

Analysis of Land Use and Land Cover Dynamics in Orlu, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Authors MCI, CPI and KOEU designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors JDN and GTA managed the analyses of the study. Authors SOA and NAC managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This research set out to ascertain the land use and land cover changes that have taken place in Orlu L.G.A from 1986 to 2013. Two fundamental tools applied were GIS and remote sensing which were used for the assessment of LULC. Remote sensing provided multi temporal images, while GIS was used to analyze the data from a geographic perspective. Field observation was also carried out in the area in order to assess the level of urbanization as well as the trend of development. The result of this analysis provided four major classifications of land use and land cover which include; bare-soil, built-up, water body and vegetation. The built up area was observed to have increased rapidly between 2000 and 2013 with a value of 46.207% while there was a drastic decrease in bare soil and water bodies as a result of the trend in development of this area within this period.

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Vegetation cover reduced from 58.03% in 1986 to about 52.09% in 2013. It is evident that Orlu is developing rapidly with respect to land use change as there has been rapid increase in socio-economic activities of the population. Consequently, there is an increase in the runoff level in the area as a result of various construction works going on in the area. This has resulted in high rate of siltation in the water bodies and their consequent shrinkage.

Keywords: Anthropogenic activities; geographic information system; landuse; landcover; multi-temporal dynamics; remote sensing.

1. INTRODUCTION

Land is a fundamental factor of production and through much of the course of human history; it has been tightly coupled to economic growth [1]. Changes in land use and land cover (LULC) therefore predates history and are the direct and indirect consequences of human actions to secure essential resources [2]. More recently, industrialization has encouraged the concentration of human population within urban areas (urbanization) and hence decreased the population of rural areas, accompanied by the intensification of agriculture in the most productive land and the abandonment of marginal land [3]. All of these processes are observable simultaneously around the world today.

Land use and land cover change is a general term for human modification of earth's surface. Though humans have been modifying land to obtain food and other essentials for thousands of years, current rates, extents and intensities of land use and land cover changes are far greater than ever in history, driving unprecedented changes in ecosystems and environment processes at local, regional and global scales. These changes encompass the greatest environmental concerns of human populations today, including climate change, biodiversity loss and the pollution of water, soils and air. Monitoring and mitigating the negative consequences of land use and land cover changes while sustaining the production of essential resources has therefore become a major priority of researchers around the world.

Deforestation is one of the major causes of land cover change and it is the most pervasive concern in developing countries [4,2]. The land use/land cover pattern of a region is an outcome of natural and socio - economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on land use/ land cover 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 land use resulting from changing demands of increasing population. The World Resources Institute [5] estimates that only one-fifth of the world's original forest cover remains. 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 in an observable pattern of change in the land use/land cover over time ranging from initial conversion of natural forest into cropland to on-going grassland management [6].

Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. Since environmental change is ubiquitous throughout the world, analyzing symptoms of emerging environmental change at local levels are essential. [3], noted that information about change is necessary for updating land cover maps and the management of natural resources. The information about the changing land cover is spatially revealed through a remotely sensed data.

Viewing the Earth from space is now crucial to the understanding of the influence of man's activities on his natural resource base and changes on the land over time. Hence remote sensing data and technique and geographic information systems (GIS) provide efficient methods and opportunities for analysis of land use and land cover dynamics and tools for land use planning and modeling [7,8]. In situations of rapid and often unrecorded land use change, observations of the earth from space provide objective information of human utilization of the landscape vis-a-viz, what, where and when changes occur as well as the rate of change [9]. Such data also provide an important link between

intensive, localized ecological research and regional, national and international conservation and management of biological diversity [10].

An increasing number of scholars are exploring the potential to gather data on land use and land cover dynamics in most emerging urban centers. Attempts have been made to document the land use and land cover of Orlu in the past from aerial photographs [11,12]. The result from their studies were commendable but lacked the multispectral capabilities of assessing the trend of land cover change over years using remote sensing and GIS techniques.

Therefore, this study aimed at mapping out the status of land use and land cover of Orlu using multi-temporal imageries spanning between 1986 and 2013, with a view to analyze the changes that have taken place in this area over a 27 years period, using both Geographic Information System and satellite remote sensing data.

2. STUDY AREA

The study area for this project is Orlu Local Government Area in Imo state Southeast Nigeria.

It lies within latitude 5°43'45" N to 5°53'00" N and longitude 7°0'00" E to 7°7'30" E with a population of 142,717 [13]. It is the third largest city in Imo state located in a sedimentary rock formation and lies within the Awka-Orlu uplands in a zone of sandy lateritic soil (Fig. 1). The climate is typically humid, the same as is obtainable in the Southeastern region of Nigeria. Two distinct seasons are familiar with the climate of the area. The rainy season, that begins in April and ends in October, with higher intensity in June and late September, and the dry season, which begins in November and ends in March. The annual rainfall varies between 1,990 mm and 2,200 mm.

Temperature is generally high with little variation during the year. The mean annual temperature is about 27°C with an average annual relative humidity of 75 percent which is high during the rainy season. The vegetation of Orlu is rain forest and the topography is undulating. Inhabitants produce agricultural products such as palm produce, cocoa and rubber. The staple crops are yam, cassava, cocoyam and maize. The economy of the area depends largely on agriculture and commerce and the chief occupation of the people is farming.

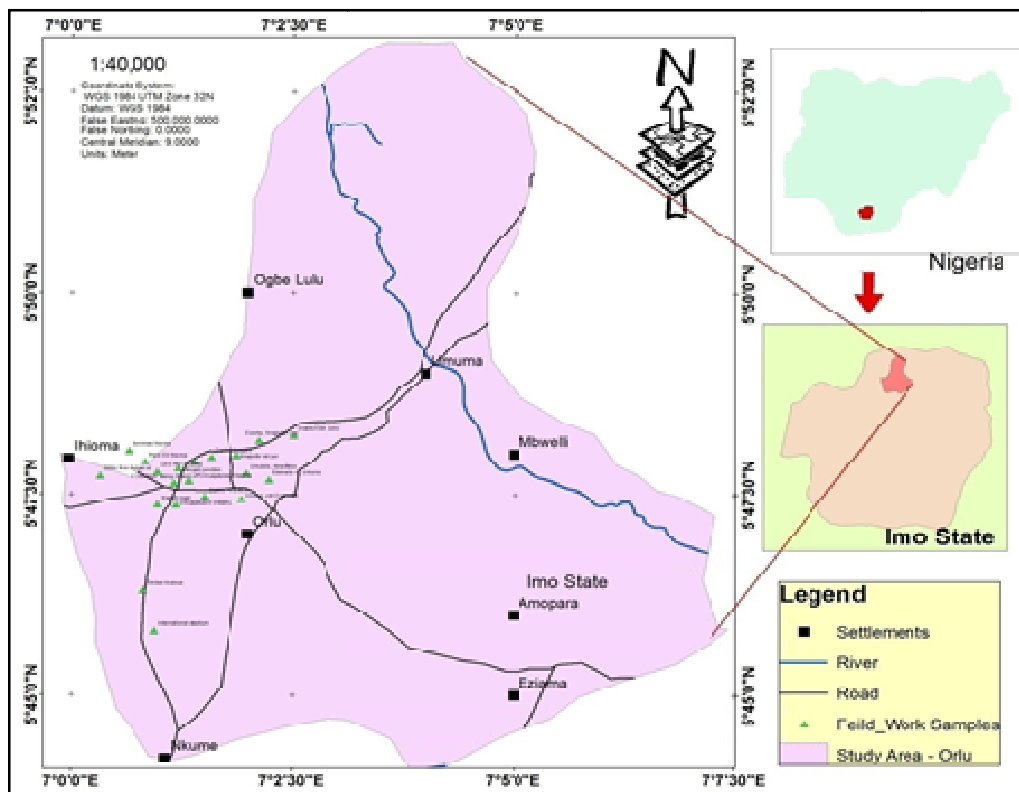


Fig. 1. Map of study area

3. RESEARCH METHODOLOGY

Data used for this study were obtained from both primary and secondary sources.

The primary data was obtained from direct field observations with a handheld GPS (Extrex Garmin Version 16.0) device. The GPS was used to acquire the coordinates of specific areas used in assessing the terrain of the study area. While secondary data was the major data used for decadal assessment of the vegetation of the area. The secondary data was a geospatial data which include the following satellite imageries: Landsat 5 thematic mapper of 1986, Landsat 7 enhanced thematic mapper of 2000 and the Nigeria Sat-X image of 2013 as well as journal literatures and articles. All the above mentioned satellite images were captured during dry season.

Tools of data analysis include software's such as;

- a. **ERDAS IMAGING 9.2:** Erdas Imagine 9.2 was used for spatial, spectral and radiometric enhancement. Spatial enhancement was carried out using a resolution merge model. It was also used to generate the land use land cover maps for the study area covering the 3 periods of assessment. The LULC classification adopted the [14] class features using the maximum likelihood model of the supervised classification which revealed the current land use in the area in the results output.
- b. **Arc-GIS 10.0:** Arc-Map was used for the vectorization and digitizing of the images to generate the map of the study area. ArcCatalogue was used in creating a personal geo-database and shape-file used to generate the study area map. Also it was used to generate the area variability of the different land cover feature assessed.
- c. **Other ancillary software used were:** Microsoft office word 2013, Microsoft office excel 2013 etc.

3.1 Techniques for Data Analysis

The Landsat data was resampled using the pixel characteristics of Nigeria Sat X data as this was to ensure similarities of the spatial and radiometric characteristics of the satellite imageries used for the study. The mapped out

area for the analysis was subjected to a supervised classification analysis and at this stage the domain of the spatial parameters mentioned above were adopted and subjected to maximum likelihood classifier of the ERDAS software.

Land-use and land cover classification was done using the [14], USGS classification scheme. Results describing the various disparities in vegetation, settlements, and the nature of the terrain are presented in maps, tables and histogram.

4. RESULTS PRESENTATION AND DISCUSSION

The results in a table form extracted using Arc Map, shows disparities in spatial parameters using the number of pixels classified and the corresponding area in hectare. Furthermore, the tables were displayed in pie charts, histogram etc., for enhanced visual interpretation of the results.

Table 1. The raster attributes for 1986 results

Class name	Area (H)	Area (%)
Bare soil	2287.702	17.68514
Built Up	3645.865	24.18446
Water Body	13.23968	0.10235
Vegetation	6988.924	58.02806
Total	12935.73	100

Table 2. Error Matrix I

Classified data	Water body	Vegetation	Built-up	Bare soil
Water body	84	6	4	0
Vegetation	2	3982	8	0
Built-up	1	2	2437	0
Bare soil	0	6	26	44
Column	87	3996	2475	44
Total				

There is no doubt that human activities have profoundly changed land use and land cover in Orlu L.G.A as observed within the period 1986 to 2013. Field observations indicates that the major drivers of this change are; Increase in commercial land use and Increase in built up areas.

The accelerated increase in commercial activities in Orlu L.G.A has brought about significant changes in the land use and land cover of the area. Another driver of this change in land use and land cover is increase in built up areas. The

built up land use found in this area include basically buildings and roads. It was observed that the number of buildings as well as the roads both constructed and undergoing construction found in this area has significantly increased. As

a result of the changes that have taken place especially from 2000 to 2013, it was inferred that the built up areas has increased from 24.18% to about 47.20% as represented in Table 7.

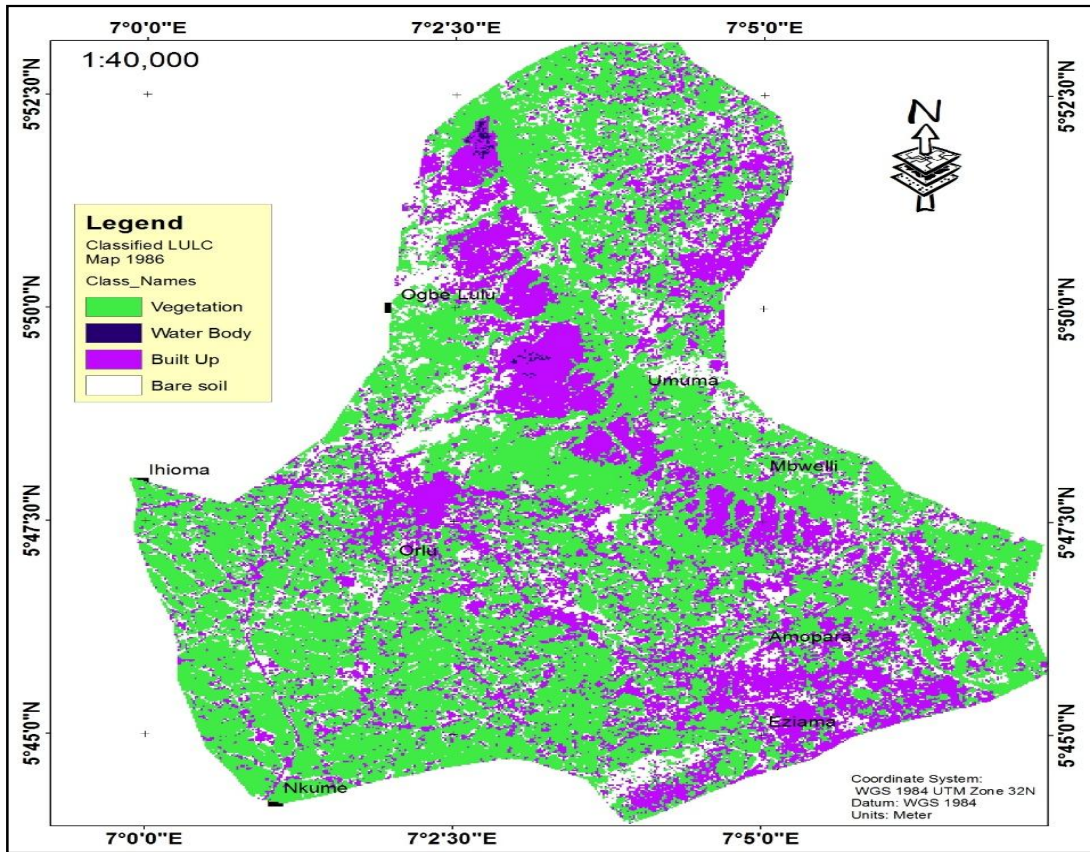


Fig. 2. Classified LULC Map 1986

Table 3. The raster attributes for 2000 results

Class Name	Area(H)	Area (%)
Water body	459.2192	3.550023
Bare soil	1133.334	8.761312
Vegetation	7485.447	53.86671
Built up	3857.674	33.82199
Total	12935.67	100

Table 4. Error Matrix II

Classified data	Reference data		Vegetation	Built up
	Water body	Bare soil		
Water body	117	0	7	65
Bare soil	0	74	79	31
Vegetation	3	0	1899	21
Built up	7	1	19	1404
Column Total	127	75	2004	1521

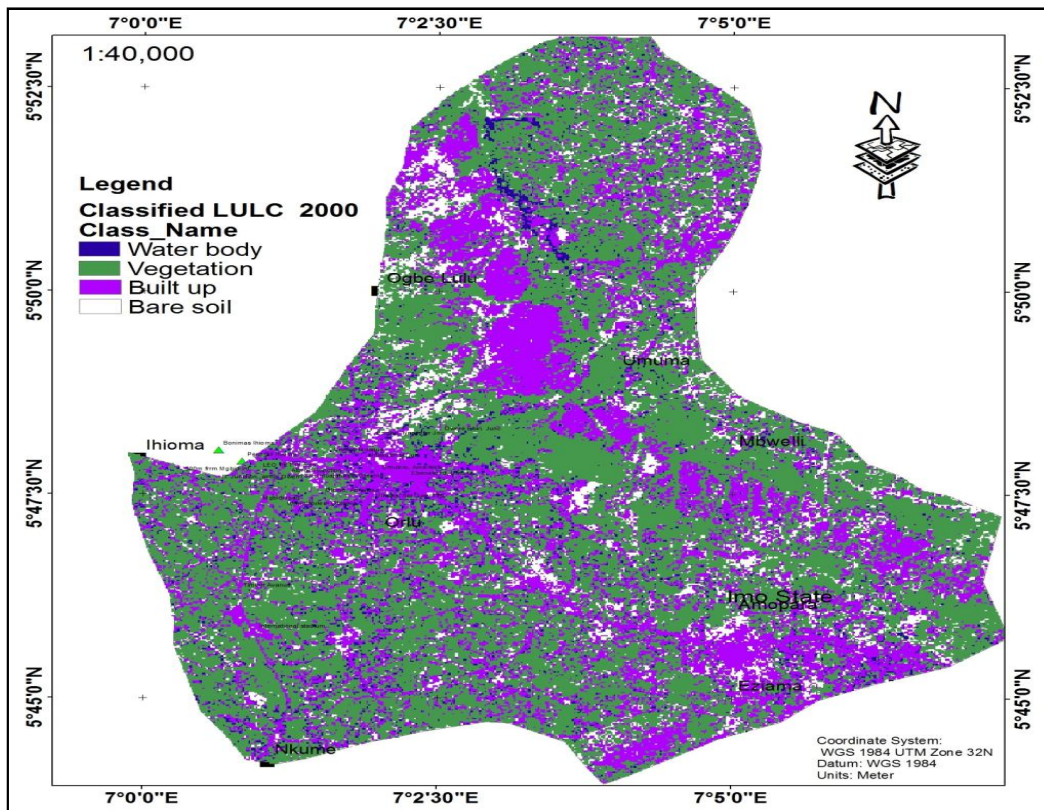


Fig. 3. Classified LULC Map of Orlu 2000

Table 5. The raster attributes for 2013 results

Class name	Area(H)	Area (%)
Bare Soil	87.362	0.672762
Water Body	3.872	0.029818
Vegetation	6894.096	52.09044
Built-up	6000.245	46.20702
Total	12985.57	100

Table 6. Error Matrix III

Classified data	Water body	Bare soil	Vegetation	Built-up
Water Body	27	0	0	0
Bare Soil	0	95	0	0
Vegetation	0	0	126	0
Built-up	0	0	0	746
Column Total	27	95	126	746

Table 7. Change detection 1986, 2000 and 2013

Lulc categories	LULC 1986		LULC 2000		LULC 2013	
	Area (Ha.)	Area (%)	Area (Ha.)	Area (%)	Area (Ha.)	Area (%)
Bare Soil	2287.702	17.69	1133.334	8.76	87.362	0.67
Water Body	13.23968	0.10	459.2192	3.55	3.872	0.03
Vegetation	6988.924	58.03	7485.447	53.87	6894.096	52.09
Built-up	3645.865	24.18	3857.674	33.82	6000.245	47.21
Total	12935.73	100	12935.67	100	12985.57	100

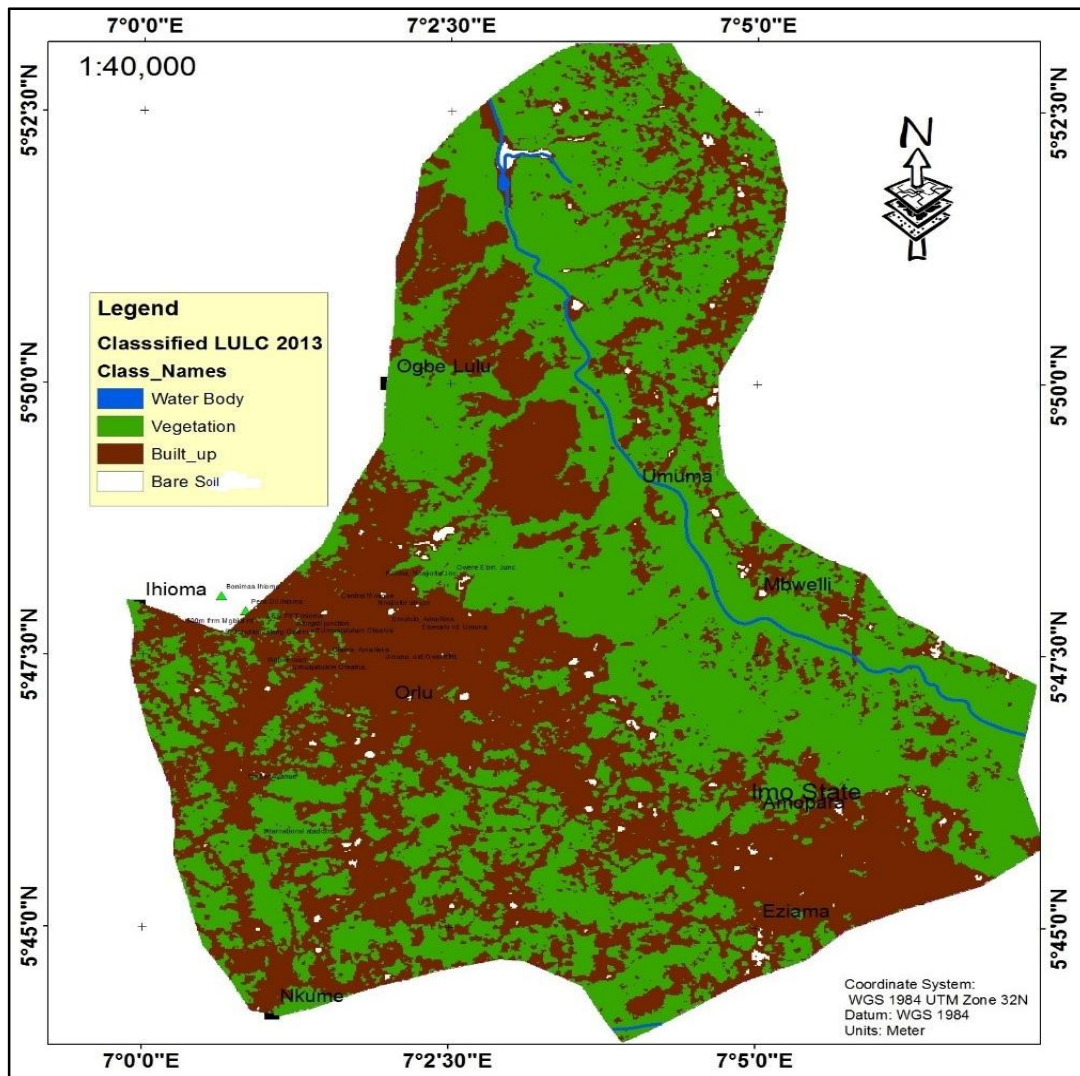


Fig. 4. Classified LULC Map of Orlu 2013

Table 8. Percentage change

LULC categories	1986 -2000		2000-2013		Annual rate of change
	Area (Ha.)	Percentage change	Area (Ha.)	Percentage change	
Bare Soil	-1154.367725	-8.92387	-1045.9724	-8.085916	0.837953
Water Body	445.979525	3.44766	-455.3472	-3.520073	-6.96773
Vegetation	496.5233	3.83839	-591.3512	-4.571456	-8.40984
Built-up	211.80825	1.63739	2142.5712	16.563202	14.92581

The land use land cover analysis result of 1986 shown in Table 1, revealed that bare soil occupied a total surface area of 2287.702 hectares constituting 17.69% of the total area. Vegetation occupied 6988.924 hectares making up the largest land surface area with a total of 54.03%. Built up surfaces occupied 3645.865

hectares or 28.18% ranking as the second largest surface cover in the study area, while water body occupied the least area of 13.24 hectares. The result therefore depicts that farming was the major occupation of the population as land was converted to agricultural use.

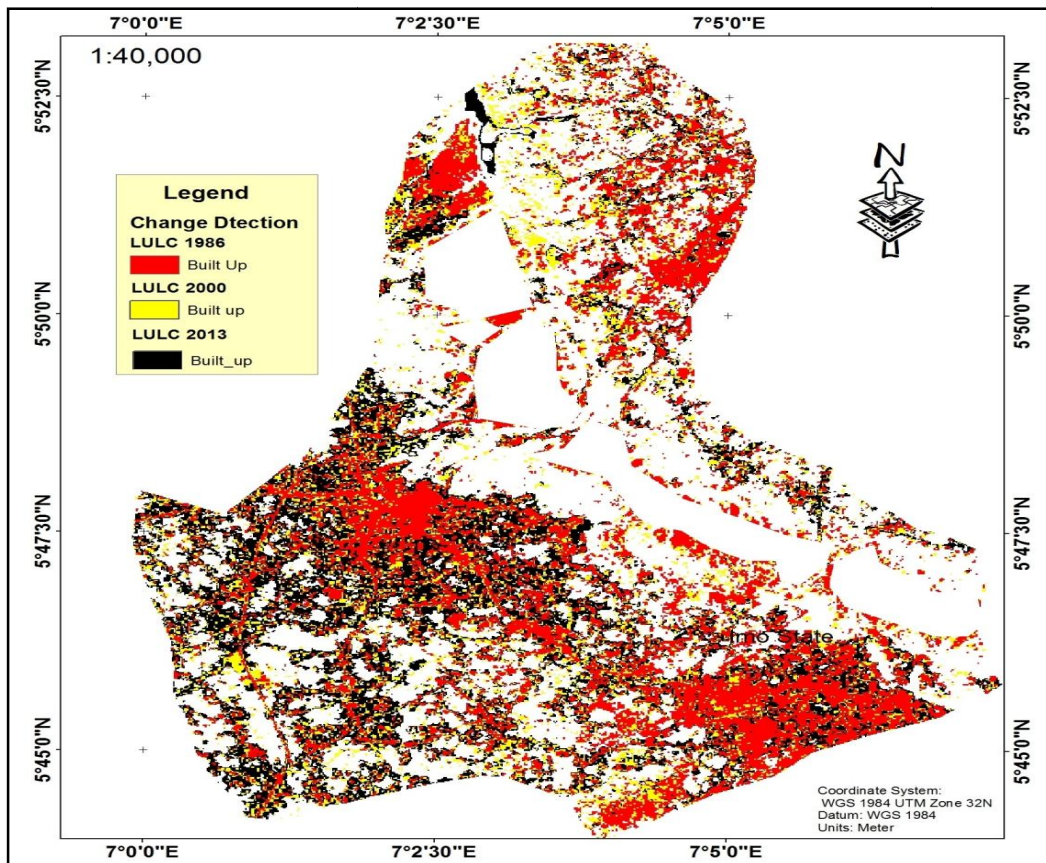


Fig. 5. Change detection LULC Map of Orlu 1986 – 2013

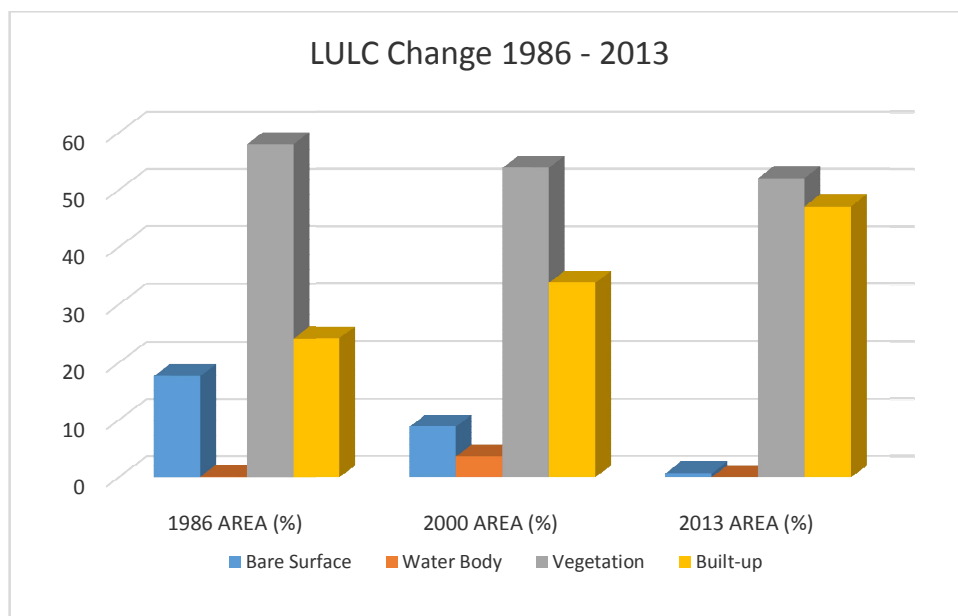


Fig. 6. LULC change 1986 - 2013

5. SUMMARY OF FINDINGS

According to the land use land cover result of 2000, it was revealed that bare soil occupied a total surface area of 1133.33 hectares constituting 8.76% of the total area. Vegetation occupied 7485.45 Hectares making up the largest land surface area with a total of 57.87%. Built up surfaces occupied 3857.674 hectares and was the second largest surface cover in the study area with fast emerging urban development covering a total of 29.82% of the area, whereas Water body occupied the least area covering only 459.22 hectares. Therefore, it was observed that there has been a trend of increase in built up areas due to development.

From the land use land cover result of 2013, it was observed that bare soil occupied a total surface area of 87.362 hectares constituting 0.673% of the total area. Vegetation occupied 6894.096 hectares making up the largest land surface area with a total of 53.1%. Built up surfaces occupied 6000.245 Hectares, hence the second largest surface cover in the study area covering a total of 46.21% of the land surface. And finally Water body occupying the least area coverage of 3.872 hectares. It was also observed that built up area is also increasing over time.

6. CONCLUSION AND RECOMMENDATIONS

Finally, it can intuitively be concluded that the trend of development taking place in Orlu L.G.A is most conspicuous with increase in built up surfaces which is also used for commercial activities in the area. There was equally noticeable decrease in vegetation in this area. Urbanization has also caused a rapid decrease in bare soil as the people convert the bare soils in this area into other land uses especially commercial activities and constructions.

From the change detection analysis, vegetative cover of the study area was observed to reduce in a linear pattern from 1986 to 2013, it significantly reduced from 58.03% to 52.09% of the total land cover. However, there was a gradual increase in the built up area of the land cover from 1986 to 2000. This indicates that there was gradual developmental activities in the study area within the years. The year 2000 there witnessed a peak increase in the extent of built up areas which was about 46.2 percent of the total coverage of the land use land cover in the area as shown in Table 5. It can as well be

concluded that Orlu L.G.A is developing rapidly and the trend of this development enhances the socio-economic activities of the population with respect to the various commercial activities practiced in the area. However the implication of this trend based on the research findings is that unregulated urbanization currently ongoing in the study area, will have dire consequences on surface water resources as increased paved surfaces will lead to higher volume of surface runoff and siltation of surface water thereby affecting ecosystem functions. Equally, there is the possibility of microclimate alteration resulting from reduced vegetation cover and increased paved surfaces hence resulting in escalation of urban heat island. This study therefore recommends that urban planning authority should regulate the massive urban growth in the area to avoid ecological decay. The Local Government Council should ensure agricultural and forest reserve land are not compromised to ensure adequate or sustainable development in the area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

- 1 Richards M. Land as a fundamental factor of production and economic growth. A remote sensing perspective, 3rd edition. Beijing: Science Press and Pearson Education Asia Ltd; 1990.
- 2 Zhao G, Pitman O. Deforestation as a major force responsible for Land use and land cover change. Island Press, Washington, DC. 2002;713-725.
- 3 Xiaomei Y, Ronqing LQY. Change detection based on remote sensing information model and its application to coastal line of Yellow River Delta – Earth Observation Center, NASDA, China; 1999.
- 4 Moore CT. Deforestation as one of the causes of land cover change in developing countries. Island Press, Washington, DC, 1996;713-725.
- 5 WRI (World Resource Institute) 1997: Biodiversity Glossary of Terms. Available:<http://www.wri.org/biodiv/gbs-glos.html> (Access: 08.06.1997)
- 6 Meyer WB. Past and present land use and land-cover in the U.S.A Consequences:

- Nat. Implications Environ. Change 1995;1:1.
- 7 Jonathan O. Landuse and landcover analysis modeling using remote sensing data and technique and geographic information systems (GIS). China Statistics Yearbook. Praeger, New York; 1997.
- 8 Miller A, Rogan C, Victor K. Investigating the physical characteristics of land using GIS and remote sensory imageries. A GI Science Approach. Dordrecht: Kluwer Academic Publishers. 2007;360.
- 9 Lambin E. Modeling and monitoring land cover change processes in tropicalregions. Progressin Physical Geography 21: 375–93. Environmental Change. 1997;11:261–269.
- 10 Wilkie DS, Finn JT. Remote sensing imagery for natural resources monitoring. Columbia University Press, New York. 1996;295.
- 11 Carlos BR. Documentation on the land use and land cover changes- A case study from Orlu, Imo state. Journal of Environmental Management. 1998; 72(1-2):1-3.
DOI: 10.1016/j.jenvman.2004.04.004
Available:<http://dx.doi.org/10.1016/j.jenvman.2004.04.004>
- 12 Okechukwu, Okezie. Analysis using aerial photograph. A case study from Orlu. Landscape Ecology. 2003;17:355-365.
DOI: 10.1023/A:1020561630963
Available:<http://dx.doi.org/10.1023/A:1020561630963>
- 13 NBS. Official Gazette, legal notice on publication of the breakdown of the national and state provisional totals 2006 census. National Bureau of Statistics; 2006.
- 14 Anderson JR, Hardy EE, Roach JT, Witmer RE. A land use and land cover classification system for use with remote sensor data. Geological survey professional paper No. 964, U.S. Government Printing Office, Washington, D.C. 1976;28.

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