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# The Dynamics of Land Use Land Cover Change: Using Geospatial Techniques to Promote Sustainable Urban Development in Ilorin Metropolis, Nigeria

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**Abstract**

Land change dynamics was studied and analyzed across the plains of Metropolitan Ilorin between 1986 and 2010. A statistical sampling design, Landsat satellite data and Geographical Information System tools were used to efficiently identify patterns of land conversion. Variability of change ranged from approximately 2 percent to greater than 50 percent, and progressed at an uneven pace. Indicative of the changes is a sequence of agricultural expansion before 1986 followed by widespread conversion to built up area by 2000 and beyond. Pattern and magnitude of conversions influenced by contextual conditions of land quality, population increase, plus economic and policy drivers. The sporadic expansion of settlements, especially the built up areas in and around the study area, resulted in rapid diminishing and conversion of other land cover types to more built up environment and thus aaccentuating urban agglomeration of Ilorin. It is recommended that various Government regulatory authorities embark on careful urban planning by strickly allocating land for various designated purposes and ensure continous monitoring of physical developments so as to safeguard distortions to the urban environment of Ilorin.

**Keywords:** Land use, Land cover, Environment, Settlement, Built up areas, Geospatial techniques,



## 1. Introduction

Studies have shown that there remain only few portions of the 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 observable pattern in the land use and land cover over time. 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.

There has been tremendous growth and development in Ilorin, the Kwara State, capital in some aspect like building construction, road construction, deforestation and many other anthropogenic activities, since its inception in 1967 like every other state capital in Nigeria. The aforementioned growth have led to increased consumption of land as well as modification and alterations in the originality of her land composition both land use and land cover over time without any comprehensive and pressing step ( as provided by remote sensing and GIS data) to evaluate the status as it changes over time with view to detecting the land consumption rate and also make to predict same and the possible changes that may occur in this status so that planners can have a basic tool for planning.

Urban land is constantly and rapidly changing due to various human development activities and natural conditions. Therefore, the management of urban environment involves procedures of monitoring and modelling which require reliable information base and robust analytical techniques. Conventional surveying and mapping methods cannot deliver the necessary information in a timely and cost effective manner. Remote sensing and GIS given their cost effective and technological soundness are increasingly being used to develop useful sources of information and to support decision making in connection with a wide array of urban applications [1].

This study is aimed at producing a layout of land use and land cover of Ilorin at different epochs in order to detect the changes that have taken place particularly in the built-up land (settlement) and to predict changes that might take place in the same location over a given period using remote sensing techniques.

## 2. Literature Review

Land cover refers to the physical materials on the surface of a given parcel of land, while land use refers to the human activities that takes place on or make use of land e.g. residential, commercial, industrial etc. Gupta and Srivastava [2] described urban landscape as land use that is perceived as a way by which human beings utilize land while land cover exists as a natural environmental system. They stated further that change detection in land use and land cover can be obtained on a temporal scale such as by considering decades to assess landscape change resulted due to anthropogenic activities on the land. These anthropogenic activities on land are the consequence of rapid urbanization and industrialization.

Zubair [3] used remote sensing and GIS technologies to detect the land use and land cover changes in Ilorin, Nigeria from 1972 to 2001 by Landsat TM images of 1972, 1986, and 2001. He has used Maximum likelihood algorithm of supervised classification method to delineate five land use and land cover classes for the study, namely: farmland, wasteland, forest, built-up and water-bodies.

Nigam [4] applied RS and GIS for land use / land cover mapping and change detection in the rural urban fringe area of Enchede City, the Netherlands. He evaluated the effectiveness of High Resolution Satellite data and computer aided GIS techniques in assessing the landuse change dynamics within Enschede city, from 1993 to 1998 and thus hot links and user interface were developed so that the information can be provided to the user with a well-documented procedure using Arc view environment.

However, there are still limitations in this study as delineation of built up boundaries was based on image classification alone. Higher accuracy may be achieved using Vegetation Soil Water [VSW] Index or Normalized Difference Vegetation Index [NDVI] Shigenobu, et al. [5] applied this approach to delineate new urban areas in Bangkok metropolitan region in Thailand. By the late 80s and early 90s most studies have gone beyond just monitoring urban growth to examining impacts of these growth on Land use/land cover changes.

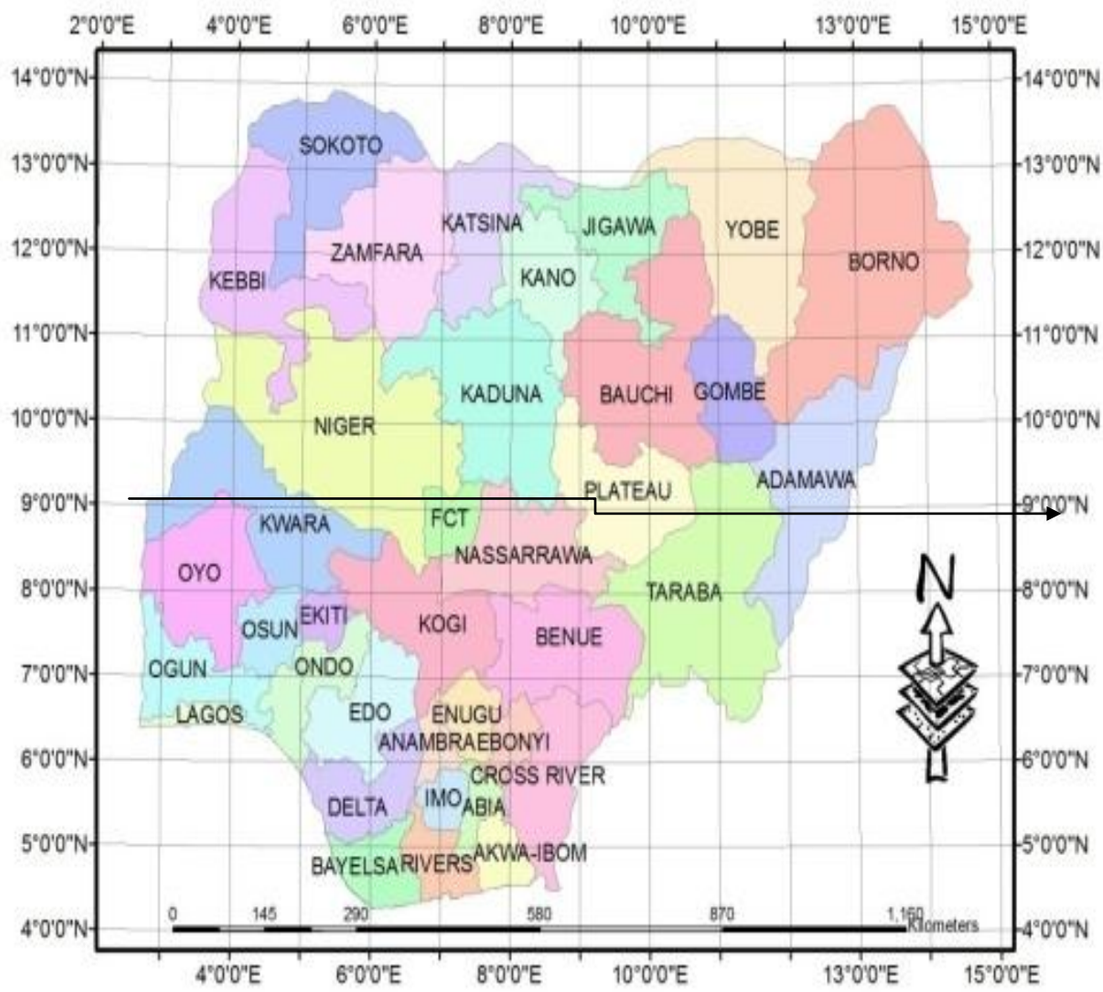
Abubakar, et al. [6] in their study on assessment of environmental degradation using satellite remote sensing technologies, examine landuse/landcover changes in Talata Mafara area of Zamfara state, Nigeria. Their results showed that changes among six land use / land cover classes between 1986 and 1995, Agricultural land increased from 117.00 $km^2$ to 158.50 $km^2$, while grass, shrub and thicket Land cover decreased from 20.13$km^2$ to 12.50 $km^2$. There was a drastic increase in bare surfaces from 5.38 $km^2$ to 27.13 $km^2$. Settlement showed a slight decrease from 1.25 $km^2$ to 1.13 $km^2$ rather than the expected growth. Uncultivated vegetated wetland also showed a decrease from 14.63 to 8.25 $km^2$ and Water bodies increased from 3.88 $km^2$ to 5.00 $km^2$.

Symeonakis, et al. [7] in their study on land use and land cover change and land degradation study in Spain and Greece using RS and GIS succeeded in mapping the various types of LULC in Alicante province in South East Spain and the Aegeon Island of Lesbos, Greece. They achieved these using the land sat data and the fuzzy classification and convolution modules of Erdas Image 8.5 software. Five (5) fuzzy layers per pixel were used and the resulting classified images were assessed using 100 random points and the aerial photographs as ground truth. The 1978 clssification indicate the catchment area was covered by various types of orchards, with an approximate area of 12392 ha of the entire catchment. The second LULC type in terms of area covered was matorral 7541 ha, thirdly is bare land 7363 ha, fourthly forest, 1039 ha, fifthly urban 889ha and lastly horticultural 879ha. For the year 2000 matorral had increased to 940 ha, orchard decreased to 895 ha, bare land decreased to 650 ha, horticulture increased to 2527 ha, urban increased to 1937 and forest decreased to 817 ha.

### 2.1. The Study Area

The study area (Ilorin) is the capital of Kwara State. It is located on latitude $8^0$ 31' N and $4^0$ 35' E with total land area of about 100 $km^2$ [8]. It is situated on the transitional zone between the Forest and the Savanna region of Nigeria and therefore serve as a "melting point" between the Northern and Southern culture". Ilorin falls into the Southern Guinea Savanna Zone. This zone is a transition between the high forest in the Southern part of the country and the North with woodland characteristics.

The geology consists of pre-Cambrian basement complex with an elevation which ranges between 273 meter to 333 meter in the West and 200 meter to 364 meter in the East. The landscape of the region (Ilorin) is relatively flat and this means it is on a plain and is dissected by two rivers; River Asa and River Oyun which form the core of the drainage system, flowing in a North – South direction and thus dividing the plain into two; Western and Eastern parts [9].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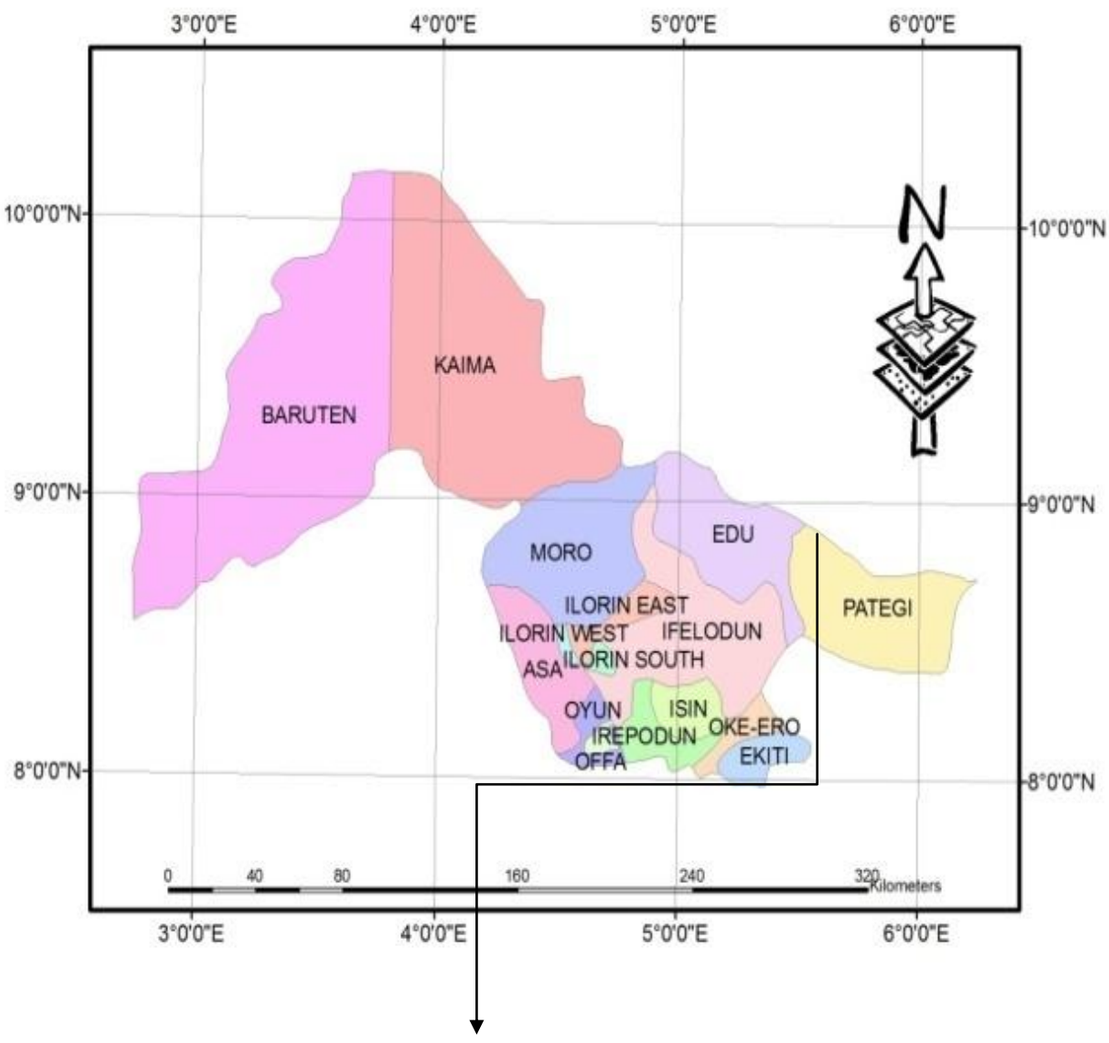
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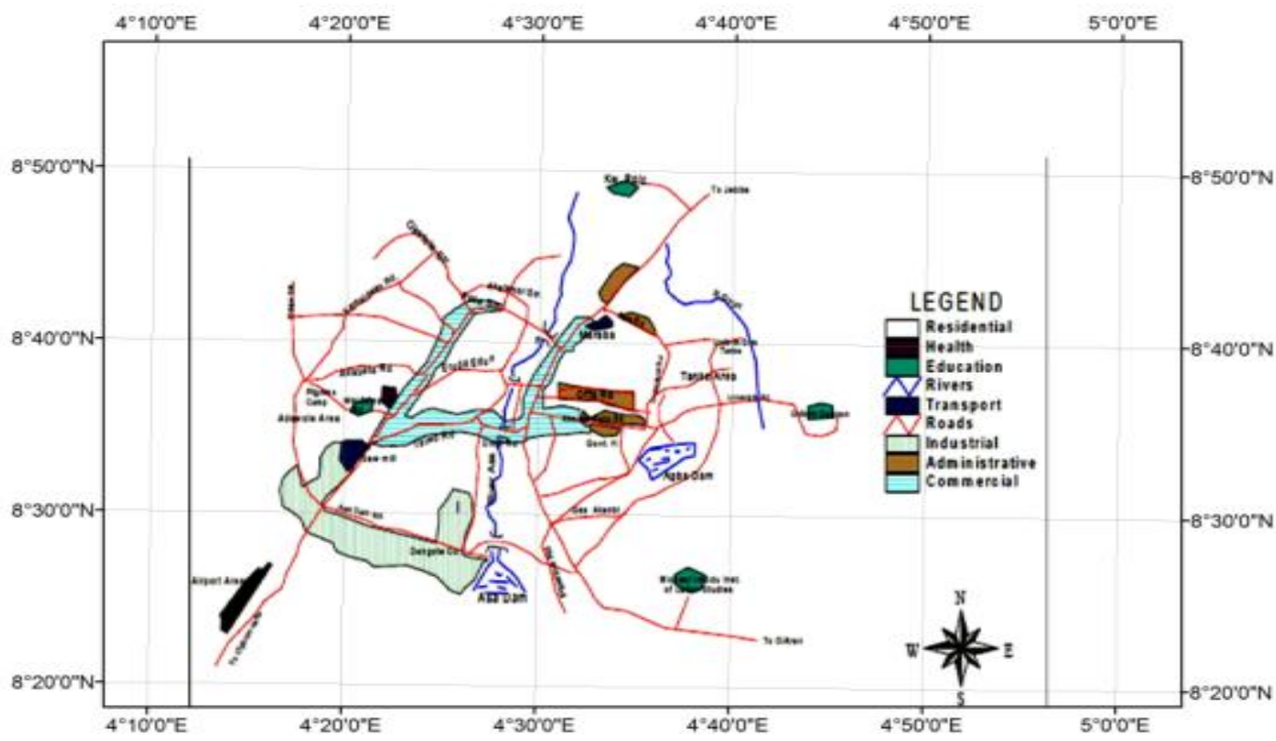


Oyegun [10] noted that Ilorin is one of the fastest growing urban centers in Nigeria, with the rate of population growth and areal extent at a fast pace since 1967, which is much higher than for most cities in Nigeria. He supported his claim, stating that Ilorin the town had an estimated population of 40, 990 in 1952, 208, 546 in 1963, 474, 835 in 1982 and in 1984, the population was 480, 000. This trend in population growth is rapid and the growth rate between 1952 and 1963 according to Oyebanji [11] is put at 16 percent which is higher than other cities in the country. The population as estimated by the 1991 population census was put at 570,000.

## 3. Materials and Methods

The data used for this research include;

(i) Landsat satellite imageries of Ilorin, Kwara State for 1986, 2000 and 2010 were collected and utilized for this study. The 1986 and 2000 imageries were sourced from Global Land Cover Facility (GLCF) and the 2010 imageries was sourced from National Space Research and Development Agency (NASRDA), Abuja, Nigeria.

(ii) ArcGIS 10.1 was used for the display and processing of the data, Ilwis was used for the development of land use and land cover classes and for change detection analysis of the study area and Idrisi; for projecting future change.

(iii) Markov Chain and Cellular Automata Analysis for predicting change was utilised for data analysis. Markovian Chain Analysis describe land use change from one period to another and this is used to form the basis for projecting 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 .

(iv)The transition probability may be accurate per category basis. However, it does not provide knowledge of the spatial distribution of occurrences within each land use category. 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. In essence, the CA developed a spatially explicit weighting of more heavily areas that proximate to existing land uses. This ensure that land use change occurs proximate to existing like land use classes and not wholly random.

## 4. Results and Discussion

Figures 2, 3 and 4 depicts the pattern of Land use Land cover change in Ilorin for 21 year period (1986 to 2010); and the projected change for the year 2020. The figures indicated increase in the percentage of built up areas and corresponding decrease in vegetal cover and farmlands

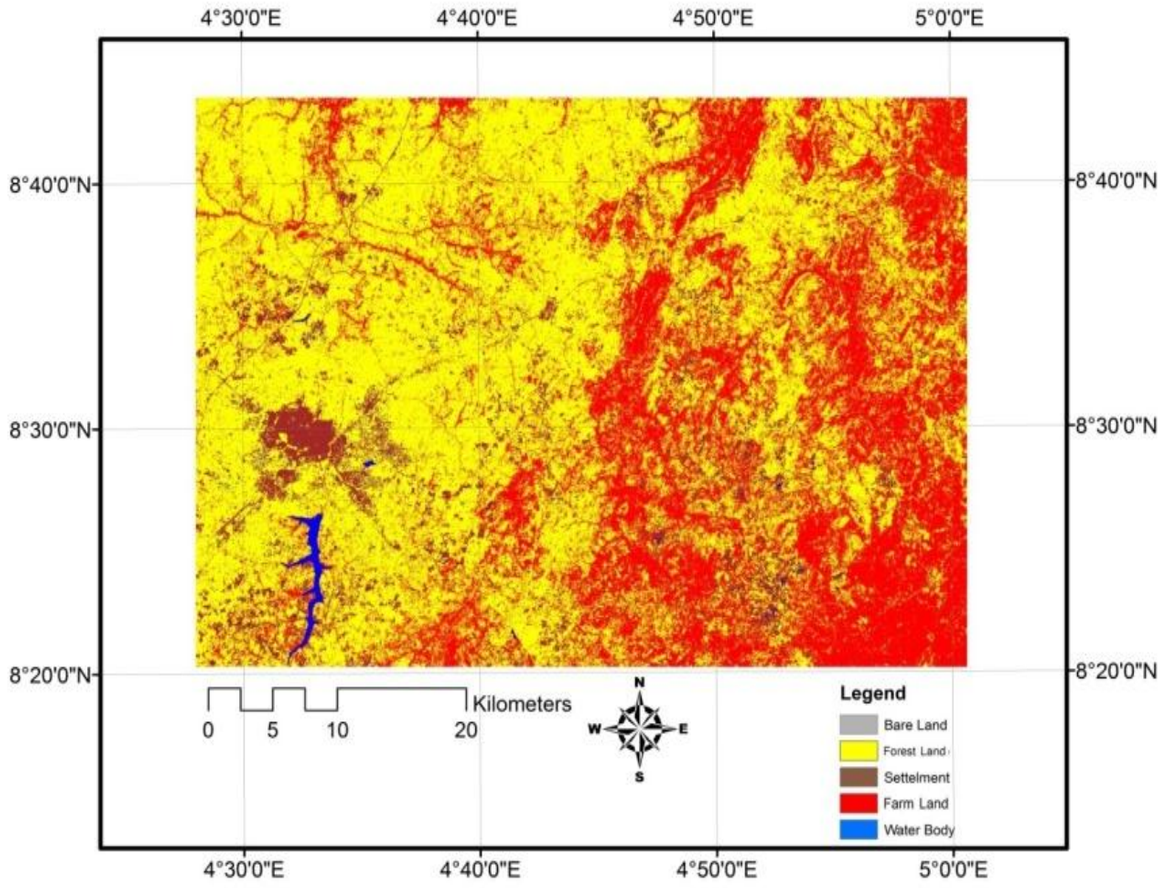


**Figure-2.**Land use / Land Cover Ilorin (1986)

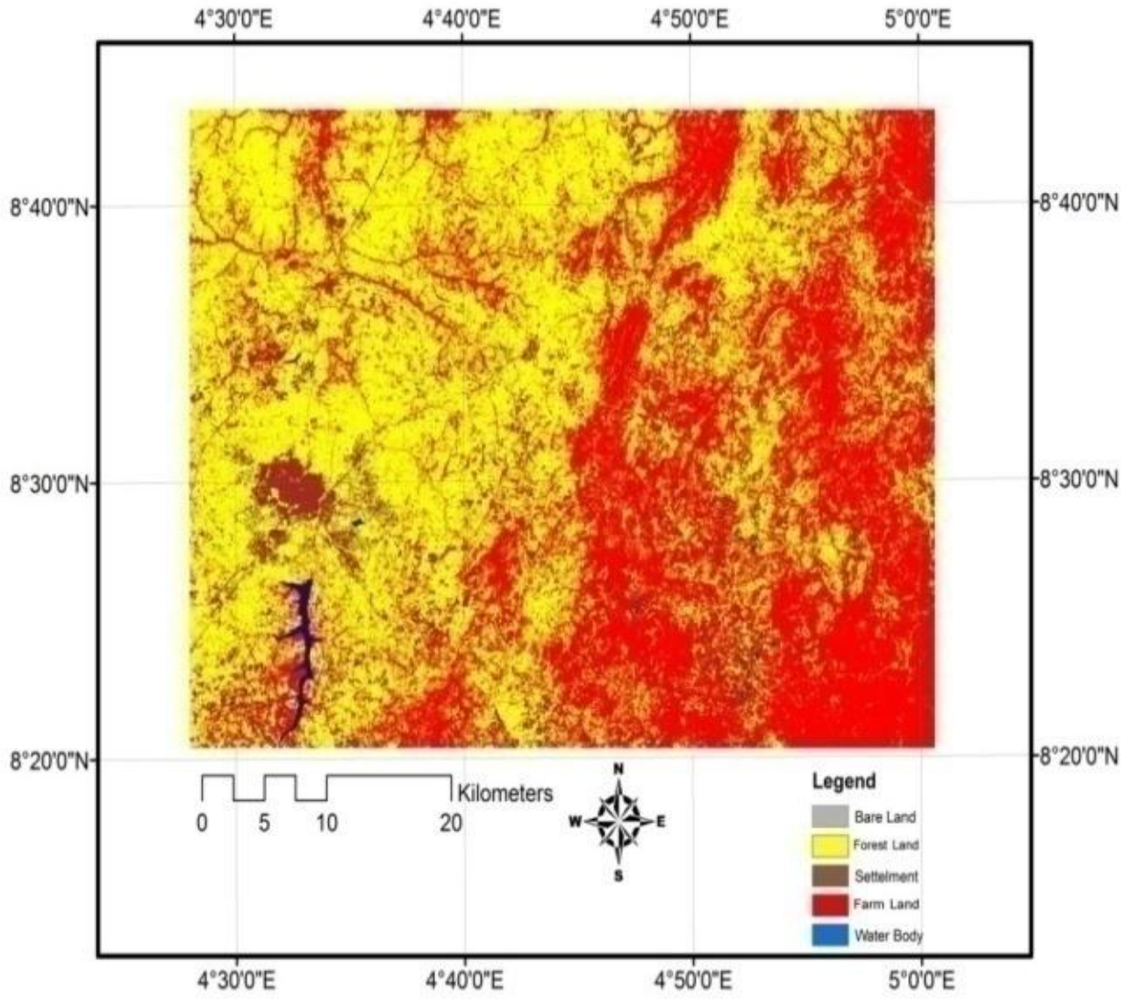


**Figure-3.** Land use/Land cover of Ilorin (2000)

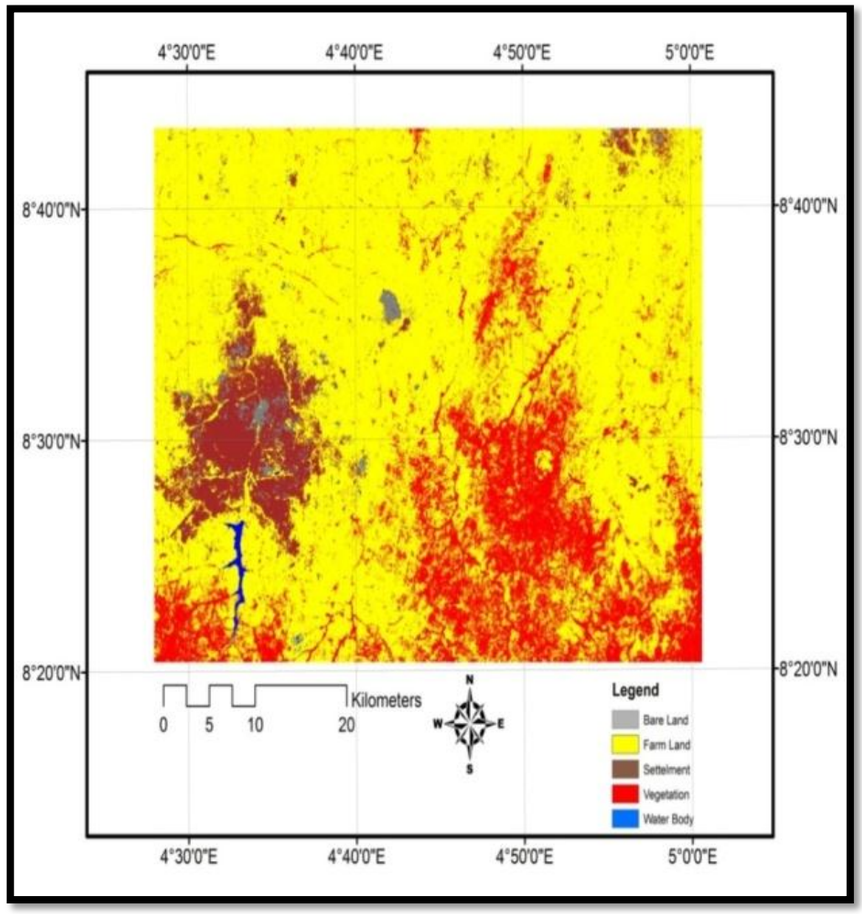


**Figure-4.**Land use / Land Cover of Ilorin (2010)

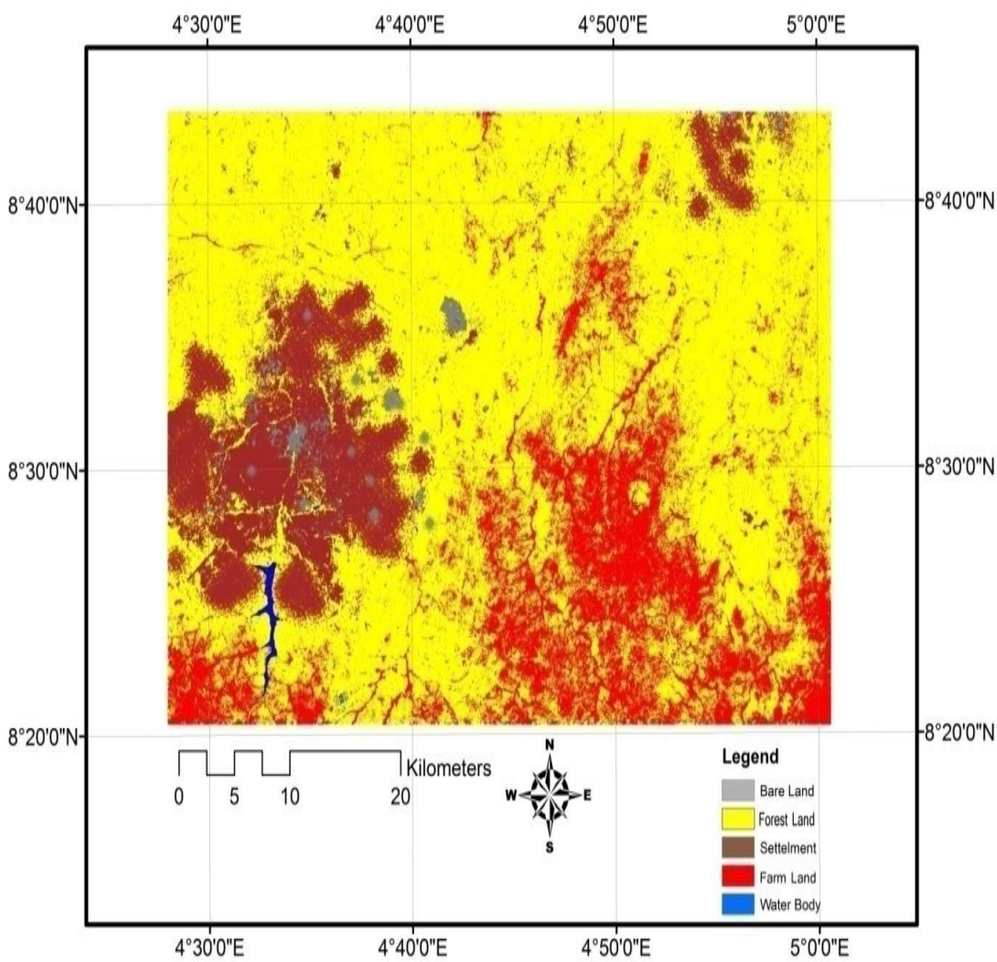


**Figure-5.**Land Use Land Cover Projection for Ilorin (2020)

**Table-1.** Categorised Land use/Land Cover Statistics for Ilorin (1986)

| Categories | Area Covered (Hectares) | % of the total Land cover |
|---|---|---|
| Bare lands | 49409.1 | 21.6 |
| Forestland/Vegetation | 119588.1 | 52.2 |
| Built-up Areas | 28980.2 | 12.6 |
| Farmlands | 30008.0 | 13.1 |
| Water Bodies | 1064.6 | 0.5 |

**Table-2**. Categorised Land use/Land Cover Statistics for Ilorin (2000)

| Categories | Area Covered (Hectares) | % of the total Land cover |
|---|---|---|
| Bare lands | 33105.1 | 14.5 |
| Forestland/Vegetation | 119588.1 | 52.1 |
| Built-up Areas | 41026.2 | 17.9 |
| Farmlands | 43266.0 | 15.0 |
| Water Bodies | 1064.6 | 0.5 |

**Table-3.** Categorised Land use/Land Cover Statistics for Ilorin (2010)

| Categories | Area Covered (Hectares) | % of the total Land cover |
|---|---|---|
| Bare lands | 33805. 1 | 14.8 |
| Forestland/Vegetation | 111116.0 | 48.5 |
| Built-up Areas | 49863.2 | 21.8 |
| Farmlands | 33205.1 | 14.5 |
| Water Bodies | 1060.6 | 0.4 |

**Table-4.** Categorised Land use/Land Cover Statistics for Ilorin (2020)

| Categories | Area Covered (Hectares) | % of the total Land cover |
|---|---|---|
| Bare lands | 35044.6 | 10.0 |
| Forestland/Vegetation | 104675.9 | 20.0 |
| Built-up Areas | 58178.7 | 59.8 |
| Farmlands | 30463.6 | 10.0 |
| Water Bodies | 687.1 | 0.2 |

Tables 1, 2, 3 and 4 shows the classifications of land use and land cover in Ilorin. Five categories were identified; namely; bare lands, forested/vegetated lands, built up areas, farmlands and water bodies.

As at 1986, forest and other vegetal covers account for over 52 percent of total land cover of Ilorin. The built up areas and water bodies accounted for 12.5 percent and 0.5 percent respectively (Table 1). However, built up areas increased from 12 percent in 1986 to 18 percent in the year 2000. Within the same period, bare land decreased from 21 percent to 14 percent. No significant change was recorded in other land use patterns (Tables 2, 3 and 4).

**Table-5.**Comparative Distribution Statistics of Land use Land Cover Pattern forIlorin (1986 - 2020)

| | Year | | | |
|---|---|---|---|---|
| Categories | 1986 | 2000 | 2010 | 2020 |
| Bare lands | 21.6 | 14.5 | 14.8 | 10.0 |
| Forestland/Vegetation | 52.2 | 52.1 | 48.5 | 20.0 |
| Built-up Areas | 12.6 | 19.3 | 21.8 | 59.8 |
| Farmlands | 13.1 | 13.6 | 14.5 | 10.0 |
| Water Bodies | 0.5 | 0.5 | 0.4 | 0.2 |
| Total | 100 | 100 | 100 | 100 |

It became evident that enormous changes in land use occurred as a result of sporadic urban growth that Ilorin witnessed in recent times. The territorial extent of farmlands, vegetation and water bodies have been greatly tampered with, as a result of human activities through exploitation and development of built up areas. The continuous increase in built up areas is due to increase in the inflow of population that places heavy demand on the environment and thus leading to great increase in the size of the settlement in both the city center and the surburbs (Table 5).

The land use land cover change projection to the year 2020 shows that there is going to be further population increase in Ilorin. This will be necessited by net gain due to immigration and uncontrolled birth rate.

## 5. Conclusion and Recommendations

The sporadic expansion of settlements, especially the built up areas in and around the study area, resulted in rapid diminishing and conversion of other land cover types to more built up environment and thus aaccentuating urban agglomeration of Ilorin. It is recommended that various Government regulatory authorities embark on careful urban planning by strickly allocating land for various designated purposes and ensure continous monitoring of physical developments sos as to safeguard distortions to the urban environment of Ilorin.

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