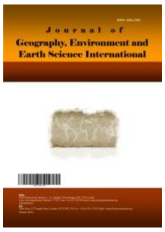

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Land Use/Land Cover Changes of Ado-Ekiti LGA, Ekiti State, Nigeria Using Remote Sensing Techniques

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Authors' contributions

This work was carried out in collaboration among all authors. Author AAB designed the study, performed the statistical analysis and wrote the protocol. Author OSS wrote the first draft of the manuscript. Author AIT managed the literature searches and analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Land use assessment and land cover transition need remote sensing (RS) and geographic information systems (GIS). Land use/land cover changes of Ado-Ekiti Local Government Area, Ekiti State, Nigeria, were examined in this research. Landsat 5 TM, Landsat 7 ETM+ and Landsat 8 OLI were acquired for 1985, 2000, and 2015 respectively. Image scene with path 190 and row 055 was used for the three Landsat Images. A supervised digital image classification approach was used in the study, which was carried out using the ArcMap 10.4 Software. Five land use/land cover categories were recognised and recorded as polygons, including Built-up Areas, Bare surface, water body, Dense Vegetation and Sparse Vegetation. The variations in the area covered by the various polygons were measured in hectares. This study revealed that between 1985 and 2015, there was a significant change in Built-up areas from 1694 hectares to 5656 hectares. However, there was a reduction in water body from 25 hectares in 1985 to 19 hectares in 2015; there was a

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severe reduction in the bare surface from 4641 hectares in 1985 to 2237 hectares in 2015. Generally, the findings show that the number of people building houses in the study area has grown over time, as many people reside in the outskirts of the Local Government Area, resulting in a decrease in the vegetation and bare surfaces. The maps created in this research will be useful to the Ekiti State Ministry of Land, Housing, Physical Planning, and Urban Development to develop strategies and government policies to benefit people living in the Ado-Ekiti Local Government Area of the State.

Keywords: Geographic information system; assessment; landsat; classification; spatial changes; Ado-Ekiti LGA; Ekiti State; Nigeria.

1. INTRODUCTION

With an increase in population and industrialisation growth, land has become a precious resource. Natural and socio-economic variables and man's use of land through time and space determine a region's land use/land cover pattern. As a result, land use/land cover information is critical for land use choices, planning, and implementation. It may be utilised to satisfy the growing demand for fundamental human requirements and welfare.

Changes in land use/land cover are becoming more prevalent throughout the world, posing major environmental challenges that must be documented [1]. Land cover change is the single most significant variable of global change influencing ecological systems [2], having an environmental effect at least linked to climate change [3]. Land use/land cover change is a frequent occurrence all around the globe. These changes may be quick (forest clearance for agriculture) or gradual (tree damage and mortality due to acid rain) [4], and they can have an impact on both socioeconomic and ecological circumstances [5].

In addition to improving human behavior, land use assessment may be a handy tool for dealing with climate change [6]. Policymakers and scientists need to understand the spatial dimensions of land use/land cover consistency to make educated choices about land resources. As a result, a diverse group of scientists and practitioners, including earth system scientists, land and water managers, and urban planners, are scouring the globe for data on the location, distribution, type, and scale of land use/land cover change [7]. The tropical rainforests in the southwestern part of Nigeria have been under severe strain due to the country's fast population and economic development. The uncontrolled removal of vegetation did not spare the forest reserves that had pioneered the creation of reserves in the 1920s, causing rapid changes in land cover patterns in these regions. As a consequence of excessive logging, conversion to forest plantations, and large-scale farming, natural vegetation has been destroyed and quickly altered due to man's activities. Excessive unregulated hunting for bushmeat has also destroyed the wildlife ecosystem [8].

Land use/Land cover change mapping offers valuable and vital information for land resource management and predicting future trends in land efficiency for production and efficient land use planning, landscape monitoring, natural resource management, and habitat evaluation [9]. These changes affect the ecosystem stability, making it necessary to identify and study the condition of a resource like a forest cover and settlement, which is an important component of resource management and monitoring on a local and global scale [10]. Remote sensing (RS) and Geographic Information Systems (GIS) have proven to be one of the most precise methods for determining the extent and pattern of changes in land patterns over time [11-16]. The study aims to use Geographical information system and remote sensing techniques to assess land use/cover changes in the Ado-Ekiti Local Government Area in Ekiti State, Nigeria, from 1985 to 2015. The specific objectives are to; Identify the trend and geographical pattern of land use and land cover in the research region and provide recommendations.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study area is Ado-Ekiti in Ekiti State. It is the largest town and the capital of Ekiti- State. Ado-Ekiti is located between latitude 7º34' and 7º41' North of the equator and longitudes 5º11' and 5º16' East of the Greenwich meridian [17]. The state capital has a total land area of 29300 hectares. It is situated 254 kilometers East of Ibadan, capital of Oyo State, Nigeria; 218 kilometers, South of Ilorin, capital of Kwara State;

351 kilometers, North East of Lagos, the commercial capital of Nigeria [18].

2.2 Climate

Ado-Ekiti is located in Koppen's "A" climatic belt, which means it has a tropical wet climate. This region's average yearly temperature is 25.1ºC. The annual rainfall averages 1334mm. The rainy season (April-October) and the dry season (November-March) are the two most common seasons. Precipitation is lowest in January, with an average of 9mm. The month with the most precipitation in September, with an average of 235mm in length [18]. With an average temperature of 27.1ºC, March is the warmest month of the year, followed by the dry season (November-March). Harmattan is a phenomenon that occurs in December because of the Northeast wind blowing over the country at that time. In summary, the city receives more than 1500mm of rain each year, with precipitation confined to the rainy season [18].

2.3 Geology

Ado-Ekiti is located wholly inside the pre-Cambrian basement complex, which underpins most of Nigeria geologically. This comprises granitic and metamorphic rocks and ultrabasic rocks, including amphibolite and talc-rich schists. Because of the abundance of feldspar in granitic rocks, they serve as storage sites for chemical elements such as potassium, sodium, and aluminium.

2.4 Vegetation and Soil

The high temperatures and copious rainfall are responsible for large trees with broad evergreen leaves. The increase in human activities has reduced the number of trees present in the city due to urbanisation. Yet, there is still a significant area of forest where Mahogany, Iroko, Ebony, and Teak trees are found. Ado-Ekiti soil is made up of ferruginous tropical laterite, which is derived from crystalline foundation rocks. It's also known as a "pedalfer," and it's used to make bricks. Palm trees, kola nuts, cocoa, and yam are among the food and income crops that thrive in the town's well-drained clay soil [19].

2.5 Population and Socio-Economic Characteristics

According to the Nigerian National Population Commission's population projections, Ado-Ekiti has 444,057 people (NPC). The Ekiti tribe's Yoruba-speaking people make up the majority of the population. A small Hausa and Igbo ethnic groups live in the town and are mostly involved in various economic activities. Various commercial enterprises and commercial banks, such as Polaris Bank, Wema Bank, First Bank, and Bank PHB, are among the socio-economic features in Ado-Ekiti, with the majority of them concentrated around the Governor's Office and around a major market known as 'Oja Oba,' to boost the region's trade further.

Ado-Ekiti has 14 public secondary schools, a state-owned university (Ekiti State University, Ado-Ekiti), an Ekiti State Technical College, Ado-Ekiti, a School of Nursing, a private university (Afe Babalola University, Ado-Ekiti), and a Federal polytechnic (Federal Polytechnic, Ado-Ekiti). It also has two television stations – NTA Ado Ekiti and Ekiti State Television – and a State Government-owned radio station and a Federal Government-owned radio station (EKTV). Several hotels, including the Pathfinder Hotel, Dave Hotel, Spotless Hotel, and Fabian Hotel, are strategically located to provide people with recreational and tourist opportunities. Restaurants such as Captain Cook, Tantalizers, and the Chicken Republic are in the study area. Ado-Ekiti also has a stadium for sporting events. In addition, the city serves as the commercial hub for a farming region that produces yams, cassava, grain, and tobacco [17].

2.6 Data Description

Satellite Images for this study were obtained directly from the Landsat website (https://landsat.usgs.gov/). The EROS Data Center of the United States Geological Survey (USGS) is now in charge of the LANDSAT satellite remote sensing constellation. Landsat 5 TM, Landsat 7 ETM+ and Landsat 8 OLI was acquired respectively for 1985, 2000, and 2015. The four scenes are matched to path 190 and row 055 of the WRS-2, which was used to create them (Worldwide Reference System). The landscapes were cloud-free and might have a few scanlines, which the Landsat toolbox can later correct in ArcMap 10.4. To extract the Landsat image of the study area, a process known as masking under extraction was used, which involved overlaying the shapefile of the study area on each of the scenes and finally clipping out a new raster layer that perfectly depicted the study area while other parts of the image were removed to have a perfect study area map.

2.7 Image Processing

Image processing is primarily concerned with four fundamental operations: image restoration, image enhancement, image classification, and image modification. Image restoration is concerned with the correction and calibration of pictures to produce the most accurate depiction of the earth's surface possible, which is a critical issue for any application that uses photos of the planet. Image enhancement is primarily concerned with the alteration of pictures to improve their appearance to the visual system. Image enhancement is also concerned with the optimisation of images to the visual system. When it comes to digital image processing, visual analysis is a critical component, and the results of these approaches may be rather striking. Image classification is the computer-assisted interpretation of images, which is an essential function for geographic information systems (GIS). After then, image transformation which refers to creating novel images due to the application of mathematics to a set of raw picture bands. The clipping method in ArcMap 10.4 was used to clip out the study area from the satellite image before processing the imagery.

In this study, image processing was performed to compare the three Landsat images. Overlay of the images was done by combining the image map layers to create mosaic images. Geometric correction which is the process of transforming the X- and Y-dimensions of a remotely sensed image in such a way that spatial distortions in the original image are eliminated or reduced, and the output X- and Y-dimensions correspond to a selected geographic reference system was performed. Geometric Correction was employed in this study to eliminate scan lines and geometric distortions from a warped image. Using calibration data from the sensor, measured data of position and altitude, ground control points (GCPs), and other information, it was possible to connect the image coordinate system and the geographic coordinate system, among other things.

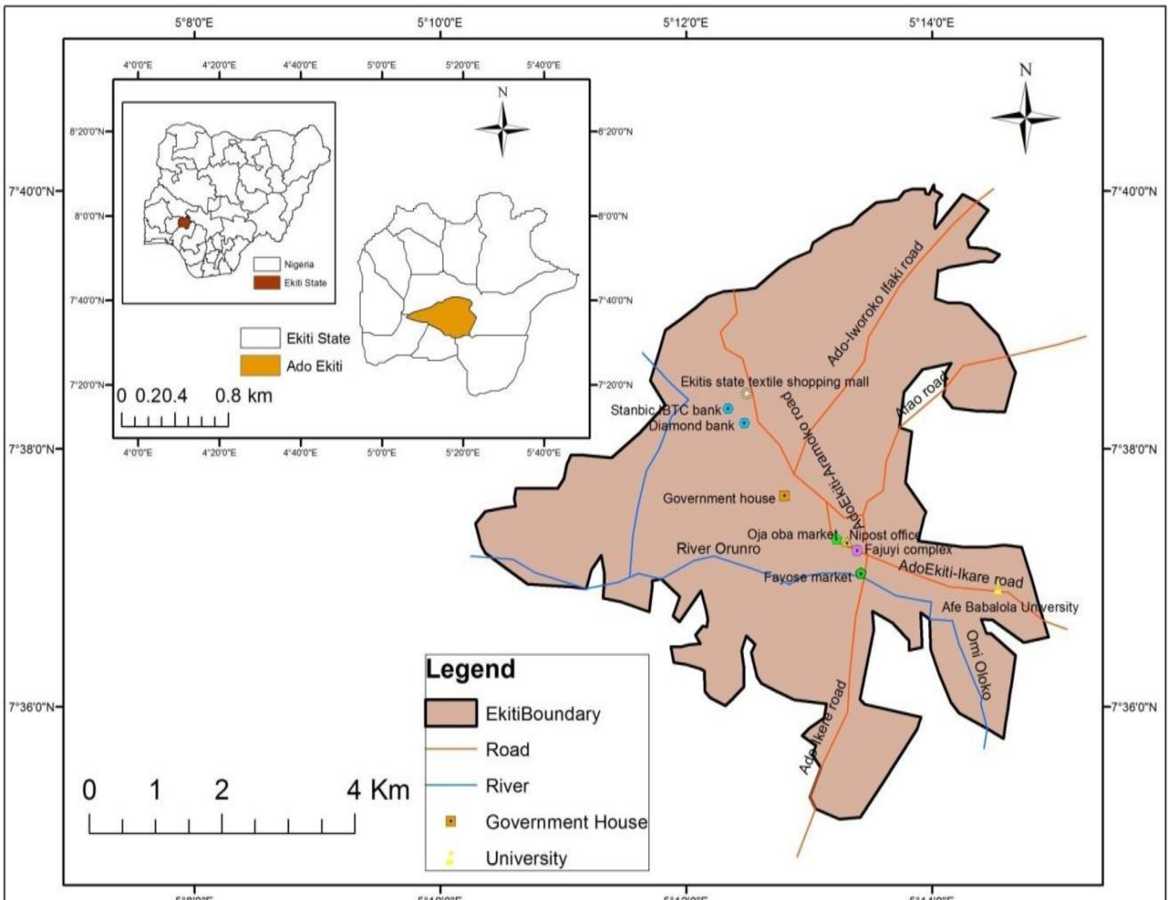

Fig. 1. Showing map of Ado-Ekiti local government area

Table 1. Image classification kappa coefficient and overall accuracy of different images used

Year	Kappa coefficient	Accuracy %
1985	0.9613	92.5
2000	0.9421	97.5
2015	0.9466	95.0
Total	0.9500	95

2.8 Image Classification

The image classification method converts multiband raster images to a single-band raster with several categorical classifications corresponding to various kinds of land cover. There are two general approaches to image classification: supervised and unsupervised. They vary in the manner in which the categorisation is carried out. In this study, supervised classification was used for image classification. Twenty-five training samples were picked for each category and used to create a signature file that was eventually used for maximum likelihood classification in Arcmap 10.4. The method was used to identify the cover type whose signature has the most significant resemblance and assign each pixel in the picture to a certain cover type. The variance and mean of the classes as it pertains to every input band are derived from the training area using the software and information collected [20]. All the pixels in the images were given values based on their spectral signatures, with each one being classified according to how well it matched the other pixels. In this study, ArcGIS 10.4 (Arcmap 10.4), Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, Google Earth, and Universal Map Downloader were used.

As mentioned earlier, different data analysis methods were carried out to attain the intended goal for this study. Types of land use/landcover were studied, delimited, plotted, and presented as maps, tables, and charts. Three distinct satellite imageries were identified within the same time period with an average kappa coefficient and total accuracy of 0.9500 and 95.00 per cent.

3. RESULTS AND DISCUSSION

The analysis involves the presentation of data collected in figures and tables. Land use types were analysed, mapped, and presented in the form of maps and tables. Three different satellite images acquired in 1985, 2000, and 2015 within the same period were classified to see the changes in land use over the years. The main categories of land use classification schemes developed for this study are Built-up areas, Dense vegetation, Sparse vegetation, Bare surface, and Water body.

3.1 Land Use /Land Cover types

The different kinds of land use in the study area were categorised into five main categories, which are as follows: Built-up areas, Dense vegetation, Sparse vegetation, Bare surfaces, and Water body. Figs.2-4 depicts the land use categories for 1985, 2000, and 2015 respectively. Tables 2-3 shows the distribution of land use categories, boundary area covered by each category in hectares, percentages, and their differences in the research area. Each category is represented by a different colour Figs.2-4. This was accomplished via the use of the supervised classification method in ArcGIS software version 10.4.

Table 2. Extent of land use types and changes in land use type in the study area between 1985, 2005, and 2015

Land Use Type	1985		2000		2015	
	Hectares	%	Hectares	%	Hectares	%
Built Up Areas	1694	5.26	3533	10.97	5656	17.56
Bare Surface	4641	14.41	3270	10.15	2237	6.94
Dense Vegetation	7622	23.66	8960	27.82	10303	31.98
Sparse Vegetation	18227	56.59	16420	50.98	13994	43.44
Water Body	24	0.07	23	0.07	19	0.059
Total	32208	100	32208	100	32208	100

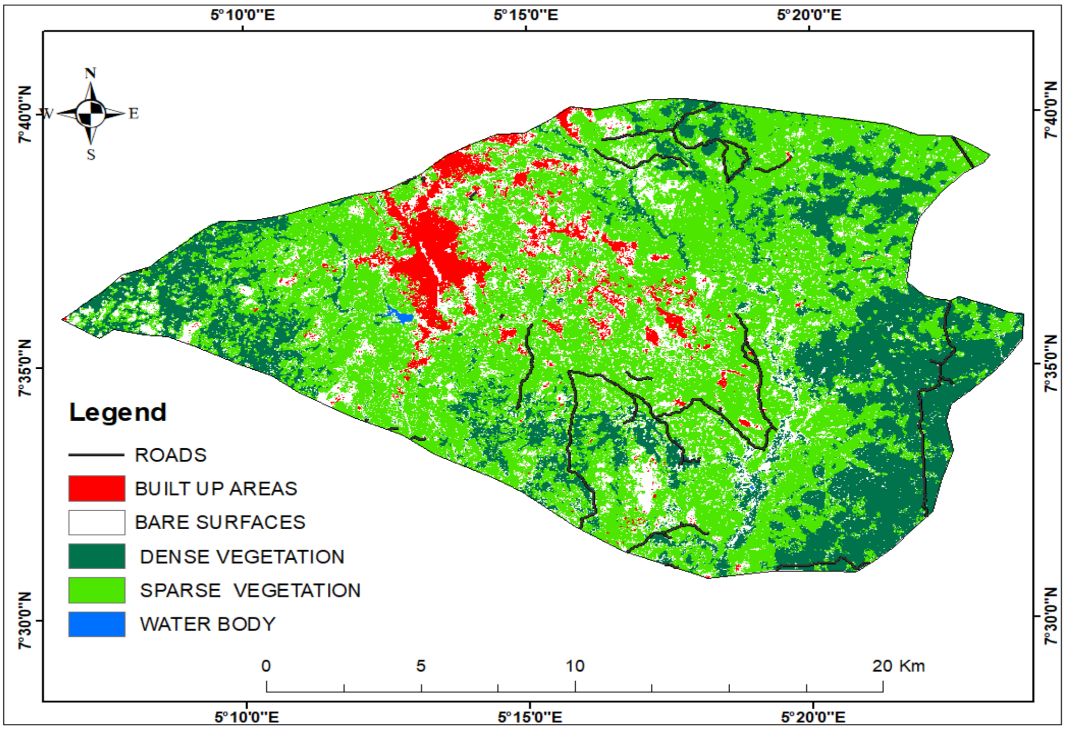

Fig. 2. 1985 Satellite image land use classification for Ado-Ekiti local government area

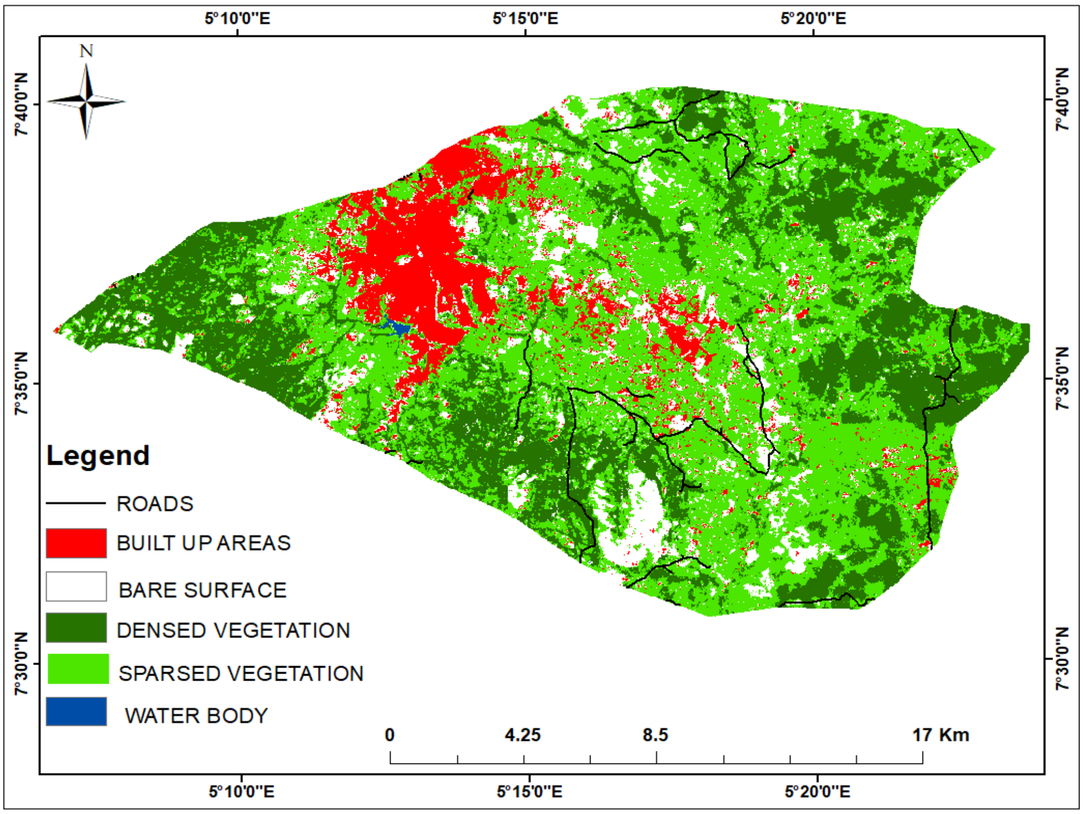

Fig. 3. 2000 Satellite image land use classification for Ado-Ekiti local government area

Table 2 shows that in 1985, the Built-up areas occupied 1694 hectares, a percentage of about 5.34% of the total 32208 hectares of the study area. The bare surface occupied 4641 hectares (14.41%), Sparse vegetation and Dense vegetation 18227 hectares (50.98%) and 7622 hectares (23.66%) respectively, while water body covered 24 hectares (0.07%).

From Table 2 above, it is evident that in 2000, the Built-up area had increased to 3533 hectares, a percentage of 10.97% of the total 32208 hectares of the study area. The bare surface also decreased to 3270 hectares (10.15%), Dense vegetation had increased to cover 8960 hectares (27.82%), sparse vegetation decreased to occupy 16420 hectares (50.98%), while water body reduced slightly to about 23 hectares (0.09%). All these changes can be seen in Fig. 3 when compared to Fig. 2.

Table 2 above shows that in 2015, the built-up area had further increased to occupy 5656 hectares, a percentage of 17.56% of the total 32208 hectares of the study area. The bare surface had reduced drastically as a result of urban expansion to occupy 2237 hectares (6.94%), Dense vegetation had increased to cover 10303 hectares (31.98%), while sparse vegetated areas had reduced to cover 13994 hectares (43.44%). Water body covered 19 hectares (0.059%) which is a reduction compared to 23 hectares in 2000.

Table 3 above shows the change rate in the area covered by the class category. As shown in the table, there was a 5.73% increase in Built-up areas between 1985 and 2000, about 1839 hectares. Also, there was a 4.26% (1371 hectares) decrease in the area covered by bare surface within the same years, a 9.64% (4968 hectares) increase. Area covered by water body slightly reduced with about 1 hectare. Densely vegetated areas increased by 4.16% (1338 hectares) within the same period. Furthermore, between 2000 and 2015, there was a 6.59% (2123 hectares) increase in the area covered by the Built-up areas and a decrease in Bare surface by 3.21%. There was also a 4.16% increase in Densely vegetated areas (1343 hectares) and a 7.54% (2426 hectares) decrease in the area covered by sparsely vegetated areas.

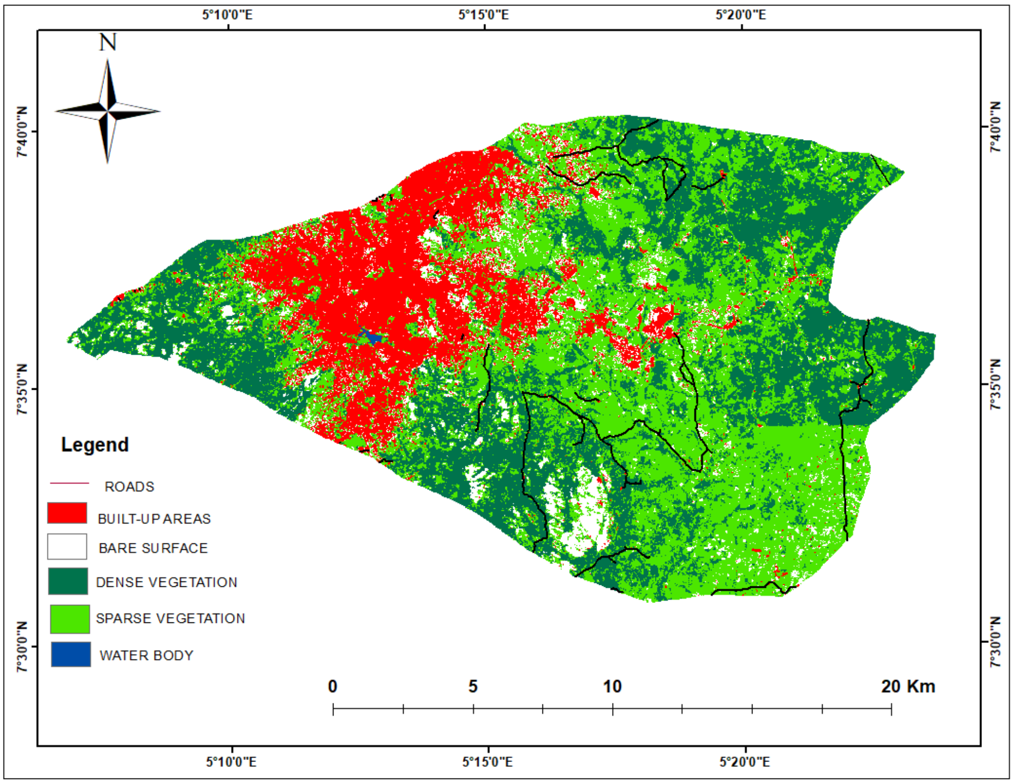

Fig. 4. 2015 Satellite image land use classification for Ado-Ekiti local government area

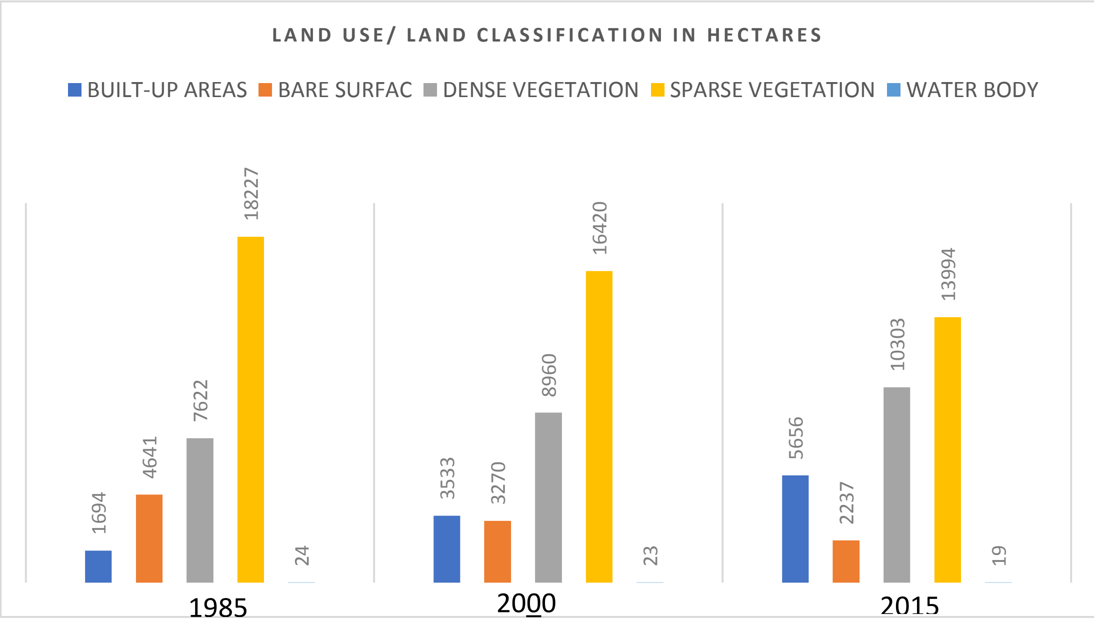

Fig. 5. Graph of land use type for years 1985, 2000 and 2015

Table 3. Land use changes of Ado-Ekiti Local Government Area between 1985 and 2015

Class Categories	1985-2000		2000-2015	
	Difference in Area		Difference in Area	
	Hectares	%	Hectares	%
Built-Up Areas	1839	5.73	2123	6.59
Bare Surface	-1371	-4.26	-1033	-3.21
Dense Vegetation	1338	4.16	1343	4.16
Sparse Vegetation	-1807	-5.61	-2426	-7.54
Water Body	-1	-0.001	-4	0.011

3.2 Land Use Change Map

A visual shift in land use change that occurred in the Ado-Ekiti local Government region between 1985, 2000 and 2015 is depicted on a final Land Use/Land Cover map (Figure 2-4).

3.3 Statistical Analysis

The changes in each land use category from 1985 to 2015 are summarised in Tables 2-3 above and visually depicted in Figs. 2-4 and analysed in this section. The geographical area of Built-up areas has increased considerably, whereas the sparsely vegetated areas have reduced drastically.

3.3.1 Built-up areas

The spatial extents of Built-up areas and non-vegetated regions indicate a clear rise in settlements overall. The majority of developing towns exhibit an increase in the Built-up area, which corresponds to an increase in population. With a population of 156,122 in 1991, Ado-Ekiti local Government now boast about 427,700 people, according to the National Population Commission in the year 2016. The fast expansion of the population has increased demand for land for food, housing, energy (particularly fuel wood), and building materials. In conclusion, built-up areas, vegetated areas, and bare surface developments mainly result of population growth over the period studied.

3.3.2 Dense vegetation

Ado-Ekiti Local Government Area has experienced deforestation and afforestation with improved management of forest resources by the regulating institutions. Densely vegetated areas increased from about 7622 hectares in 1985 to about 8960 hectares in the year 2000. From 2000 to 2015, it is evident from Table 2 above that area covered by dense vegetation also increases to reduce the number of hectares allotted to the bare surface as the surface of rocks and bare lands are now being occupied by thick forests. Part of the areas covered by sparse vegetation also increased densely vegetated areas due to reduced agricultural activities, thereby turning farmlands into thick forests.

Improved management of forest reserves and enforcement of laws to regulate deforestation in the states forest reserves is key in maintaining forests.

3.3.3 Sparse vegetation

The desire to meet the needs of millions of people around the world, particularly in Ekiti State, has had a negative impact on the environment. In particular, people's attempts to satisfy seemingly endless wants and need for food, shelter, and infrastructure development have resulted in fluctuating forest resources and urbanisation. Furthermore, the influx of people into Ekiti State, which was established nearly two decades ago, as well as ignorance and a lack of skill in managing forest resources in the past, has resulted in a threat in both temperate and tropical rainforests, resulting in forest loss, habitat fragmentation, and decreased resilience in the face of climate change.

It was estimated that between 1985 and 2000, sparsely vegetated areas reduced from about 18227 hectares to about 16420 hectares; this is as a result of urbanisation growth and the need for infrastructural developments by the Government area Ekiti state. Some of the sparsely vegetated areas also comprise the various farmlands present within the local Government. The growth in some sparsely vegetated areas is mainly due to ferruginous tropical laterite derived from crystalline foundation rocks. It's also known as a "pedalfer," which is very good for agricultural purposes [19]. The reduction of sparsely vegetated areas implies significant deforestation, degradation and the need for land for infrastructural development.

3.3.4 Bare surfaces

A bare surface in its pure and rigorous meaning is composed mainly of exposed rock or soil, accurately described as an empty land yet to be occupied by any human activity. This can be due to terrain or the kind of soil present in that particular area. Ado-Ekiti Local Government Area comprises large rocks which are now being covered by vegetation.

3.3.5 Water body

Over the course of the study, the water body displayed various variations in pattern (Table 2). Between 1985 and 2015, there was about a 5 hectares reduction in the area covered by water, compared to 1 hectare between 1985 and 2000. It is possible that human activities on the land in the watersheds are contributing to the shrinking of the body of water. The water body was shrinking compared to a rising tendency in the area of bare surfaces and sparsely vegetated areas that were cut off from the resource. According to this, changes in land use and land cover are having a detrimental effect on the water body, as shown by the decrease in the aerial coverage of the water body as a result of the changes.

Surface water in the study area is fluctuating over time. This can be attributed to the fact that water resource is critical to the population of Ado-Ekiti Local Government Area and Ekiti state as a whole for domestic and industrial use. One of the primary reasons for the decrease in areas covered by the water body is climate change; factors such as drought occurrences are characterised by increased temperatures and decreased precipitation in the study area. Excessive groundwater exploitation by farmers for irrigation purposes is also responsible for the variations in the pattern of the water body, as illustrated in Table 2 above. Land use activities that can reduce water coverage in the study area should be avoided at all costs, and proper land use planning and management in the catchment areas should be adopted by the Ministry of Environment and Water Resources for effective control of surface water.

4. CONCLUSION

This study identified significant changes in land use and land cover throughout the study area. Precise, frequent, and timely remote sensed data were used in this study to efficiently manage, analyse and predict land use and land cover characteristics for the benefit of conservation of forest resources, regional planning, and urban management. This study showed the application of contemporary technologies, particularly geographic information system and remote sensing, in evaluating the amount and pattern of changes in the forest, settlement, bare surfaces, cultivated lands, and water body over a long period. From the analysis of the results, it can be concluded that the land use/land cover type from the study is as a result of human and/or anthropogenic activities in the study area as revealed in the studies by [21,22] and [23]. To minimise activities that have a detrimental impact on forest reserves, water body, cultivated land, and bare surfaces, the local authorities should implement environmental rules and regulations to address landscape changes in reserved and protected regions within the Local Government Area. The development of a broader and more integrated GIS system of the regions land resources is critical for planners, governmental authorities, and other decision-makers involved in a variety of planning and management activities, including forest and other land resource management. Remote sensing and geographic information systems (GIS) are flexible methods that may be used to produce data and information for sustainable development in a cost-effective manner. This is especially true in the face of fast resource loss, such as that occurring in forest areas. Because of this, Authorities in the local government area of Ado-Ekiti must manage these fragile resources with caution, using sound planning and sustainable natural resource management techniques to protect them.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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