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Geospatial Analysis of Land Use/Land Cover Changes in Monitoring Urban Sprawl in Ede, Osun State, Nigeria.

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Abstract*:* This paper examines the trend of urban sprawl and land use/land cover changes in Ede between 1991 and 2018 with the view of investigating the direction of the continuous expansion of the city. Much of this is due to rural urban migration of people in search of higher education, jobs and or higher standards of living. This is the case of Ede town and its surrounding. The trends of urban sprawl appear to be haphazard in Ede town with the increase population. A lot has happened within the last fifteen years and the impact is hugely felt on land and natural resources. With the population of Ede town expected to grow even further, there is need to assess the extent of urban sprawl. The underlying problem in this paper was based on the fact that a lot of land in Ede town has seen major changes in use and a lot of urbanization activities are witnessed especially along the major roads without development control measures. The main goal of this paper was to analyzing spatial dimension of land use changes to monitor urban sprawl using GIS and Remote Sensing techniques. To achieve this main objective, a joint approach of non-spatial and spatial techniques was used in the methodology of the study. The pattern of urban sprawl was identified and modelled using remotely sensed data. The analysis in this paper included land cover and land use, spatial and temporal changes and urbanization growth pattern recognition as well as non-spatial analysis such as environment and economic indicators. In view of this, this paper suggests effective zoning strategy to check the indiscriminate nature of urban expansion whose effects on land use are well prominent in the study area. Adequate monitoring by the Development Control Department and other stakeholders in urban planning is equally suggested to mitigate the incompatible land use change in the area.

Keywords: - Geo-spatial, GIS and Remote Sensing, Land Use/Land Cover, Monitoring and Urban sprawl.

1.0 INTRODUCTION

Ede town has experienced rapid growth in the past two to three decades which has led to the expansion of the core urban areas of the town into adjoining rural lands. Land use change is a noticeable feature of any growing society since the advent of human civilization. In recent times there has been a rampant growth of towns and cities in this state. This growth has been accompanied with an ever increasing physical, social and the technological changes as well as complex Urban Pattern of development. This fast development with its attendant sprawling effects on the original settlement and town out skirted always cause some land use congestion. Personal and political pressures etc. within and around the area involved. According to Aguda and Olayiwola (2011) stated that the most noticeable problems in many African countries are those that relate to economic, political and social challenges. The economic problem, according to them, relate to poverty and political problems which have to do with bad governance and corruption while the social problems is more of the rapid population increase especially within the major urban areas where more than half of the population live. Urbanization worldwide continues at a rapid rate and it is estimated by the united nations population fund 1999 that by the year 2025, 80% of the world population would live in cities most major metropolitan area faces the growing problem of urban sprawl. Residential and commercial development is replacing underdeveloped lands at an unprecedented rate. These urban sprawl result in the loss of natural vegetation, open spaces and at most the productive agricultural lands while the move to suburbs have brought a lot of benefits to the average citizen, it has also caused numerous urban problem. Cities that were once compact now spread over the landscape, consuming open spaces and wasting resources. This pattern of urban growth is known as sprawl (Cunningham, 2002). The natural environment particularly in Nigeria is gradually going into extinction at a rapid rate due to increasing population which is accompanied by demand for resources. The need for more habitats, places to live and protect ourselves from the various factors of environment, has led to the destruction of natural resources. Due to serious anthropogenic activities, the earth surface is being significantly altered in several ways. Forest and vegetation covers are getting depleted day by day at a greater rate. In view of the above, this study assesses the trend, rate and spatial patterns of urban sprawl around Ede fringe areas to generate and provide geo-spatial information for the realization of the main objective of the National Urban Development Policy which is "to ensure that land is available for the purpose of controlled and orderly development in the urban areas" (Agbola, 2006). There is need for land use data in the analysis of environmental processes and problems that must be understood if living conditions and standards are to be improved or maintained at current levels.

2.0 Study Area

This study is carried out in Ede Town covering two local government areas (LGAs) in Osun state namely: Ede North and Ede South. These two LGAs make the most part of the popular ancient city. It lies between latitudes 7º36`N and 7º46`N of the equator and on longitudes 4º22`E and 4º34`E of the Greenwich meridian. in the Southwestern Nigeria. The people engage in farming, trading and commercial activities are found on a large scale because of the central nature of the town and closeness to major cities like Osogbo, Iwo, Ife and Ejigbo. Ede is important in the history of the State due to the presence of the Federal Polytechnic, Redeemer's University and Adeleke University , railway tracks connecting Lagos and Northern Nigeria, River Osun which passes through the town and Ede Water Works that supplies water to about twenty (20) local governments in the state. The population is put at 159,866 according to the 2006 Population Census. The landscape of the region (Ede) is relatively flat this means it is located on a plain terrain.

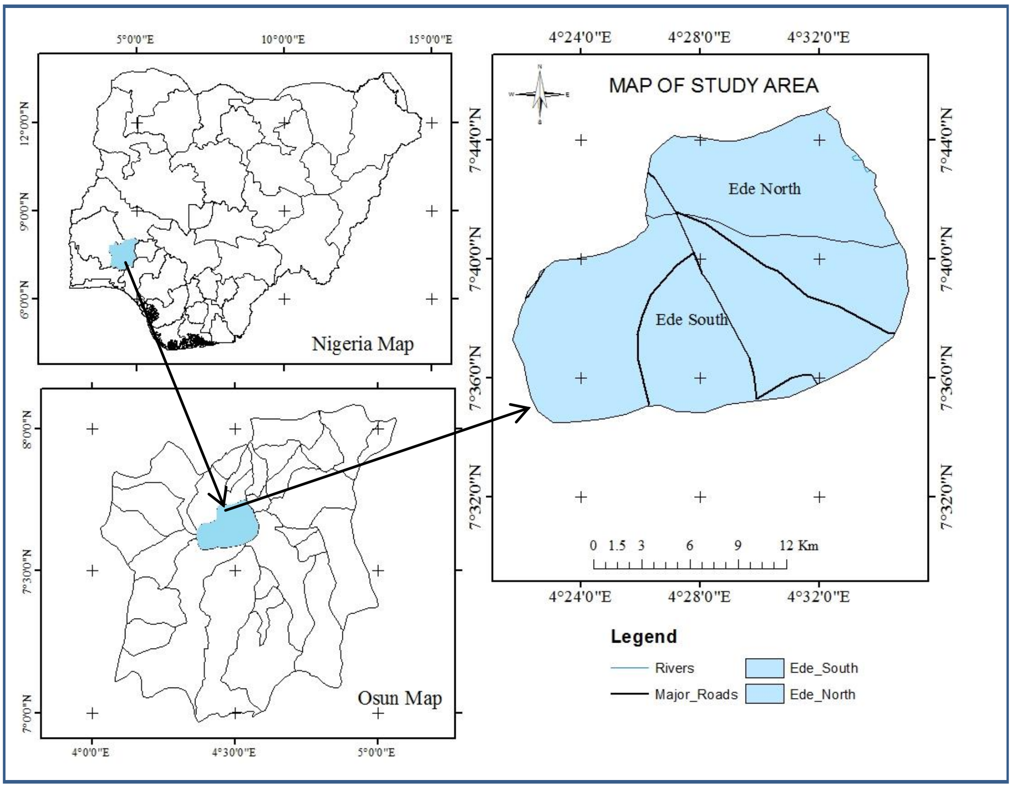

Figure: 1. Map of study Area, Ede metropolis

3.0 METHODOLOGY

3.1 Data Acquisition and Sources

Data acquisition is very important aspect of GIS, the type of data obtained and the accuracy of the data is important because it determines the output of the information obtained. In carrying out this project, the following was undertaken: need assessment, data collection, data preparation and data analysis. Both primary and secondary data with spatial and non-spatial attribute were utilized. Those data include: Landsat images of 1991, 2002 and 2018 comprising of different band including band 4, 3, 2 and band 5, 4, 3 which was used in this study. The topographic map of Ede at scale 1:50000 was also used for the study. The Landsat imageries used in

this study were downloaded from the Earth Explorer while the topographic map was acquired from the Office of the Surveyor General, Osun state, the characteristic of this data are shown in table 3.1. The images were made to pass through processes of image enhancement, geo-referencing, image classification and digitizing. A supervised classification was performed on colour composites of band 2, 3, 4, and 3, 4, 5, the following landuse and landcover classes are identified; Built-up land, forest land, bare rock, agricultural land and water body.
The spatial resolution of TM, ETM+ and OLI images are 30m for band under consideration. The pre-processing procedures to correct for geometric and radiometric errors as well as calibration of the images to percent reflectance were carried out. The selected images were geo-referenced in decimal degree coordinate system and rectified to correspond to the WGS1984 and UTM Zone-31N Coordinate System.

3.2 Satellite Data Processing

Knowledge of both Remote Sensing and Geographical Information Systems (GIS) was used to generate the land cover maps of the period in consideration (1991 – 2018) and to calculate the area in square kilometers of each land use type for each year in order to determine the change and percentage of change in the total area covered by that land use type. The first step taken during the course of this work, involved the extraction of the Area of Interest (AOI) in the study area. This was imperative granted that the images which were acquired covered Ede - North and Ede - South LGA (the study area). The geographical coordinates of the study area were extracted from the vectorised map of the same. The coordinate were then input in Idrisi environment using image windowing in the window toolbox. The output of this operation was an extract of the study area of the three image bands.
Colour composite creation was carried out using the false colour composite of band 4-3-2 for landsat image 1991 and 2002 while false colour composite of band 5-4-3 was used for landsat image 2018. The image classification process after establishment of the false colour composites involved creation of the map list, sample set creation and classification domain creation.
Having undertaking the above state stated steps and assigned commensurate number of pixels to various land use/land cover classes, each image was separately classified using the supervised classification maximum likelihood algorithm in Idrisi 17.0 Selva edition. Four separable land use/cover categories have been identified in this study for landsat image TM 1991 ETM+ 2002 and OLI 2018 such as Built-up land, forest land, agricultural land and water body. The classification made it possible to capture each land use type in polygons and calculations of the areas in square kilometres of each landuse/landcover was easily determined.

3.3 Rate of change of land use/land cover between 2002 and 2018

After the image processing and classification change detection function in Idrisi 17.0 selva edition using Land Change Modeler tools was used to compute the changes in the land use/land cover between 1991 and 2018. The change analysis panel provides a rapid assessment of quantitative change by graphing gains and losses by land cover categories.

3.4 Image Classification

Lnduse/Landcover classification used in this study was based on four categories which are, Built-up land, forest land, agricultural land and water body. Supervised classification through maximum likelihood algorithm was applied to perform image classification. This classification has been found to be the most commonly and widely used classifier. (Diallo et al., 2009; Dewan and Yamaguchi; 2009 Chandola and Vatsavai 2010).

The supervised classification requires training areas for each category. The training areas were used to define spectral reflectance pattern or signature of each LULC category. The signatures would then be used in classifying the pixels into a certain category which has the same spectral patterns using the classifier algorithm. Training areas of each category were created with the assistance of visual analysis on the images via the colour composite

(Band 2, 3, 4 and 3, 4, 5) and also using the ancillary information from the digital land use map and Google Earth.

Anderson et al., 1976 classification scheme was adopted in this study and five categories of classes of land use/land cover were identified which include; Built-up land, Forest land, Agricultural land and water body for 1991 and 2002 landsat images and 2018 image.

3.5 Accuracy Assessment

Accuracy assessment is the agreement between a standard assumed to be correct and a classified image of unknown quality." (Campbell, 2007) Precision defines the level of detail found within the classification. It is possible to increase the accuracy of a classification by decreasing the amount of detail or by generalizing to broad classes rather than very specific ones.

Classification error occurs when a pixel (or feature) belonging to one category is assigned to another category. Errors of omission occur when a feature is left out of the category being evaluated; errors of commission occur when a feature is incorrectly included in the category being evaluated. An error of omission in one category will be counted as an error in commission in another category. Accuracy assessment is performed by comparing the map created by remote sensing analysis to a reference map based on a different information source. One might ask why the remote sensing analysis is needed if the reference map to compare it to already exists. One of the primary purposes of accuracy assessment and error analysis in this case is to permit quantitative comparisons of different interpretations. Classifications done from images acquired at different times, classified by different procedures, or produced by different individuals can be evaluated using a pixel-by-pixel, point-by-point comparison. The results must be considered in the context of the application to determine which is the "most correct" or "most useful" for a particular purpose. (Karen Schuckman, John A. Dutton, 2015).

4.0 RESULTS AND DISCUSSION

4.1 Introduction

In order to achieve the set objective for this work different data analysis processes was carried out as specified in the methodology in the earlier chapter. Landuse/landcover types were analyzed, defined, mapped and presented in form of maps, table and charts.

Three different satellite images acquired in 1991, 2002 and 2018 within the same period were classified. The main classes of landuse/landcover classification scheme developed for the study are: Built-up Land, Forest land, Agricultural land and Water body.

Apart from the above four classes, other landuses in the study area include: open space, upland vegetation etc. However, the above four categories of landuse/landcover which are evidence from the satellite imageries was of paramount important for this work.

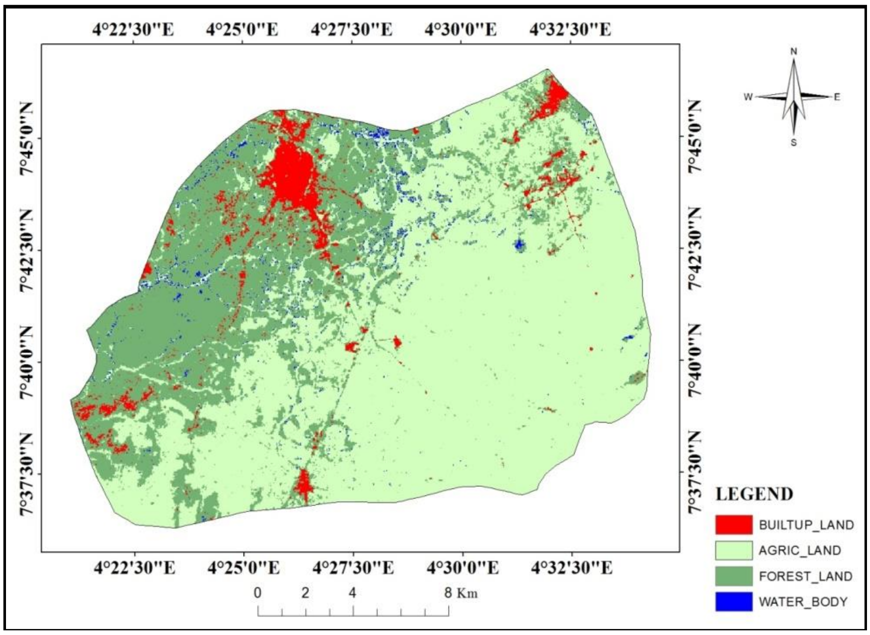

Figure 2. Land use / Land cover map of Ede 1991

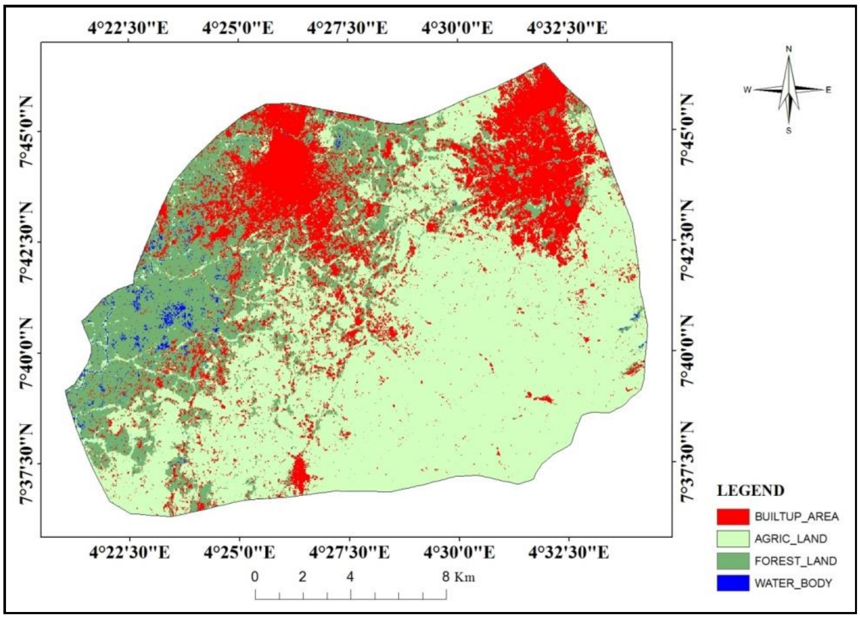

Figure 3. Land use / Land cover map of Ede 2002.

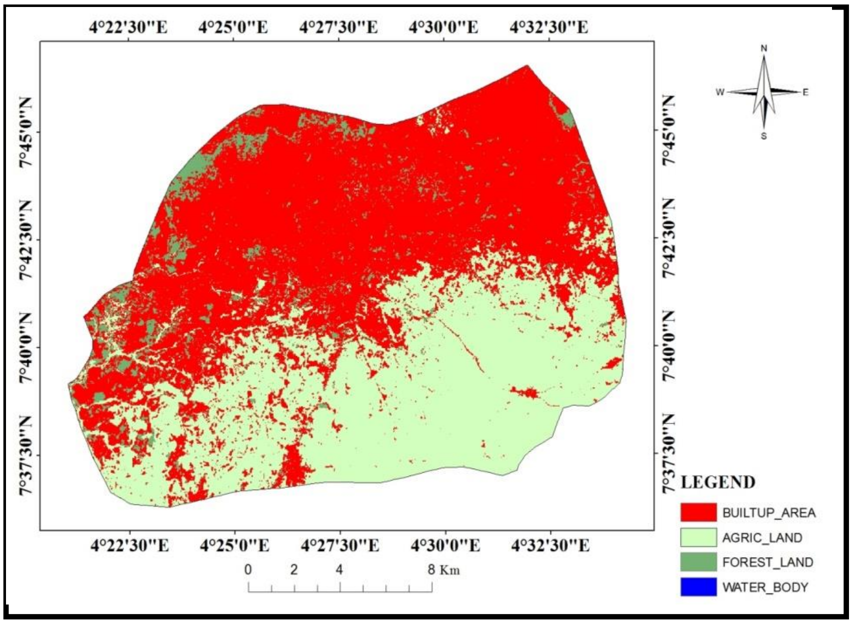

Figure 4. Land use / Land cover map of Ede 2018

The landuse/landcover changes of the study between 1991 and 2018 was analyzed and calculated from the classified multi-date imageries of 1991, 2002 and 2018. Four categories of landuse/landcover class were used for the change analysis. In addition, general comparative analyses were carried out on all the participating class in order to determine and appreciate the dynamic nature of the study area. After the classification and other post classification analysis, the class statistics which was automatically generated both in square kilometer and percentage and was use to carry out different analysis in Microsoft Excel.

Table 1: Class statistics in Square Kilometer (Km^2) and Percentage (%)

LULC CLASS	1991		2002		2018	
	km^2	%	km^2	%	km^2	%
Built-up Land	13.53	4.00	71.33	21.00	156.37	47.00
Agricultural Land	209.02	63.00	172.46	52.00	106.91	32.00
Forest Land	105.55	32.00	85.33	26.00	65.92	20.00
Water Body	3.45	1.00	2.44	1.00	2.35	1.00
Total	331.55	100.00	331.55	100.00	331. 55	100.00

Table 1. Show that in 1991, built-up land occupied about 4% (13.533Km^2) of the total 331.558 Km^2 of the study area. Forest land occupied 32% (105.548Km^2), Agricultural land cover 63% (209.022Km^2) and water body occupied 1% (3.454Km^2) respectively.

The result for 2002 shows that built-up land has increased to 21% (71.328Km^2), Agricultural land also decreased to 52% (172.462Km^2), water body decreased to 1% (2.44Km^2) while forest land reduced to 26% (85.828Km^2). In 2018, the results show that the built built-up land increased from 21% in 2002 to 47% (156.367Km^2) and agricultural land decreased to 32% of (106.915Km^2) while forest land also reduced to 20% (65.917), and water body reduced 1% (2.359Km^2) respectively.

Table 2 : Land use/land cover changes of Ede between 1991 and 2018

LULC CLASS	1991-2002		2002-2018	
	Diff. in Area		Diff. in Area	
	(Km^2)	%	(Km^2)	%
Built-up Land	57.80	17.00	85.04	26.00
Agricultural Land	-36.56	-11.00	-65.55	-20.00
Forest Land	-20.22	-6.00	-19.41	-6.00
Water Body	-1.015	0.00	-0.09	0.00
Total	0.005	0.00	-0.01	0.00

Source: Researcher fieldwork 2021

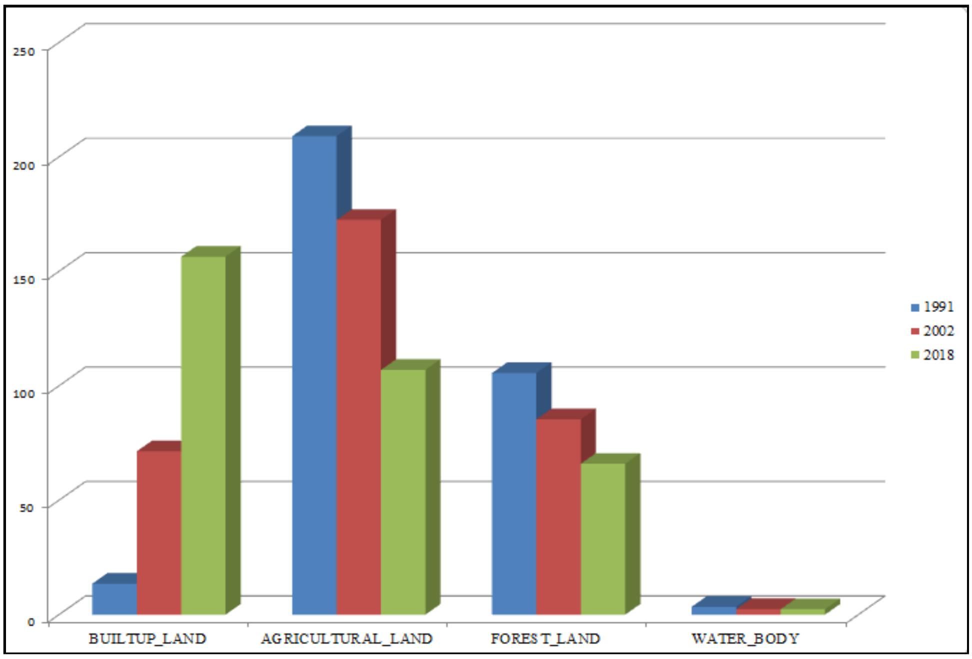

Figure 5. Comparative analysis of landuse/landcover change between 1991, 2002 and 2018

4.3 Interpretation and analysis of rate of changes of LULC between 1991 and 2018

Land use / land cover change is a gradual and constant process in every given geographical unit. However, past studies as indicated in the literature reviewed shows that spatial analysis of change is quite complex and depends on different data sets. In Ede, (the study area) land use/land cover change is visible and well pronounced using remote sensing techniques. Utilizing multidate satellite imageries of Ede between 1991 and 2018, i.e. a period of 27 years shows that landuse/landcover has witnessed change in pattern, structure and extent.

Table 4.3, and 4.4, present the degree, annual frequency and percentage of change. The degree of change for different year interval (1991-2002, 2002-2018 and 1991-2018) was calculated by subtracting the area of each landuse/landcover type of recent year from the former i.e 2002-1991. The percentage of change was calculated by dividing the degree of change of each landuse/landcover category by the value of the base year, then multiplying the result by 100.

Annual frequency of change was obtained by dividing the degree of change of each landuse/landcover category by the number of years between the periods under consideration. (See table 3, 4 and 5).

1991 landuse/landcover area = x1, 2002 landuse/landcover = x2

2018 landuse/landcover area =x3 Year Interval = a, Base Year = b

Therefore;

Degree of change = x2- x1

Annual frequency of change = $\frac{x2 - x1}{a}$

Percentage of change = $\frac{(x2 - x1) \times 100}{b}$

Table 3: Degree, Annual frequency and percentage of change between 1991-2002

	1991	2002	Degree	Annual Frequency	Percentage of Change
LULC CLASS	(%)	(%)	(Km²)	(Km²)	(%)
Built-up Land	4.00	21.00	57.80	5.25	68.11
Agricultural Land	63.00	52.00	-36.56	-3.32	-9.58
Forest Land	32.00	26.00	-20.22	-1.84	-10.59
Water Body	1.00	1.00	-1.02	-0.09	-17.32
Total	100.00	100.00	0.00	0.00	30.62

Table 3 shows the Degree, Annual frequency and percentage of change between 1991 and 2002. In details, built-up land, recorded a degree of change of 57.80 (km²) respectively, an annual frequency of 5.25(km²) respectively and percentage of change of 68.11 (%) respectively, while agricultural land, forest land and water body recorded a degree of change, annual frequency and percentage of change of -36.56, -20.22 (km²), respectively an annual frequency of -3.32, -1.84, -0.09 (km²) and percentage of change -9.58, 10.59, -17.32 (%) respectively. This indicates that between 1991 and 2002, agricultural land forest land and water body recorded a negative degree and annual frequency of change. (See table 3).

Table 4: Degree, Annual frequency and Percentage of change between 2002 and 2018

	2002	2018	Degree	Annual Frequency	Percentage of Change
LULC CLASS	(%)	(%)	(Km²)	(Km²)	(%)
Built-up Land	21.00	47.00	85.04	5.32	37.35
Agricultural Land	52.00	32.00	-65.55	-4.10	-23.46
Forest Land	26.00	20.00	-19.41	-1.21	-12.83
Water Body	1.00	1.00	-0.09	-0.01	-1.88
Total	100.00	100.00	-0.01	0.00	-0.82

Source: Researcher fieldwork 2021

In details built-up land recorded a degree of change, annual frequency and percentage change of 85.04, 5.32 (km²) respectively and 37.35 (%) respectively while agricultural land forest land, and water body recorded degree of change, annual frequency and percentage of change of -65.55, -19.41, -0.09 (km²) and -4.10, -1.21 and -0.01 (%) respectively. (See table 4).

4.4 Change detection analysis using LCM method

A number of LUCC models have been developed; however it is difficult to compare which one gives more accurate representation (Wu & Webster 2000). Among the numbers of land use modeling tools and techniques, the commonly used models are the modeling techniques embedded in IDRISI. These are Land Change Modeler (LCM), Cellular Automata (CA), Markov Chain, CA_Markov, GEOMOD, and STCHOICE (Eastman, 2006). But LCM is widely used modeling tool. Land Change Modeler was used to analyze the land use/cover changes for various classes during the period 1991-2018.

4.5 Prediction of land use / land covers changes based on land change modeler (lcm)

Markov Chain determines the amount of using the earlier and later land cover maps along with the date specified. The procedure determines exactly how much land would be expected to transition from the later date to the predicted date based on a projection of the transition potentials into the future and creates a transition probabilities file. The transition probabilities file is a matrix that records the probability that each land cover category will change to every other category. A Markov Chain is a random process where the following step depends on the current state. Markov produces transition matrices from two different dates (1991 and 2018). In table the rows stand for the older land use and land cover categories and the columns stand for newer land use and land cover categories (Table 5).

Table 5: Markov prediction to 2038 based on land use and land cover maps of 1991 and 2018

LULC CLASS	Built-up Land	Forest Land	Agricultural Land	Water Body
Built-up Land	0.8892	0.0019	0.1211	0.0003
Agricultural Land	0.0771	0.5814	0.3325	0.0015
Forest Land	0.2897	0.1317	0.5103	0.0065
Water Body	0.1024	0.1817	0.5010	0.0284

Source: Researcher fieldwork 2021

Table 6: Projected land use and land cover statistics of the study area for 2038

LU/LC CLASS	Built-up Land	Forest Land	Agricultural Land	Water Body
Area (Sq. Km.)	189.877	53.496	85.364	2.822
Area (In %)	57.00	16.00	26.00	1.00

Source: Researcher fieldwork 2021

From the table 6 it is clear that over the year there are significant changes in land use/cover categories especially for agriculture land and built up areas.

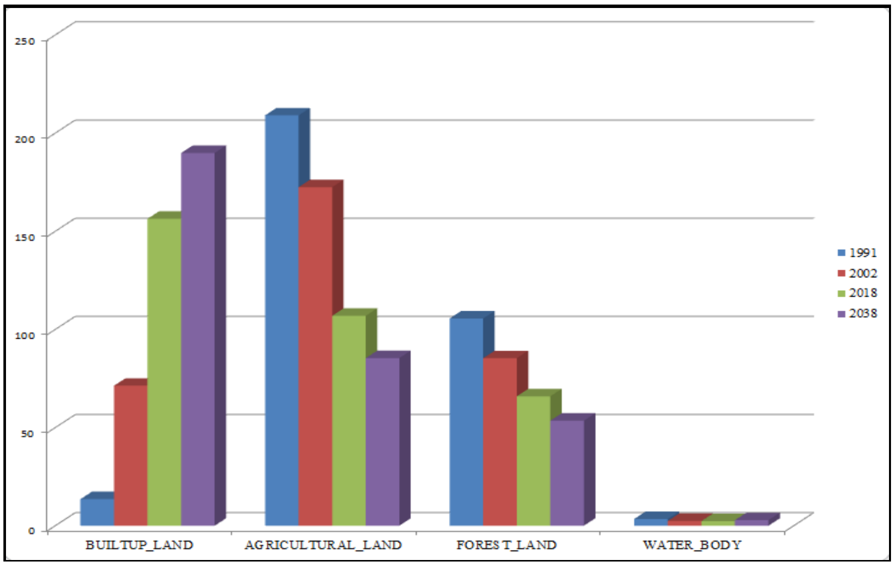

Figure 6. Area statistics of different landuse/landcover categories among 1991, 2002, 2018 and 2038.

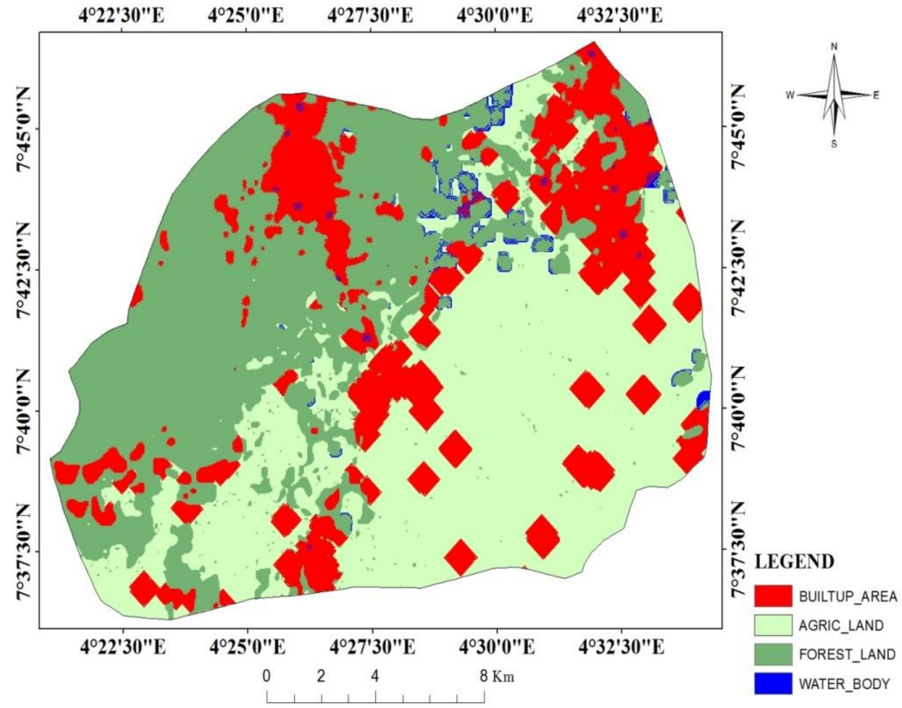

Figure 7. Projected land use and land cover maps of 2038.

4.6 Causes of Urban Land Use/Land Cover Change in the study area

In identifying the causes of landuse/landcover change requires understanding both how people make land-use decisions (decision–making processes) and how specific environmental and social factors relate to influence these decisions (decision making context).

It is also critical to understand that land use decisions are made and predisposed by environmental and social factors across a wide range of spatial scales, from household level decisions that impact local land use practices, to policies and economic forces that can change land use regionally and even worldwide. The major causes of landuse changes include Natural Variability, Economic and Technological factors, Demographic factors, Institutional Factors, and Cultural Factors.

5.0 CONCLUSION

The analyzed results show that urban land use in Ede is fast growing with disordered spatial configuration taking place indicating a typical sprawling tendency. Urban growth has both positive and negative impacts to a town. The following specific sprawl features are identified: obvious land fragmentation and irregularity of land use, unsuccessful enforcement of land use planning; unadvisable pattern of land use growth with typical discontinuous development, strip development and leapfrog development; high densities of land use, high population density; and other negative impacts on agriculture, environment and city life. The increased land fragmentation and conversion is as a result of anticipated higher returns over a short period of time once commercial and other urban land use activities are undertaken. This has come at a cost as most of the agricultural land is now converted to urban land use, meaning less agricultural productivity.

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