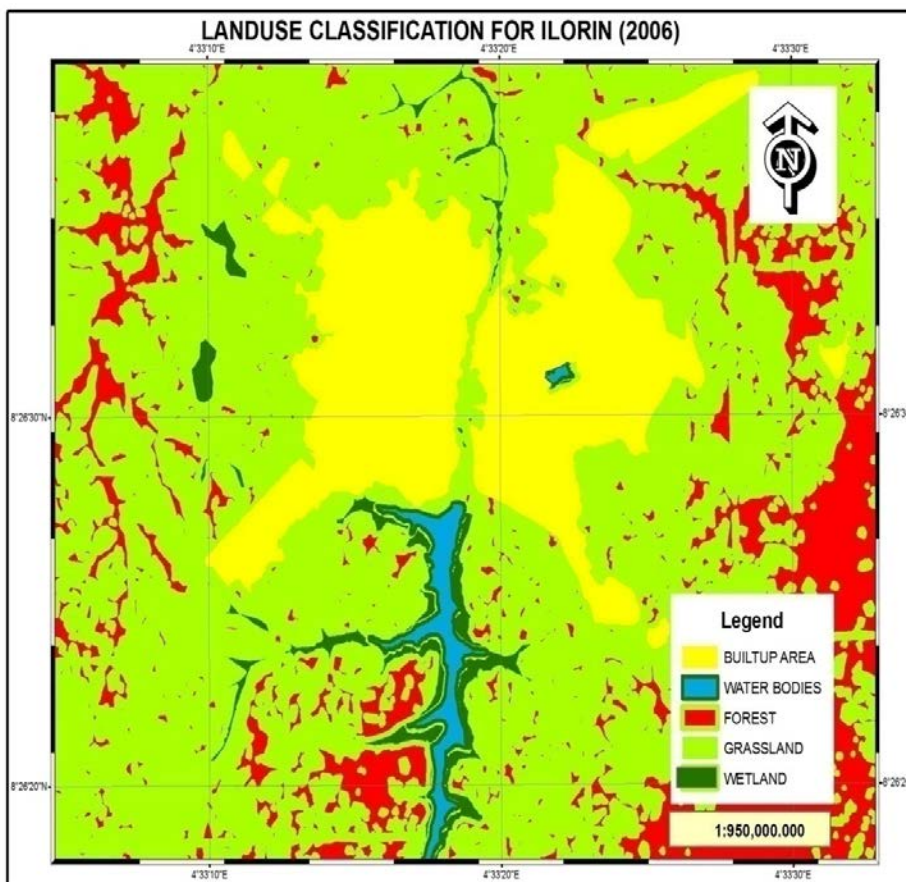


Figure 4: Landuse/Landcover Distribution of the Study Area in 2006

Changes in Landuse/Landcover

The result of landuse/landcover within the study area is presented below with regards to (i) the trend and rate of changes and (ii) the nature of changes. On the other hand, the result of wetland changes for agricultural purpose (represented by cultivation) is presented with regards to (i) the trend and rate of changes (ii) the nature of changes.

Changes in Landuse/Landcover: Trend and Rate

The absolute, percentage and annual rates of landuse/landcover within the study area for the periods: 1986-1994, 1994-2000 and 1986-2000 are shown in Table 3 shows the annual rates of change for 1986-2000.

Table 3: Landuse/Landcover change statistics in the study area between 1986, 2000 and 2006

LAND USE/ LANDCOVER	Landuse/Landcover Change						Annual Rate of Change		
	1986-2000		2000-2006		1986-2006		1986-2000 Area (sq. hectare)	2000-2006 Area(sq. hectare)	1986-2006 Area(sq. hectare)
	Area (sq.hec)	% Change	Area (sq.hec)	% Change	Area (sq.hec)	% change			
Built-up Area	4709.5019	32.3827	4743.6706	24.5953	9453.1725	49.0134	336.3929	790.6118	472.6586
Grass Cover With Scattered Trees	-3957.2440	-3.6181	-1500.0520	-0.0139	-5457.2960	-5.0591	-282.6602	-250.0087	-272.8648
Forest	-432.7189	-0.0218	-3099.1002	-0.1849	-3531.8191	-0.1740	-30.9085	-516.5167	-588.6365
Wetland	-226.8194	-0.0723	-49.8774	-1.6161	-276.6968	-8.2276	-16.2014	-8.3129	-46.1161
Water Bodies	-92.7186	-0.0643	-94.6410	-7.0280	-187.3606	-13.9134	-6.6228	-15.7735	-31.2268

Source: GIS Analysis of Change Detection (Area Analysis) (2013)

Note: The positive sign means gain and the negative sign indicates loss in areal extent.

As shown in Table 3, built-up area recorded 32.3827%, 24.5953% and 49.0134% percentages of change during the periods 1986-2000, 2000-2006 and 1986-2006 respectively; while the annual rates of change for the same periods are 336.3929 sq. km, 790.6118 sq. km and 472.6586 sq. km respectively. This shows that built-up area increased during 1986-2000 at the rate of 32.3827 sq. km per year, while during 2000-2006 the rate was 24.5953 sq. km per year and 49.0134 sq. km per year during the period 1986-2006. Grass cover with scattered trees recorded -3.6181%, -0.0139% and -5.0591% percentages of change during the periods 1986-2000, 2000-2006 and 1986-2006 respectively; with -282.6602 sq. km, -250.0087 sq. km and -272.8648 sq. km as the annual rates of change during the same periods respectively. Forest recorded -0.0218 %, -0.1849 % and -0.1740% percentage of change respectively with -30.9085 as annual rates of change for the period 1986-2000. For 2000-2006 (-516.5167) and 1986-2006 (-588.6365) as annual rate of change. Water bodies

recorded -0.0643, -7.0280 and -13.9134 % percentage of change respectively for the periods of 1986-2000, 2000-2006 and 1986-2006 while it recorded -6.6228 sq. km, -15.7735 sq. km and -31.2268 sq. km respectively as annual rates of change for the periods 1986-2000, 2000-2006 and 1986-2006.

Changes in Wetlands: Trend and Rate

Table 3 above shows the percentage of change for wetlands. Wetlands recorded -0.0723%, -1.6161% and -8.2276% as percentages of change during 1986-2000, 2000-2006 and 1986-2006 respectively. This shows that wetlands recorded only loss in terms of areal extent during the period under investigation. The annual rates of change for wetlands during 1986-2000, 2000-2006 and 1986-2006 are -16.2014 sq. km, -8.3129 sq. km and -46.1161 sq. km respectively.

Changes in Landuse/Landcover: Nature

The nature of Landuse/Landcover change refers to the identification of 'what landuse/landcover is changing and from what

to what?' Nature of landuse/landcover changes information helps in highlighting the spatial or locational stability of the landuse/landcover over time, also it reveal changes that are desirable or undesirable and the response of the resource base to management decisions (Adeniyi and Omojola, 1999). The nature of changes has been examined in this study in terms of (i) landuse/landcover stability (areas of landuse/landcover with no change; (ii) areas of landuse/landcover classes gained by other classes; and (iii) the areas of landuse/landcover classes lost to other classes. Losses to a class indicate an encroachment on that particular class at time t1 by other class(es) at time t2. In the same way, gain to a class is an emergence of that particular class on other class(es) at a later time; while no change areas indicate the spatially consistent or unchanged part of a particular landuse/landcover.

Table 3 shows the observed changes between 1986 and 2006. Looking at the nature of change, no class is actually stable during the periods of investigation. However, built-up area recorded increase. It recorded positive change which implied that it has gained in areal extent during the three epoch used for the studies. While other land use classes recorded decrease which means that they have loosed their areal extent to the built up area. Built-up area therefore, gain 9453.1725 sq hectares from other landuse classes.

Changes in Wetlands and Cultivation: Nature

During the period 1986-2000, 2000-2006 and 1986-2006, table 2 above shows that wetlands was not a stable area in that it continued to decrease these periods. Regarding loss, wetlands recorded 276.6968 sq. hectare (representing 2.9270% of the total area loss during 1986-2006.

Discussion of Results

Firstly, the spatio-temporal analyses through the use of remote sensing and GIS techniques shows that in 1986 the total areal extent of wetlands was 3363.0351 sq. hectares, . In 2000 it decreased to 3136.2157 sq. hectares . However, in 2006 wetlands decreased to 3086.3383 sq. hectares . Generally, wetlands is one of the most affected with more area been taken over by other landuse/landcover. As shown in the study, more and more wetlands are being encroached either for development purpose or for cultivation.

The trend and rate of change analysis revealed that wetlands continuously experience loss with all negative annual rates of change during the period under investigation (-0.0723 for 1986-2000, -1.6161 for 2000-2006, and -8.2276 for 1986-2006). In terms of nature of changes and location, the study shows that built-up areas encroached almost all other landuse/landcover especially wetlands.

Generally there was reduction in the areal extent of wetlands in the study area between 1986-2006. Most of the wetlands in the study areas have been encroached and used for residential, industrial and agricultural purposes.

Conclusion/Recommendations

Changes in the patterns of land use/land cover as demonstrated in this study are a reflection of increasing anthropogenic pressure on landscape which needs to be seriously addressed. Rapid population growth and its twin brother, urbanization remain the major causes of environmental degradation. More and more people, especially the urban poor, are getting engaged in urban agriculture using the mostly unprotected and uncontrolled wetlands in the Ilorin Metropolis. Although this could lead to increased food production and food security there is need for further research into sustainable management and

utilization of fragile ecosystem such as wetlands.

The study also observed human modification in terms of the reduction in the size of the original wetlands in the study area. This is as a result of the conversion of the wetlands into other land uses which support various findings of existing studies. These include residential quarters and small scale industries. The implication of these findings is

that the area is susceptible to devastating flooding which can culminate in the loss of lives and properties. The study recommended that there is need for the control and planning of activities around the existing wetlands by government to avoid unsustainable encroachment of the fragile wetlands. Demarcating wetland zones in the cities can do this.

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