MONITORING THE GROWTH OF SETTLEMENTS IN ILORIN, NIGERIA (A GIS AND REMOTE SENSING APPROACH)

Zubair Ayodeji Opeyemi (Bsc, Msc)

National Space Research and Development Agency, Abuja-Nigeria
- azubair@nasrda.net,opemorenikeji@yahoo.com

ABSTRACT

This paper examines the use of GIS and Remote Sensing in monitoring settlement (built-up) growth in Ilorin between1972, and 2001 so as to detect the changes that has taken place in this class between these periods. Landsat data for three epochs were used in the study. Supervised classification was carried out to identify five land use/cover types with particular emphasis on settlement. Subsequently, an attempt was made at projecting the observed growth in the next 14 years. In achieving this, Land Consumption Rate and Land Absorption Coefficient were introduced to aid in the quantitative assessment of the change. The result of the work shows a rapid growth in built-up land between 1972 and 1986 while the periods between 1986 and 2001 witnessed a reduction in this growth. It was also observed that change by 2015 may likely follow the trend in 1986/2001.An attempt was also made to suggest possible ways to use the information contained therein optimally.

1. INTRODUCTION

Studies have shown that there remain only few landscapes on the Earth that is still in their natural state. Due to anthropogenic activities, the Earth surface is being significantly altered in some manner 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 accelerated growth in settlement expansion.

Land is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on settlement growth i.e. consumption of new land with each unit of population growth and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of settlement expansion resulting out of changing demands of increasing population. Studies on settlement expansion have become a central component in current strategies for managing land as a resource and in monitoring environmental changes.

Viewing the Earth from space is now very crucial to the understanding of the influence of man's activities on the earth over time. In situations of rapid and often unrecorded growth in settlement, observations of the earth from space provide objective information of human utilization of the landscape. Over the past years, data from Earth sensing satellites has become vital in mapping the Earth's features and infrastructures, managing natural resources and studying environmental change.

The collection of remotely sensed data facilitates the synoptic analyses of Earth - system function, patterning, and change at local, regional and global scales over time.

2. MOTIVATION

Ilorin, the Kwara State, capital has witnessed remarkable expansion, growth and developmental activities such as building, road construction, deforestation and many other anthropogenic activities since its inception in 1967 just like many other state capitals in Nigeria. This has therefore resulted in increased land consumption and a modification and alterations in the status of her land use land cover over time without any detailed and comprehensive attempt (as provided by a Remote Sensing data and GIS) to evaluate this status as it changes over time with a view to detecting the rate at which land is being consumed and also make attempt to predict same and the possible changes that may occur in this status so that planners can have a basic tool for planning. It is therefore necessary for a study such as this to be carried out if Ilorin will avoid the associated problems of a growing and expanding city like many others in the world.

Indeed, attempt has been made to document the growth of Ilorin in the past but that from an aerial photography (Olorunfemi, 1983). In recent times, the dynamics of Land use, particularly settlement expansion in the area requires a more powerful and sophisticated system such as provided by a GIS and Remote Sensing data which provides a general extensive synoptic coverage of large areas than area photography.

3. AIM

The aim of this study is to document the growth of Ilorin Township as obtained from satellite data and GIS between 1972 and 2001 and also predict the pattern of growth in same over a given period.

4. OVERVIEW

This paper has its focus on growth in built up land (settlement) but attention was given to a general mapping of land use land cover of the study area. The resultant maps served as a basis for identifying growth in settlement and subsequently predicting same over a given period. Therefore, in the related works, attention will be given to change in land use and land cover in the study area since the product of each image classification is a

land use land cover type although built-up (settlement) was later isolated in the study.

5. RELATED WORKS

Studies on settlements are vital because settlements are the result of man's activities throughout the various stages of his evolution. They are dynamic and constantly changing with man's changing social and economic needs. Settlements have held a dominant place in early statements, like that by Brunhes (1925) and contemporary reviews like that by Leong et al (1992). Forming such distinctive features on the landscape, they were viewed as a fundamental expression of "man-land' relationship.

In recent times, efforts on settlement studies is being directed towards its growth i.e. increase in the rate of landuse consumption. According to Meyer, 1999 every parcel of land on the Earth's surface is unique in the cover it possesses. Land use and land cover are distinct yet closely linked characteristics of the Earth's surface. The use to which we put land could be grazing, agriculture, urban development, logging, and mining among many others all which culminate to form what we know as settlement. An essential ingredient in the study of settlement which is growth is its ability to affect biodiversity. Many shifting land use patterns driven by a variety of social causes, result in land cover changes that affects biodiversity, water and radiation budgets, trace gas emissions and other processes that come together to affect climate and biosphere (Riebsame, Meyer, and Turner, 1994).

Globally, land cover today is altered principally by direct human use: by agriculture and livestock raising, forest harvesting and management and urban and suburban construction and development. There are also incidental impacts on land cover from other human activities such as forest and lakes damaged by acid rain from fossil fuel combustion and crops near cities damaged by tropospheric ozone resulting from automobile exhaust (Meyer, 1995).

Hence, in order to effectively monitor settlement growth, it is not only necessary to have the information on existing land use land cover but also the capability to monitor the dynamics of land use resulting out of both changing demands of increasing population and forces of nature acting to shape the landscape.

Conventional ground methods of land use mapping are labour intensive, time consuming and are done relatively infrequently. These maps soon become outdated with the passage of time, particularly in a rapid changing environment. In fact according to Olorunfemi (1983), monitoring changes and time series analysis is quite difficult with traditional method of surveying. In recent years, satellite remote sensing techniques have been developed, which have proved to be of immense value for preparing accurate land use land cover maps and monitoring changes at regular intervals of time. In case of inaccessible region, this technique is perhaps the only method of obtaining the required data on a cost and time – effective basis.

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh, 1989). Change detection is an important process in monitoring and managing natural resources and urban development (settlement growth) because it provides quantitative analysis of the spatial distribution of the population of interest.

The basis of using remote sensing data for change detection in settlement is that changes in land use result in changes in radiance values which can be remotely sensed. Techniques to perform change detection with satellite imagery have become numerous as a result of increasing versatility in manipulating digital data and increasing computer power.

Arvind C. Pandy and M. S. Nathawat (2006) carried out a study on land use land cover mapping of Panchkula, Ambala and Yamunanger districts, Hangana State in India. They observed that the heterogeneous climate and physiographic conditions in these districts has resulted in the development of different land use land cover in these districts, an evaluation by digital analysis of satellite data indicates that majority of areas in these districts are used for agricultural purpose. The hilly regions exhibit fair development of reserved forests. It is inferred that land use land cover pattern in the area are generally controlled by agro – climatic conditions, ground water potential and a host of other factors.

Furthermore an analysis of land use and land cover changes using the combination of MSS Landsat and land use map of Indonesia (Dimyati, 1995) reveals that land use land cover change were evaluated by using remote sensing to calculate the index of changes which was done by the superimposition of land use land cover images of 1972, 1984 and land use maps of 1990. This was done to analyze the pattern of change in the area, which was rather difficult with the traditional method of surveying as noted by Olorunfemi in 1983 when he was using aerial photographic approach to monitor urban land use in developing countries with Ilorin in Nigeria as the case study.

Daniel et al, 2002 in their comparison of land use land cover change detection methods, made use of 5 methods viz; traditional post – classification cross tabulation, cross correlation analysis, neural networks, knowledge – based expert systems, and image segmentation and object – oriented classification. A combination of direct T1 and T2 change detection as well as post classification analysis was employed. Nine land use land cover classes were selected for analysis. They observed that there are merits to each of the five methods examined, and that, at the point of their research, no single approach can solve the land use change detection problem.

Also, Adeniyi and Omojola, (1999) in their land use land cover change evaluation in Sokoto – Rima Basin of North – Western Nigeria based on Archival Remote Sensing and GIS techniques, used aerial photographs, Landsat MSS, SPOT XS/ Panchromatic image Transparency and Topographic map sheets to study changes in the two dams (Sokoto and Guronyo) between 1962 and 1986. The work revealed that land use land cover of both areas was unchanged before the construction while settlement alone covered most part of the area. However, during the post - dam era, land use /land cover classes changed but with settlement still remaining the largest.

6. DATA USED AND SOURCE

For the study, Landsat satellite images of Kwara State were acquired for three Epochs; 1972, 1986 and 2001. Both 1972 and 1986 were obtained from Global Land Cover Facility (GLCF) an Earth Science Data Interface, while that of 2001 was

obtained from National Space Research and Development Agency in Abuja, Nigeria (NASRDA). Also, Ilorin and its environs were indentified using the local government boundary map and Nigerian Administrative map and were also obtained from NASRDA. These were brought to Universal Transverse Marcator projection in zone 31

7. METHODS OF DATA ANALYSIS

Six main methods of data analysis were adopted in this study

(i)   Maximum Likelihood Classification
(ii)   Calculation of the Area in hectares of the resulting land use/land cover types for each study year and subsequently comparing the results
(iii)   Overlay Operations
(iv)   Markov Chain and Cellular Automata Analysis for predicting change
(v)   Land Consumption Rate and Absorption Coefficient

The first three methods above were used for identifying change in the land use types particularly in settlement.

The comparison of the land use land cover statistics assisted in identifying the percentage change, trend and rate of change between 1972 and 2001.

In achieving this, the first task was to develop a table showing the area in hectares and the percentage change for each year (1972, 1986 and 2001) 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

$$(\text{trend}) \text{ percentage change} = \frac{\text{observed change}}{\text{Sum of change}} * 100$$

In obtaining annual rate of change, the percentage change is divided by 100 and multiplied by the number of study year 1972 – 1986 (14years) 1986 – 2001 (15years)

Going by the second method (Markov Chain Analysis and Cellular Automata Analysis), Markov Chain Analysis is a convenient tool for modeling land use change when changes and processes in the landscape are difficult to describe. A Markovian process is one in which the future state of a system can be modeled purely on the basis of the immediately 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. This is achieved by developing a transition probability matrix of land use change from time one to time two, which shows the nature of change while still serving as the basis for projecting to a later time period .The transition probability may be accurate on a per category basis, but there is no knowledge of the spatial distribution of occurrences within each land use category (Idrisi 32). Hence, Cellular Automata (CA) was used to add spatial character to the model.

CA_Markov uses the output from the Markov Chain Analysis particularly Transition Area file to apply a contiguity filter to "grow out" land use from time two to a later time period. This will ensure that land use change occurs proximate to existing like land use classes, and not wholly random (Idrisi 32).

Overlay operations which is the last method of the three, identifies the actual location and magnitude of change although this was limited to the built-up land because the focus of this study is to monitor growth in settlement within the area of study. Boolean logic was applied to the result through the reclass module of idrisi32 which assisted in mapping out separately areas of change for which magnitude was later calculated for.

The Land consumption rate and absorption coefficient formula are give below;

$$L.C.R = \frac{A}{P}$$

A = areal extent of the city in hectares

P = population

$$L.A.C = \frac{A_2 - A_1}{P_2 - P_1}$$

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

Both the 2001 and 2015 population figures were estimated from the 1991 and the estimated 2001 population figures of Ilorin respectively using the recommended National Population Commission (NPC) 2.1% growth rate as obtained from the 1963/1991 censuses.

The first task to estimating the population figures was to multiply the growth rate by the census figures of Ilorin in both years (1991, 2001) while subsequently dividing same by 100. The result was then multiplied by the number of years being projected for, the result of which was then added to the base year population (1991, 2001). This is represented in the formula below;

$$n = r/100 * Po \qquad (1)$$
$$Pn = Po + (n * t) \qquad (2)$$

Pn = estimated population (2001, 2015)
Po = base year population (1991 & 2001 population figure)
r = growth rate (2.1%)
n = annual population growth
t = number of years projecting for

*The formula given for the population estimate was developed by the researcher

In evaluating the socio – economic implications of change, the effect of observed changes in the land   use and land cover between 1972 and 2001 were used as major criteria.

8. INSTRUMENTATION

For this study, landsat system was used with three different sensors representing the three epochs for the study

Landsat ETM+ 2001-11-03
Landsat TM   1986-11-15
Landsat MSS 1972-11-07

9. RESULT AND DISCUSSION

Landuse/ Land Cover Categories	1972		1986		2001	
	AREA (Ha.)	AREA (%)	AREA (Ha.)	ARE (%)	AREA (Ha.)	ARE (%)
Farm Land	2437.63	25	7965.57	8	14068.5	15
Waste Land	41436.77	43	55561.1	59	50317.2	52
Built-up Lan	2198.27	2	9702.81	100	10815.9	11
Forest Land	11036.49	12	21393.0	22	19960.2	21
Water Body	16874.66	18	1326.89	1	787.56	1
TOTAL	95949.47	100	95949.4	100	95949.4	100

Table 1 Static land use land cover distribution of Ilorin and environs in 1972, 1986 and 2001

Built-up which is the focus of this study occupies the least class with just 2% of the total classes in 1972. This may not be unconnected to the fact that the town (Ilorin) was made the state capital in 1967 which is just five years old from the date of creation to the date the image was taken. Fig 1

It is important to state again that settlement or built up as used here remains the focus of this study and as such no particular attention was given to the accuracy of the other classes
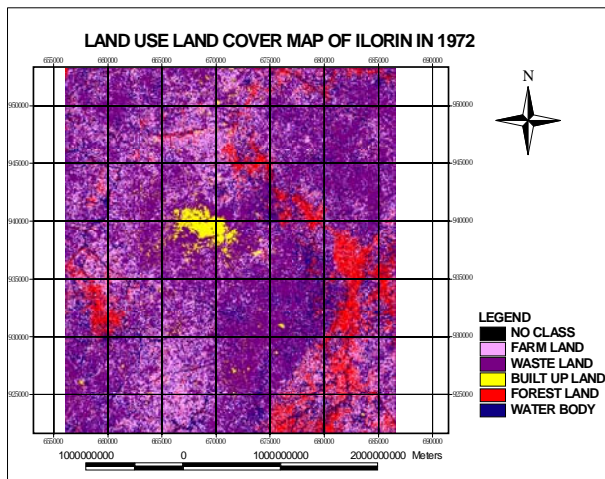

Figure 1

Land Land F1 Categories	1972 - 1986		1986 – 2001		Annual Rate of Change	
	Area (Ha.)	% Change	Area (Ha.)	% Change	72 - 86	86 - 2001
Farm Land	-16410.699	-17	6102.9216	7	14068.4949	1.05
Waste Land	14124.3777	16	-5243886	-7	50317.263	-1.05
Built-up Land	7504.5402	8	1113.1074	1	10815.921	0.15
Forest Land	4518.3838	10	-1432.809	-1	19960.2315	-0.15
Water Body	16874.6562	-17	-539.334	0	787.5576	0

Table 2 Land use land cover change of Ilorin and its   environs: 1972, 1986 and 2001

As indicated in the table above, built up land which denotes settlement has grown by 8%. This may not be unconnected to the fact that many projects were embarked on after the creation of Kwara State which also falls within the oil boom era of the 1970s and this attracted a lot of people to the area thus contributing to the physical expansion of the city as evident in the increased land consumption rate from 0.005 to 0.02 and land absorption coefficient by 0.09 between 1972 and 1986 as shown in table 3 below. Many of these projects include the Army barracks at Sobi, Adewole Housing Estate, the International Airport, Niger River Basin Authority Headquarters, University of Ilorin among many others which all encouraged migration into the city.

The period between 1986 and 2001 witnessed a drop in the rate at which the physical expansion of the city was going as against 1972 and 1986. For instance, the built-up land only increased by 1% as against the 8% increase between 1972 and 1986. This is also evident in the drop observed in the land absorption coefficient from 0.09 between 1972 and 1986. In deed, the austerity measure known as (SAP) introduced into the country at this period to restore the country's economy could be a major factor to what was witnessed at this period.

Year	Land Consumption Rate	Year	Land Absorption Coefficient
1972	0.005	1972/86	0.09
1986	0.02	86/2001	0.005
2001	0.01		

Table 3   Land Consumption Rate and Absorption Coefficient

Year	Population Figure	Source
1977	400,000	Eplan Group 1977
1984	480,000	Oyegun 1986
2001	689,700	Researcher's Estimate

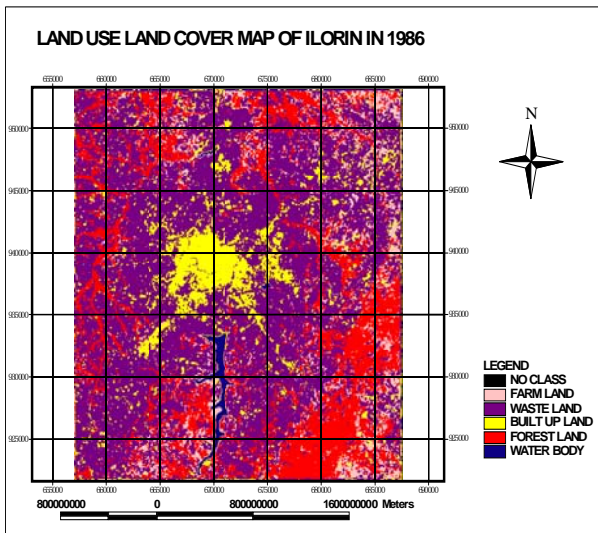Table 4   Population figure of Ilorin in 1977, 1984 and 2001

Figure 2

An important aspect of change detection is to determine the quantity of change. This information will serve as a vital tool in management decisions. This process involves a pixel to pixel comparison of the study year images through overlay.

In terms of location of change, the emphasis is on built-up land. Fig 4 shows this change between 1972 and 1986. The observation here is that there seem to exist a growth away from the city centre following the concentric theory of city growth in the literatures. Although the pattern seems to be uniform, there exist more growth towards the south western part of the city comprising of the Asa dam area, Adewole Estate and Airport. Between 1986 and 2001 as shown in Fig 6, there exist drastic reductions in the spatial expansion of the city. The only noticeable growths are on the edges of the developed areas of 1986 built-up land. For the projected change as shown in Fig 5, the edges of built-up land seems to have been filled up with developments by 2001 leaving the only noticeable developments to areas around the city centre. These therefore suggest that there might be a high level of compactness in Ilorin by 2015.
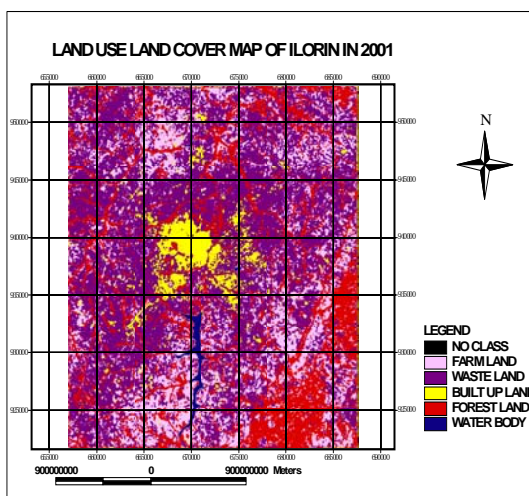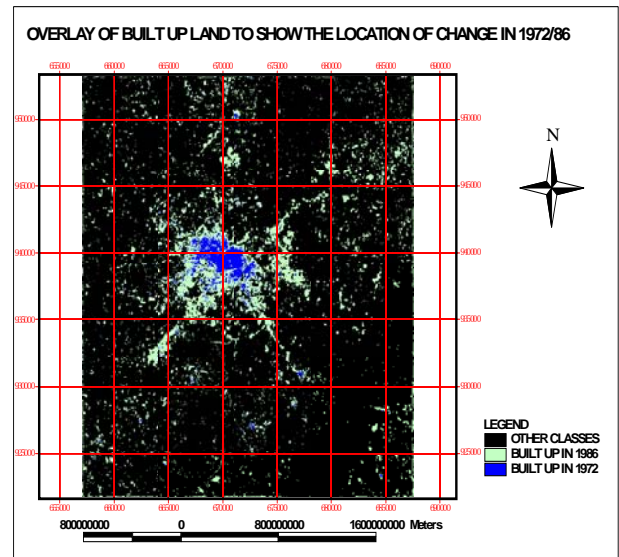

Figure 3

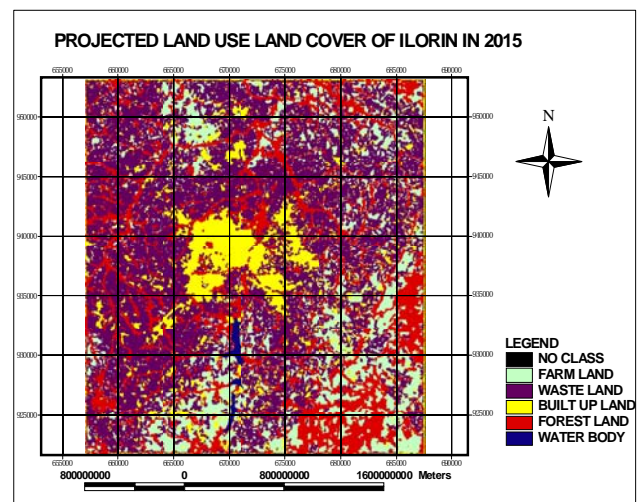Figure 4   Derived from the overlay of 1972 and 1986 land use land cover map
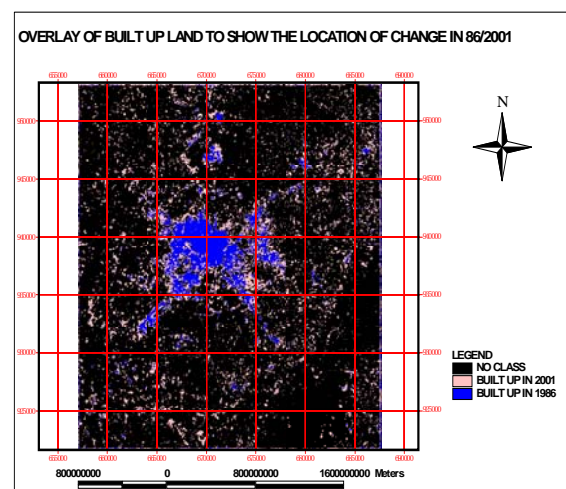

Figure 5

Figure 6 Derived from the overlay of 1986 and 2001 Land use land cover map

Land Use Land Cover Classes		Farm Land	Waste Land	Buil-Up Land	Forest Land	Water Body
2015	Area In Ha	16583.55	47432.48	11026.45	20397.88	509.12
	Area In %	17	50	11	21	1

Table 5   Projected Land use land cover for 2015

The table above shows the statistic of land use land cover projection for 2015. Comparing the percentage representations of this table and that of table 2, there exist similarities in the observed distribution particularly in 2001. This may tend to suggest no change in the classes between 2001 and 2015, but a careful look at the area in hectares between these two tables shows a change though meagre. For instance, built up seems static when observed from the percentage column but a careful look at the area shows a growth of 210.535 in hectares.

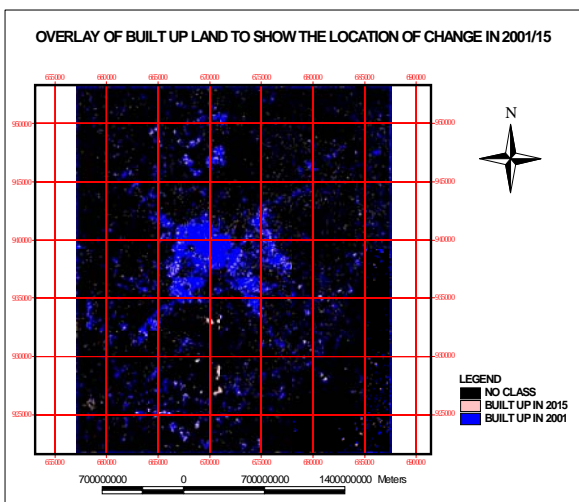As seen in fig 6, there is likely to be compactness in Ilorin by 2015 which signifies crowdedness

OVERLAY OF BUILT UP LAND TO SHOW THE LOCATION OF CHANGE IN 2001/15

LEGEND
NO CLASS
BUILT UP IN 2015
BUILT UP IN 2001

Figure 7   Derived from the overlay of 2001 and 2015 Land use land cover map

10. DISCUSSION

➢ Indeed, between the period of 1986 and 2001, there has been a reduction in the spatial expansion of Ilorin compared to the period between 1972 and 1986. There is a possibility of continual reduction in this state over the next 14yrs. This may therefore suggest that the city has reduced in producing functions that attracted migration into the area. Indeed, there have been many defunct industries within this period. It is therefore suggested here that Kwara State government should encourage investors both local and foreign and more importantly, see how the defunct industries will come up again.

➢ Land consumption rate which is a measure of compactness which indicates a progressive spatial expansion of a city was high in 1972/86 but drop between 1986 and 2001 and this drop is also anticipated before 2015.

➢ Also, land absorption coefficient being a measure of consumption of new urban land by each unit increase in urban population which was high between 1972 and 1986, reduced between 1986 and 2001. This therefore suggests that the rate at which new lands are acquired for development is low. This may also be the trend in 2001/2015 as there seems to be concentration of development at the city centre rather than expanding towards the outskirts. This may be as a result of people's reluctance to move away from the centre of activities to the outskirts of the city. It is being suggested here that the Kwara Sate government should make effort in developing the outskirts so that development will spread evenly in the State and particularly in the city.

11. CONCLUSION

This paper demonstrates the ability of GIS and Remote Sensing in capturing spatial-temporal data. Attempt was made to capture as accurate as possible five land use land cover classes as they change through time. Five classes were distinctly produced for each study year but with more emphasis on built-up land settlement as it is a combination of anthropogenic activities that make up this class; and indeed, it is one that affects the other classes. In achieving this, Land Consumption Rate and Land Absorption Coefficient were introduced into the research work.

The result of the work shows a rapid growth in built-up land between 1972 and 1986 while the periods between 1986 and 2001 witnessed a reduction in this class. It was also observed that change by 2015 may likely follow the trend in 1986/2001 all things being equal.

REFERENCES

Adeniyi P.O and Omojola A. (1999) *Landuse landcover change evaluation in Sokoto – Rima Basin of North Western Nigeria based on Archival__of   the Environment (AARSE) on Geoinformation Technology Applications for Resource and Environmental Management in Africa*. Pp 143-172.

Arvind C. Pandy and M. S. Nathawat 2006. *Land Use Land Cover Mapping*

Through Digital Image Processing of Satellite Data – A case study from Panchkula, Ambala and Yamunanagar Districts, Haryana State, India.

Brunhes, J. 1925 *La Gegrahie Humaine,*Paris
Daniel, et al, 2002 A comparison of Landuse and Landcover Change Detection Methods. *ASPRS-ACSM Annual Conference and FIG XXII Congress* pg.2.

Dimyati, et al.(1995). An Analysis of Land Use/Land Cover Change Using the Combination of MSS Landsat and Land Use Map- A case study of Yogyakarta, Indonesia, *International Journal of Remote Sensing* 17(5): 931 – 944.

Leong, G.C & Adeleke B.O 1992 *Certificate Physical and Human Geography for senior secondary schools*, Oxford University press, Nigeria

Meyer, W.B. 1995. *Past and Present Land-use and Land-cover in the U.S.A. Consequences*. p.24-33.

Olorunfemi J.F (1983). Monitoring Urban Land – Use in Developed Countries – An aerial photographic approach, *Environmental Int.*9, 27 – 32.

Riebsame, W.E., Meyer, W.B., and Turner, B.L. II. 1994. Modeling Land-use and Cover as Part of Global Environmental Change. *Climate Change*. Vol. 28. p. 45.

Singh, A. 1989. Digital Change Detection Techniques Using Remotely Sensed Data. *International Journal of Remote Sensing*. Vol. 10, No. 6, p. 989-1003.

Yeates, M and Garner, B. (1976). *The North American City*, Harper and Row Pub. New York.

ACKNOWLEDGEMENT