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RESEARCH ARTICLE

SAPTIO-TEMPORAL ANALYSIS OF LAND USE CHANGES IN ONDO METROPOLIS, ONDO STATE, NIGERIA FROM 1980 TO 2020

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ABSTRACT

This work seeks to analyze Saptio-temporal Analysis of Land Use Changes in Ondo Metropolis, Ondo State, Nigeria From 1980 to 2020. The main approach used was post classification comparison analysis of satellite imageries of Ondo city at four decadal variations between 1980 and 2020. Since satellite data downloads usually cover more area than one is interested in, a portion of the larger image was selected to work with which was accomplished by: (i) opening an image, (ii) given the latitude and longitude of the location (iii) the image was reformatted (vi) file chosen and subset opened. The Region of Interest (ROI) vector frame created in ArcGIS 10.3 from the study area map and imported into Erdas 9.2 environment as shape file. With this, the ROI of the study area was delineated from the satellite image scene. The result emanating shows that the built–up area experienced continuous growth while bare surface experienced a rapid decrease over the period of study. The increase in the built-up area and its concomitant decrease in the vegetation cover were due to conversion of natural vegetative surfaces to settlements and impervious surfaces. These results provide vital data for policy makers and planners to mitigate the major challenges of indiscriminate land utilization in the area.

Keywords: land use cover, metropolis, region of interest, vector frame, built –up area, impervious surfaces

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1.0. INTRODUCTION

Land use according to Environmental Literacy Council (2002) is used to describe the various ways in which land and its resources are utilized by different people, for farming, mining, building and grazing. The choices of how land is being used are made by those who own or control the land but the choices are limited by the physical and biological characteristics of the land, which include the climate, soil and topography as well as institutional and economic factors (Owoeye and Ogunleye, 2015). Urban land uses are classified into different parts such as residential, commercial, industrial, institutional, public area, open space, infrastructural, and mixed land uses. Land cover, on the other hands, refers to the physical and biological cover over the surface of land which includes water, vegetation, bare soil, and or artificial structures (Ryan Coffey, 2013).

Rapid growth of cities in most African countries is traceable to rural-urban migration. It appears that large number of migrants to cities originates from smaller urban centres, and particularly from rural areas, leading to urban expansion (Ellis, 2012; Owoeye, 2013). Ondo State was one of the seven states created on the 3rd of February 1976. The state was carved out of the western Region. Ondo town is the second largest town in Ondo State after Akure the State Capital. It had a population of 364,960 during (2006 national population census) projected to 492,600 in 2020 (National Population Commission of Nigeria (Web), National Bureau of statistics (web)and it sprawls across two local government areas which are Ondo East and Ondo West. Ondo town has become a major trading and distribution center for the surrounding towns and villages within and outside its immediate environment which made it a center of attraction and growth.

Understanding the characteristics of urban expansion of Ondo metropolis has the potential to promote sustainable urban development. With the United Nations Sustainable Development Goals (SDGs) providing a global development pathway (Anderson et al., 2017), an appreciation of urban expansion dynamics in Ondo town has become increasingly important and tenable. Thus, this study centres on analysis of urban growth and environmental changes in Ondo metropolis from 1980 – 2020.

2.0. THEORETICAL REVIEW

Urban centres throughout the world exhibit an incredible diversity of characteristics, economic structure, levels of infrastructure, historical origins, patterns of growth and degree of formal planning. In Nigeria, urbanization parameters progress at a phenomenal rate without any articulated policy to stem its tide. The dynamics of the scenario in Nigeria is typified by the fact that while less than 15% of the total population lived in urban area of 20,000 or more population by 1950, 25 years later in 1975, this proportion increased to 23.4% and by 2000, the proportion had increased to 43.3%. The prognosis is that by 2025, more than half of the nation's population will live in urban centres (Eke et al., 2017).

Urbanisation is an inevitable process that goes along with economic development and rapid population growth. It is generally believed that urbanisation has both direct and indirect impacts on land use transformation such as urban sprawl and urban degradation. Urban areas and their urban rural linkages are characterized by high dynamics of human influence and the associated land use patterns (Owoeye and Ogunleye, 2015).

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Globally, land cover is often altered principally by direct human use such as agriculture and livestock raising, forest harvesting and management, urban and suburban construction and development. As submitted in several researches, hardly can we find any vegetation that has not been affected or altered by man in the world (Oyinloye, 2010, Olofin, 2012, Rimal, 2013, Oduwaye, 2013, and Oduwaye, 2015). In this regard, about 400,000 hectares of vegetation cover are confirmed to be lost annually (Balogun, et al, 2011). Due to anthropogenic activities, the earth surface is being significantly altered by man's presence and several activities on earth. According to Fazal, 2000, land transformation has been asserted to be one of the most important fields of human induced environmental transformation. Environmental protection is facing critical challenges due to several factors like increasing population, depletion of natural resources, environmental pollution, unplanned land use, and several others.

3.0. RESEARCH METHODOLOGY

3.1. Sources and Types of Data

The sources and types of data for this study are essentially through Aerial Imagery Overlay (AIO) with the aid of GIS and RS, and personal observations. Research design is the overall strategy that a researcher chooses to integrate the various component of the study in a logical and coherent manner. It entails the specification for the collection, measurement and data analysis. The main approach used in this study is majorly post classification comparison analysis of satellite imageries of Ondo city at five decadal variations between 1980, 1990, 2000, 2010 and 2020 as shown in Table 3.1. It helps to examine variation in the change and to show the direction and extent of the growth from one period to the other and the accompanied land surface temperature changes.

Table 3.1: Spatial Data characteristics and their Sources

S/N	Images/Population	Year	Spatial Resolution (m)	Landsat launched year	Number of bands	Source	Scene Path/row
1	Landsat 3 RBV-MSS	1980	60	1978	4	www.usgs.gov	190/55
2	Landsat 4 TM	1990	30	1982	7	www.usgs.gov	190/55
3	Landsat 7 ETM+	2000	30	1999	8	www.usgs.gov	190/55
4	Landsat 7 ETM+	2010	30	1999	8	www.usgs.gov	190/55
5	Landsat 8 OLI/TIRS	2020	30	2013	11	www.usgs.gov	190/55

3.2. Change Detection Procedure

Detecting and analysing LULCC over large geographic area as well as over regional areas have been highlighted both in a manner of discrete long-time span and in sequential time series with high temporal resolution remote sensing satellites through a process commonly called 'change detection' (Coppin, Bauer 1996). This is considered an important process in monitoring LULCC because it provides quantitative analysis of the spatial distribution of the population of interest and this makes LULC study a topic of interest in remote sensing applications (Song, *et al.* 2001, Gallego 2004). Using remotely-sensed data to detect LULC changes, six main steps are important as mentioned by Jensen in 2005 (see figure 3.1).

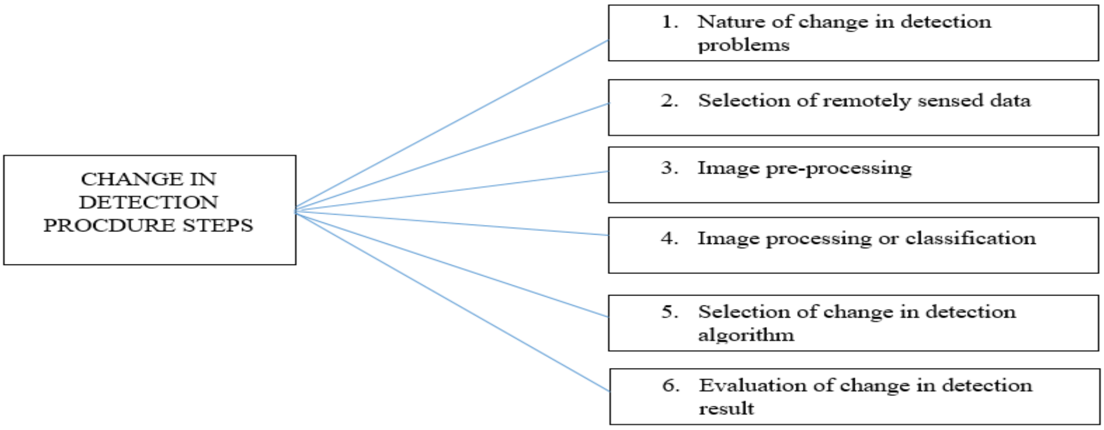

Figure 3.1: Major Change Detection Procedure Steps
Figure 3.3 Image Enhancements

3.3. Image Classification

Image classification is the process of categorizing and labeling groups of pixels or vectors within an image based on specific rules. The categorization law can be devised using one or more spectral or textural characteristics. Two general methods of classification are 'supervised' and 'unsupervised'. Unsupervised classification method is a fully automated process without the use of training data. Using a suitable algorithm, the specified characteristics of an image is detected systematically during the image processing stage. The classification methods used in here are 'image clustering' or 'pattern recognition'. Two frequent algorithms used are called 'ISODATA' and 'K-mean'.

Supervised classification method is the process of visually selecting samples (training data) within the image and assigning them to pre-selected categories (i.e., roads, buildings, water body, vegetation, etc.) in order to create statistical measures to be applied to the entire image. 'Maximum likelihood' and 'minimum distance' are two common methods to categorize the entire image using the training data.

The land use/land cover (LULC*)*: The land use or land cover for the study area is grouped into four categories (as it physically applies to the study area) and it includes: Build up, bare land, light and thick vegetation. Google Earth images of 15m spatial resolution was used to measure area of water bodies/ wetland.

Built-up area: Built-up areas are built up lands in the urban that involve commercial, industrial, road/Circulation, agriculture, recreational, residential and public/semi-public/educational land uses).

Vegetation: Vegetation is classified as thick vegetation (forested land areas); light vegetation (cultivated land areas).

Bare land: Bare land is a non-built up land without any land cover or land use activity. These are mainly barren land devoid of trees or bushes or shrubs and this may be found outside or within the urban built up area.

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3.4. Change detection technique

Change detection techniques are classified into various categories: (1) algebra, (2) transformation, (3) classification, (4) geographic information system (GIS) approaches, (5) visual inspection, and (6) other approaches. The sixth category contains some change detection algorithms that are not appropriate for classification into any of the five groups and are not yet commonly used in nature. Fig. 2 demonstrates the groups of the methodology for detecting change.

Geographical information system approach

In order to discern shift, GIS participates in the various source material. The key benefit of using GIS for change detection is its ability to give a broader perspective on the area under study and the frequent coverage of the area. Be that as it may, the presence of various source data accuracies affects the change detection outcome. This method combines earlier and recent land-use maps with topographic and geological details.

The image overlapping and binary masking strategies are helpful for quantitatively exposing the patterns of transition in each category. This approach allows the integration of aerial photography data from present and past land-use data with other map details. With this approach, the consistency of the results depends on the various GIS data with different geometric precision and classification systems.

Visual Analysis

Visual analysis visually interprets the color formula in order to distinguish the modified regions. The alternative is to introduce on-screen digitization of the modified region using visual representation based on overlaid photographs of different dates. Human experience and knowledge are useful for visual interpretation. Two or three picture dates may be examined at one time. The analyst can integrate texture, form, size, and patterns into the visual interpretation to decide on the LULC update. This method cannot deliver complete change data. The results are determined by the expert's expertise in image analysis. The disadvantage with this method is difficulty in bring up to date the results and time-consuming process.

Other approaches

Besides the popular categories of change detection, there are several other approaches that are often used to respond to changes in multi-temporal RS images. The evaluation of long-lasting spatial-temporal land cover patterns of change and the basic aims of the study were to measure the pace, trend, and magnitude of change with topography for the collection, preparation, and execution of growth strategies. To achieve these objectives, use the rich archive and spectral resolution Landsat data sets, the Bayesian ML-supervised classifier to map the land-use class, and shift detection comparison techniques to recognize the intra-image land cover change.

For object-based classification, fuzzy is used, c-means algorithm classification. Maximum likelihood algorithm, the minimal distance to mean algorithm, and the parallelepiped algorithm use three different approaches. Among them, the parallelepiped algorithm assigns a pixel to one of the predefined classes of information in terms of its value concerning the DN spectrum of each class in the same band.

The data used for this study were obtained mainly from secondary sources. These sources included Aerial Imagery Overlay (AIO) with the aid of GIS, RS, Google Earth images for higher resolution images to measure the area of water and personal observations. Materials from books, thesis, journals and internet facilities were also explored for relevant information. Other sources include government ministries and establishments for historical, urban studies, research milieu of the area as well as base maps and population data used for the study.

Evaluation of Change Detection Results

The area covers by each land use/land cover features were calculated in area in km. square and area in percentage using the formula below:

Area percentage = (count) / sum x 100

$$\text{Area in km}^2 = \frac{\text{count (number of pixels) x resolution of image}}{1000{,}000}$$

Land Surface Temperature (LST) Analysis

Land Surface Temperature: Land Surface Temperature is the measure of heat emission from land surface due to various activities associated with the land surface. Increase in paved land cover is an indication of concentrated human activities, which often leads to increased LSTs. Land surface temperature is the radioactive skin temperature of land derived from solar radiation. LST is the radioactive skin temperature of land derived from solar radiation. It is the measure of heat emission from land surface due to various activities associated with it. Increase in paved land cover is an indication of concentrated human activities, which often leads to increased LSTs.

LST is found to be one of the most important parameters in the physical processes of surface energy and water balance at local through global scales (Kustas and Anderson 2009; Karnieli *et al*. 2010). In more general terms LST can be defined as hotness of surface of earth, from RS satellite’s perspective, the surface is whatever it sees when it looks through the atmosphere to the ground. LST estimation provides information about temporal and spatial variations of the surface equilibrium state and is of fundamental importance in many applications.

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Calculation of land surface temperature from Landsat data: LST was computed from TIR bands (Landsat TM and ETM). Emissivity correction for specified LC is carried out using surface emissivity and land surface temperature is calculated as follows:

$$T_S = \frac{T_B}{1 + (\lambda \, x \, T_B / p) \, 1n \, \varepsilon}$$

Where, λ is the wavelength of emitted radiance for which the peak response and average of the limiting wavelength (λ = 11.5 µm) were used, ρ = 1.439 × 10 ° 2 mk and ε = spectral emissivity.

Land Surface Temperature: Land Surface Temperature is the measure of heat emission from land surface due to various activities associated with the land surface. Increase in paved land cover is an indication of concentrated human activities, which often leads to increased LSTs. Land surface temperature is the radioactive skin temperature of land derived from solar radiation

The whole analysis procedure was performed following the underlying flowchart:

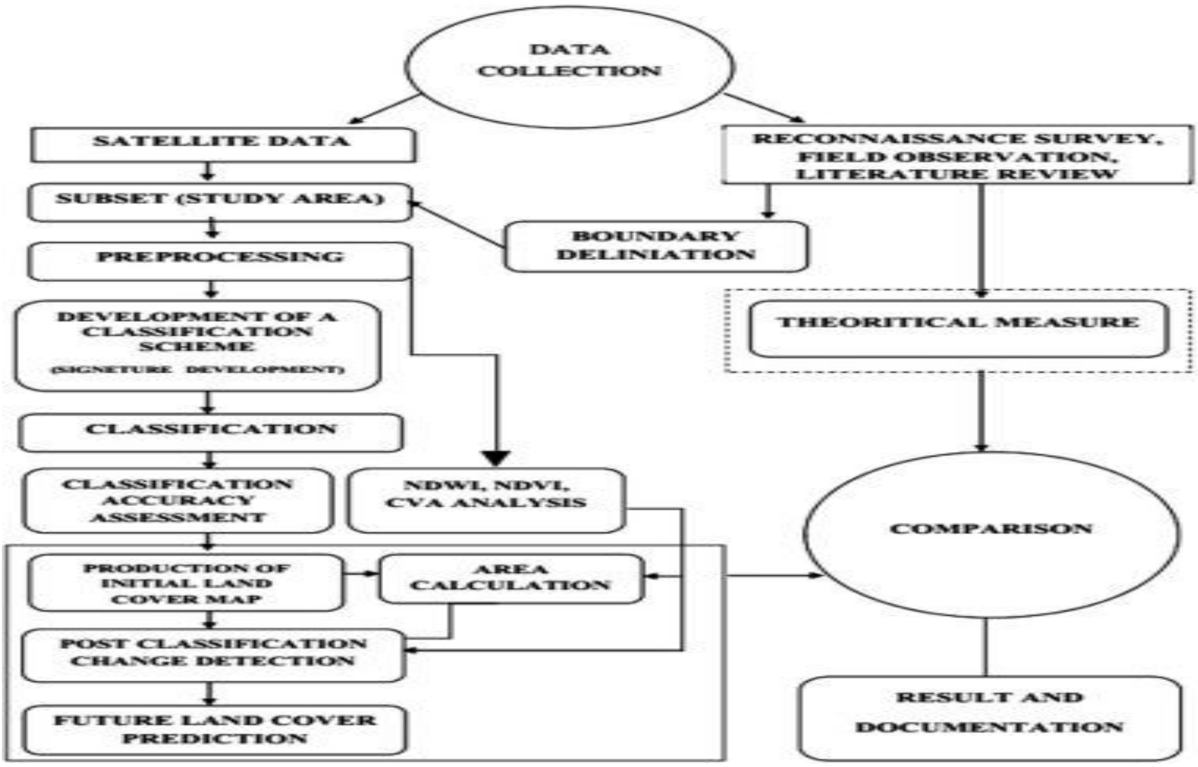

Fig. 3.5: methodology flow chart
Source: Muhammed Bayouni Zara (December 2017).

4.0. PRESESENTATION OF RESULTS AND DISCUSSION

4.1. Lateral Expansion of Ondo Metropolis from 1980 to 2020

The Land Use Land Cover maps of the various years as shown in Figures 4.1a, b, c, d and e indicate the changes that occurred within Ondo metropolis over a period of 30 years (1980 - 2020). The spatial distribution of the static Land-Use and Land Cover in the study area was obtained from Landsat imagery of 1980, 1990, 2000, 2010 and 2020 respectively.

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From the GIS output, the lateral expansion of Ondo metropolis into adjoining rural lands between 1980 and 2020 using remote sensing as shown in Fig. 4.2a indicated that in 1980, most parts of the study area were vegetation as Ondo town had not developed to what it is today while the proportion of built-up area was very small. During this period, there was apparently less exploitation of the natural resources and most of the vegetation remained as primary forest.

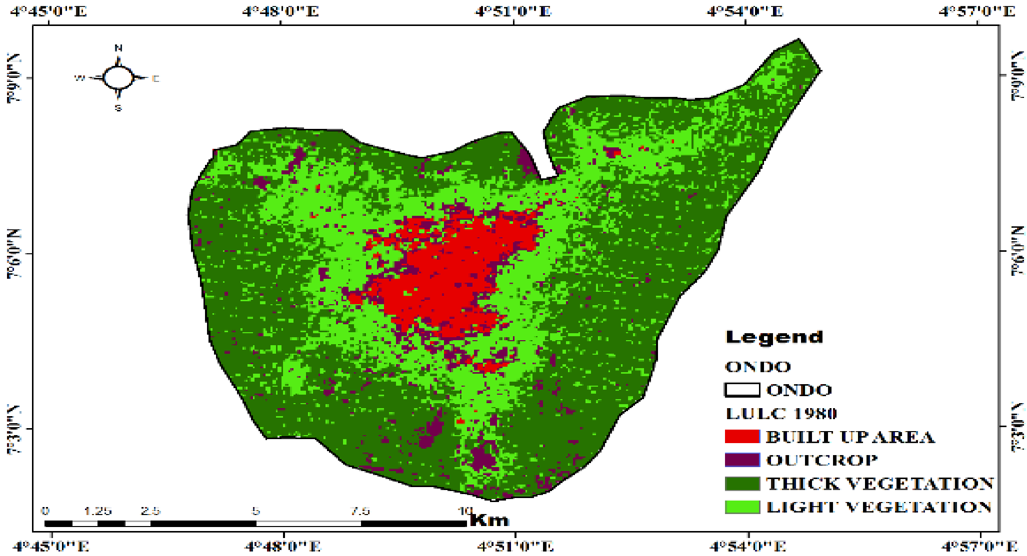

Figure 4.1 Lateral Expansion of Ondo Metropolis from 1980 to 2020

Figure 4.1a: Land Use Land Cover 1980

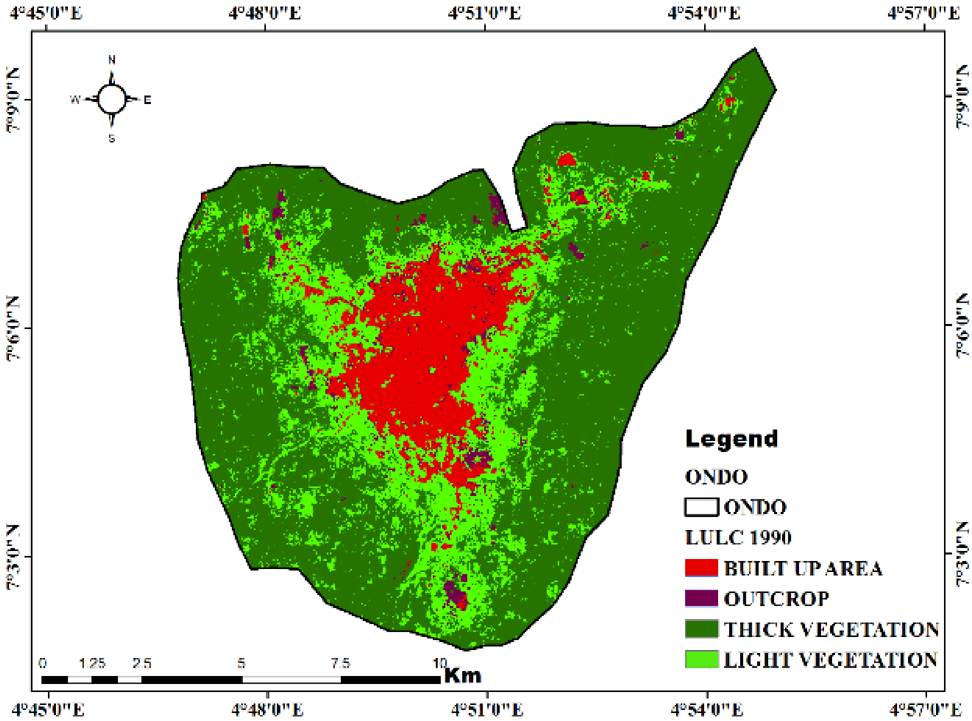

Figure 4.1b: Land Use Land Cover of 1990

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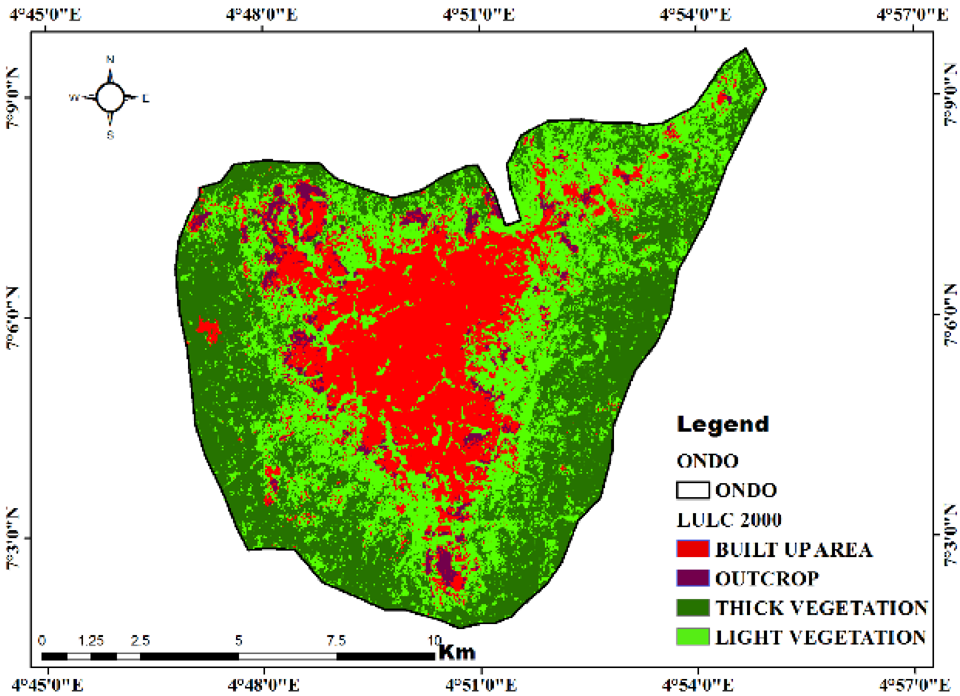

Figure 4.1c: Land Use Land Cover of 2000

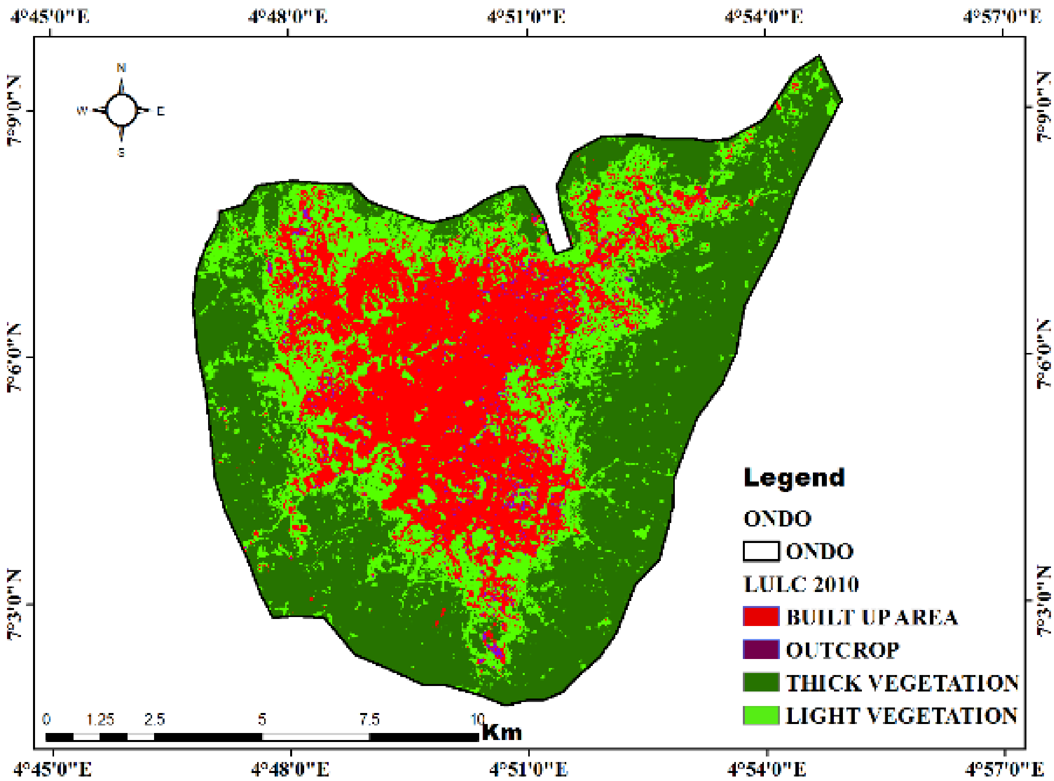

Figure 4.1d: Land Use Land Cover of 2010

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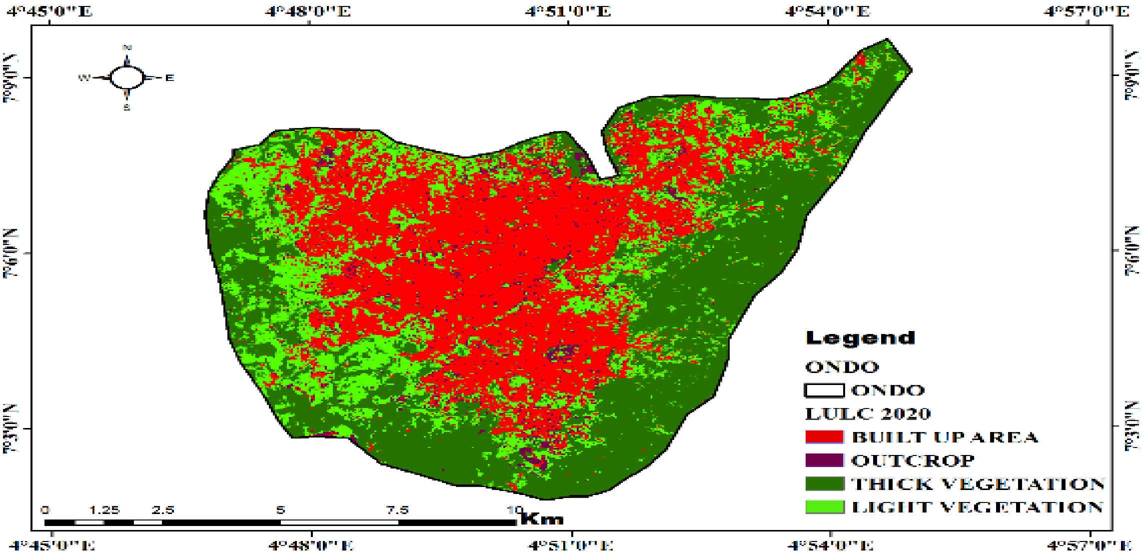

Figure 4.1e: Land Use Land Cover of 2020

4.2. Level of urban growth in Ondo metropolis from 1980 to 2020

The levels of urban growth in Ondo metropolis during the years under review are thus showed in Table 4.1 and figure 4.1f

Table 4.1: Distribution of Land Use/Cover Classes in Ondo Metropolis from 1980 to 2020

Year	Built up in Km^2 (%)	Bare land in Km^2 (%)	Light Vegetation in Km^2 (%)	Thick Vegetation in Km^2 (%)	Total in Km^2 (%)
1980	16.64 (13.27)	3.19 (2.54)	36.25 (28.90)	69.36 (55.29)	125.44 (100)
1990	24.81 (19.78)	3.47 (21.77)	37.94 (30.25)	59.22 (47.21)	125.44 (100)
2000	31.68 (25.26)	4.33 (3.45)	49.76 (39.67)	39.67 (31.62)	125.44 (100)
2010	40.30 (32.13)	5.43 (4.33)	31.44 (25.06)	48.27 (38.48)	125.44 (100)
2020	62.57 (49.88)	5.56 (4.43)	25.63 (20.44)	31.68 (25.25)	125.44 (100)

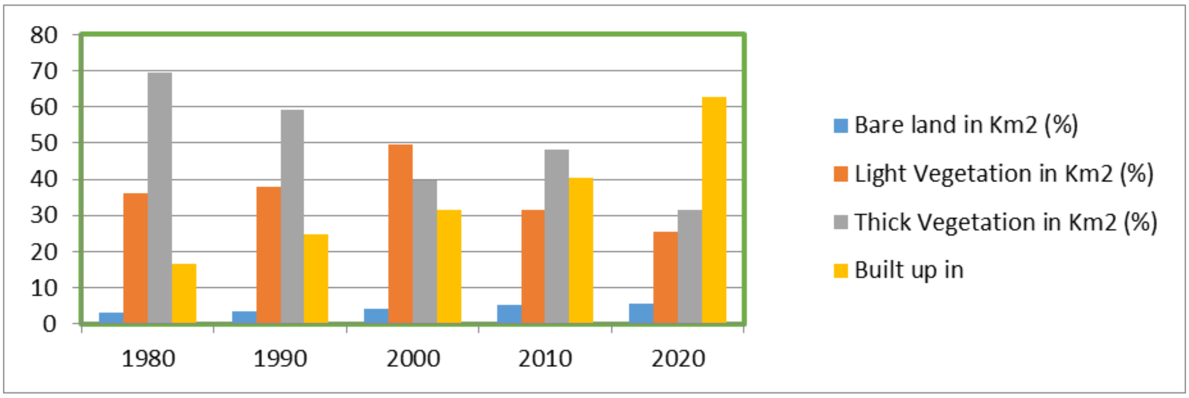

Figure 4.1f: Histogram of Land Use Land Cover for year 1980 to 2020

As shown in Figures 4.1a, lager proportion of the study area 55.29% was covered with thick vegetation in 1980 while 28.90% was cultivated and covered with light vegetation. Only 13.27%was developed as residential, commercial, recreational, industrial or educational land uses as bare land took 2.54% of the land area. The bare land represented the areas covered by road, motor parks, school playing ground etc. Ondo metropolis as at 1980 was small and compact.

As indicated in Figure 4.1b for 1990, the urban area started increasing in size with a decline in the area covered by thick vegetation from 69.36km^2 to 59.22km^{2}of the total land mass as a result of cultivation made by the occupants of the additional area covered by the built up. The expansion of the built-up area in years 1990 caused a sharp decline in the thick vegetation area because those who constituted additional population in the expansion of the built-up area also contributed to the clearing of the thick forest for farming and other activities in the area. The percentage of the built-up area and light vegetation (cultivated area) increased 19.78% and 37.94% respectively while the thick vegetation reduced drastically to 47.21%. This shows that much of the thick vegetation was cultivated while some of it gave way to further developments and urban expansion through building, constructions and provision of public utilities.

In Figure 4.1c, the LULC classifications for the year 2000 showed that the built-up area increased to 31.68km (25.26%). The light vegetation also increased to 49.76km^2 (39.67%) while areas covered with thick vegetation reduced to 39.67km^2 (31.62%). The land use for the built-up area and light vegetation continued to increase while that of thick vegetation was on the decrease. In 2010 as shown in Figure 4.1d,with the exception of the light vegetation which decreased from 49.76km^2 to 31.44km^2, the rest of the three land uses: built-up area, bare land and thick vegetation respectively increased from 31.68km^{2}to 40.30km^2, 4.33km^2 to 5.43km^2 and 39.67km^{2}to 48.27km^2. Here, it indicates that cultivated area in period of 2000-2010 was converted into built up area and also some area were to forest reserves.

Figure4.1e which showed LULC for 2020 indicated that the built-up area has greatly increased from 40.30km^2 to 62.57km^{2}as the bare land moved from 5.43km^2 to 5.56km^{2}while the light vegetation reduced from 31.44km^2 to 25.63km^2.Thethick vegetation on the other hand reduced from 31.44km^{2}in 2010 to 25.63km^2 in 2020 because some land areas meant for cultivation were acquired for provision of public utilities.

4.3: Land Use Land Cover Detection and Magnitude of Change

The LULC Classifications of Ondo Metropolis detection and magnitude of change for 1980–2020 is presented in Table 4.2 and Figure 4.3. The area gained and lost by any particular LULC type is a function of the other LULC types present in the area. The percentage increase of built-up area and light vegetation shown by positive index were higher between 1980 (16.64 Km^2 (13.27 (%)) and 1990 (24.81 Km^2 (19.78(%)) than between 2000 (31.68 Km^2 (25.26 (%)) and 2010 (40.30 Km^2 (32.13Km^2 (%)). The percentage difference for built-up area was much higher between 2010 (40.30 (32.13)) and 2020 (62.57 (49.88)) while only the thick vegetation has negative index. Thick vegetation was rapidly depleted and taken over by light vegetation and built-up land uses as indicated by the negative index throughout the studying period. This resulted in the consistent growth and rapid development in the city.

The growth in built-up area is accounted for the reduction in vegetation and bare lands as reduction in other land use categories were meant for the increase in the built-up area. However, there is a striking feature of this study that some of the old residential areas have been replaced by other land use categories while new places have been encroached for built-up in recent time (as presented by the LULC map of Ondo metropolis displayed above) besides, the wholesome feature of land use pattern changed within the time span of 40 years (1980–2020) indicates that the major cause for the shrinkage in the volume of vegetation is the unprecedented urban spread.

The spatial pattern of sprawling in Ondo over the four decades indicates the direction and extent of growth in the period examined. For instance, from figures 4.1 a, b. c. d and e of LULC map of Ondo Metropolis shown above between 1980 and 2020, the growth navigates towards the southern and the western parts of the region more than any other direction. These areas were the places where location of the then Adeyemi College of Education now known as Adeyemi Federal University of Education, Ondo (AFUED) made. outhern part of the city has much influence in attracting high population as most staff of Adeyemi College of Education and students prefer to live close to the institution. Currently, the growth around this institution has almost captured Oka, Ajagbale, Liyetu, Laje and Awoyaya (the nearest settlements) as high percentage of students of the institution find cheaper accommodation there as well as cheaper lands for staff and people from Ondo to build houses and hostel accommodation for students.

The pattern is evident in the LULC maps displayed in figures 4.1a, b, c, d and e of Ondo metropolis. This finding corroborates the work of Oyinloye (2010) and Balogun et al. (2011) who observed significant difference in stages of development and growth in Akure since its inception as a state capital. It could be observed that the settlements which are referred to as built-up area still surrounded by the bare land or cultivation while the vegetation is no longer concentrated as the built-up areas have expanded in size. Deforestation occurs due to agricultural activities, constructions of buildings for residential purposes and educational purposes.

It was also noticed (from the LULC maps of Ondo Metropolis in figures 4.1a, b, c, d, and e) that areas that were formerly vegetation has changed to bare lands due to encroachment effects of development activities. Most arable lands have been taken over for residential development by these years, thereby depriving urban dwellers spaces for urban agricultural development. This phenomenon could greatly affect the wellbeing of the people as a healthy living is a potential tool for a rapid economic development.

The invasion of natural land cover for living purpose prominently indicates the ever-increasing urban development as well as the resultant land loss. The land transformation contributes greatly to the modification of the ecosystem. Vegetation has greatly reduced at the expense of the expansion of human habitation resulting into a dynamic influence of spatial pattern of the locality.

Table 4.2: Change in Detection (LULC maps of Ondo Metropolis, figure 4.1 a, b, c, d, e).

CLASS	1981 - 1990	1991 - 2000	2001 - 2010	2011 – 2020
Built Up	8.17	6.87	8.62	22.27
Bare land	0.28	0.86	1.1	0.13
Vegetation	-8.45	-7.73	-9.72	-22.4

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Figure 4.3: LULC change in detection histogram from year 1980-2020

5.0. CONCLUSION

In this study, land use land cover analysis was carried out over a forty-year period in Ondo metropolis to examine changes in land cover and extent of such changes. The analysis showed an increase in built-up, bare soil and grassland while forest and rock outcrops decreased over the period. It is noted that occupational status, building types, road accessibility, and location of farmlands amongst others were the important variables responsible for rapid expansion of the study area.

The implication of this is that as the population of the built-up area increased, the forest area decreased due to the conversion of natural vegetative surfaces into settlements while the natural vegetative surfaces were replaced by impervious surfaces which greatly affected the LST in of the study area. Higher land surface temperatures were recorded by the man-made structures while lower land surface temperature values were observed over the vegetative areas. This implies that vegetation cover reduces the LST over a land surface which implies the vegetative surfaces such as parks and forest reserves should be preserved in Ondo metropolis to reduce urban heat.

This study observed that while the maximum value of NDVI reduces, the built-up area increases, and the trend line predict the future area cover of urban area of the study area to be about 180sqkm by 2040.

Conflict of Interest

The authors declare that no conflict of interest exist in this manuscript.

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