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Research Article

Analysis of Akure Urban Land Use Change Detection from Remote Imagery Perspective

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This study presents the analysis of Akure urban land use change detection from remote imagery perspective. Efforts were made to examine the direction that the continuous expansion of the city tends towards since its inception as a state capital in 1976. Using Aerial Imagery Overlay (AIO), the pattern of land use changes in Akure and its environs were determined. This involves imageries interpolation and overlaying to determine the land use changes, direction, and extent of the expansion. Findings revealed unguided expansion in the growth of the city which affects the pattern of land uses within the city and, by extension, into the adjoining settlements. There were incompatible conversions in land uses and undue encroachment into green areas in the adjoining communities. The study suggests effective zoning strategy on unguided nature of urban development whose effects on land use are very 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 changes in the area.

1. Introduction

Land Use Land Cover Changes (LULCC) is urbanization induced, which has led to dramatic changes in land use practices [1]. Rapid pace of urbanization is believed to be a global problem present in most of the developing countries of the world. Balogun et al. [2] submitted that urban populations in most developing countries have grown by 40% between 1900 and 1975. According to them, the trend will continue adding approximately 2 billion people to the urban population of the presently less-developed nations for the next 30 years. In similar way, Arnfield [3] observed that the world is becoming increasingly urbanized with 45% of the population already living in the urban areas in the year 2000. He projected half of the world living in urban areas by 2007. It was further estimated that by the year 2025, 60% of the world's population will live in cities [4].

Akure is not in any way going contrary to this prediction as the population has been more than triple of what it used to be before it became administrative headquarters of the state and local governments. For example, the population was just 71,106 in 1963; but with the influx of people into the town due to the state creation of 1976, the population rose to 239,124 in 1991 and 360,268 in 2006 [5]. Even in 2010 and 2014, the population was estimated at 413,060 and 476,159, respectively, using the 3.18 annual growth rates recommended by the National Population Commission of Nigeria [5]. Its administrative status and concentration of establishments like government ministries, several housing estates, Ondo State Oil Producing Area Development Commission (OSOPADEC) secretariat, Federal University of Technology, Akure (FUTA), and lot more were the centre of consideration for the attraction. The trust of this paper, therefore, is to examine definite changes that have taken place

in Akure urban land use in the past three decades with a view of providing information that can inform policy formulation towards the physical planning of the area.

2. Literature Appraisal

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 [6–11]. In this regard, about 400,000 ha. of vegetation cover are confirmed to be lost annually [2, 12]. Due to anthropogenic activities, the earth surface is being significantly altered by man's presence and several activities on earth. According to Fazal [13], 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.

Several researches have shown that unplanned changes of land use due to urbanization have become a major problem [2, 14]. Most land use changes occur without a clear and logical planning and without giving attention to environmental impacts. Major flooding and air pollution in large cities as well as deforestation, urban growth, soil erosion, and desertification are all consequences of a mismanaged planning and inappropriate projects' execution without considering their environmental impacts. As observed in Nicholson [15], the rapid land use changes by the growing population have reduced natural vegetation cover in most countries of the world.

Urban growth observation and management remains a major concern of Geographic Information System (GIS) and Remote Sensing (RS) applications. The duo provides historical vehicle to monitor and determine and evaluate long term changes in land use due to urbanization process. They have been proven to be effective means for extracting and processing varied resolutions of spatial information for monitoring urban growth. According to Cheng and Masser [16], the collection of remotely sensed data facilitates the synoptic analyses of earth in terms of system functioning, burbling, and changes at local, regional, and global scales over time. Such data provides import data link between intensive, localized, ecological research and regional, national, and international conservation and management of biological diversity [17, 18].

Land use changes arising from urbanization, housing development, agriculture, and deforestation are some of the contributing factors to land cover changes in Akure. These changes reflect on the population growth, land consumption rate, and local climate. Expansion of Akure has resulted not only in depletion of natural resources, but also in deterioration of the environment due to incompatible changes in land use pattern. Agriculturally productive land and forestland are being converted to residential and other private and public uses. Balogun et al. [2] argued that the land use land cover pattern of a region is an outcome of natural and socioeconomic factors and their utilization by man in time and space. Hence, the uncontrolled growth of urban development of Akure has adversely affected its ecosystem which has potency to indirectly reflect on weather parameters with eventual local climate modification [2, 19].

Akure is the capital of Ondo State as well as the headquarters of Akure South Local Government Area. Between 1976 and the present time, the city has experienced enormous growth and has developed independently of any spatial urban planning. This rapid growth became prominently noticed in the last two to three decades. As urbanized features extended farther from the central areas, lands populated by development are altered in significant ways. Since 1976 when the town became the state capital, there have been remarkable changes in its growth and development. Several developmental projects that brought transformation to the physical landscape of the city are very prominent. Oyinloye [7, 20] clearly observed that the construction of Ilesha-Owo expressway opened up the area for massive development. It links the city with the northern and eastern parts of the country. Presently, development and establishment of public facilities are concentrated along this route.

In order to mitigate the negative effects of the city's growth and expansion, there is need for adequate programs and policies that can foster its sustainable development. The essence of this is to encourage and monitor development in a way that it will not damage the environment for the incoming generations. This can only be achieved by taking appropriate inventory of the available resources and planning for their present and future uses. It is on this premise, therefore, that the study is set to investigate the changes in pattern of land uses in Akure and its environs to suggest policies that can be used in combating its effects.

3. Materials and Methods

3.1. The Research Locale. The study centers on Akure city and its immediate environments. Akure is a notable city in south-western Nigeria which became the capital of Ondo State on February 3, 1976. As shown in Figures 1–3, it is located between latitudes $7^0\ 15^1$ and $7^0\ 17^1$ north of the Equator and between longitudes $5^0\ 14^1$ and $5^0\ 15^1$ east of the Greenwich Meridian. It is about 204 km east of Ibadan, capital of Oyo state; 168 km west of Benin City, capital of Edo state; 311 km north-east of Lagos; and 323 km south-west of Abuja, the Federal Capital Territory of Nigeria. Akure town spreads over an area of about 15,500 km^2 in about 370 m above the sea level. Its population figure by the National Population Census of 1963 was just 71,106. With the influx of public servants into the town consequently upon state creation in 1976, the population rose to 239,124 and 360,268 in 1991 and 2006, respectively, with a projection of 476,159 in the year 2014 [5].

3.2. The Database. Data collection for this study was essentially through Aerial Imagery Overlay (AIO) with the aid of GIS, RS, and personal observations. Other sources include government ministries and establishments for historical

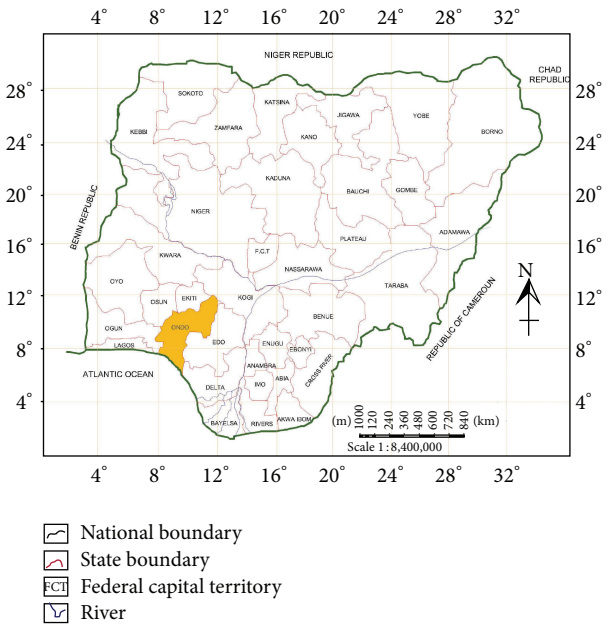


Figure 1: Ondo State in the national setting. Source: Department of Surveys, Federal Ministry of Works, Abuja (2014).

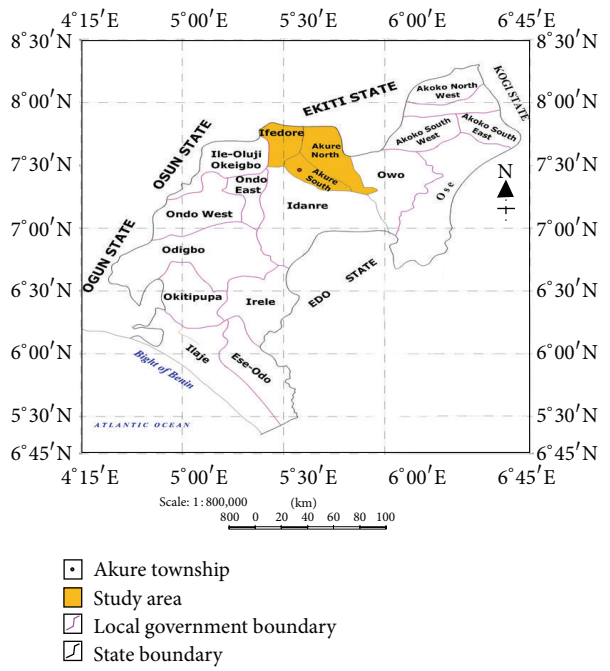


Figure 2: Ondo State and its 18 Local Government Areas. Source: Ondo State Ministry of Lands and Survey, Akure (2014).

milieu of the area as well as base maps and population data used for the study. Internet facilities were equally explored for relevant information. The study area has a total population of 476,159 in 2014 with a total land expanse of 125,212 ha. The main approach used in this study was mainly postclassification comparison analysis of satellite imageries of Akure obtained at three decadal variations between 1985

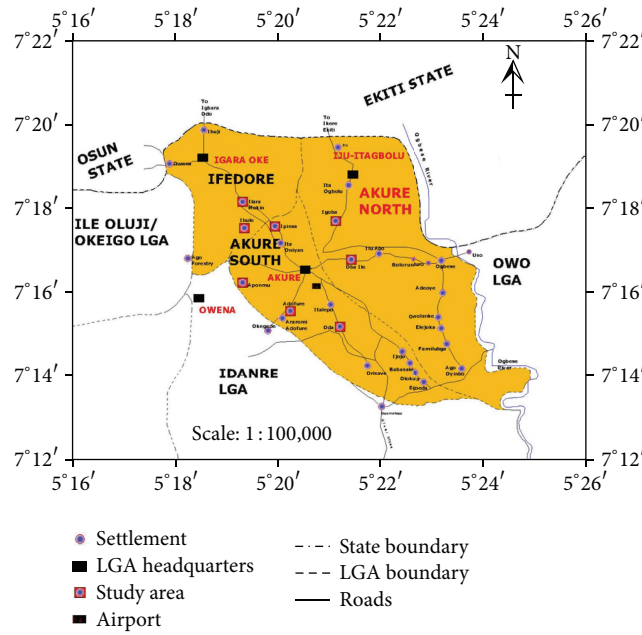


Figure 3: Locational map of the study area in regional setting. Source: Ondo State Ministry of Lands and Survey, Akure (2014).

and 2014. This helps to examine variation in the change and to show the direction and extent of the growth from one period to the other. The studying period spans through three decades and is divided as follows: 1985–1994, 1995–2004, and 2005–2014. The land use for the study area is classified into four categories (as it physically applies to the study area). It includes the built-up area (involving residential, commercial, industrial, recreational, and educational land uses); thick vegetation (forested land areas); light vegetation (cultivated land areas); and the water bodies (rivers, streams, etc.).

4. Research Findings and Discussion

4.1. Analysis of Land Use Land Cover (LULC) Classifications: 1985 to 2014. As shown in Figure 4, lager proportion (80,796 ha.) of the study area was covered with thick vegetation in 1986 which accounted for 64.53% of the land area while 37,977 ha. (30.33%) was cultivated and covered with light vegetation. Only about 5.1% were developed areas which are residential, commercial, recreational, industrial, or educational land uses, occuping just about 6384 ha. of land area. Just about 56 ha. (0.04%) was covered by water. This situation expresses the low level of development as of 1986 with a small compact urban area.

The LULC classifications for the year 2002 are shown in Figure 5. In 2002, the percentage of built-up area had increased to 16.63% (20,885 ha.) and cultivated area (light vegetation) also increased to 68,940 ha. (55.06%) while the area covered by thick vegetation reduced drastically to 32,978 ha. (26.34%). This shows that much of the thick vegetation was cultivated while some of it gave way to further development and urban expansion through building constructions and provision of public utilities.

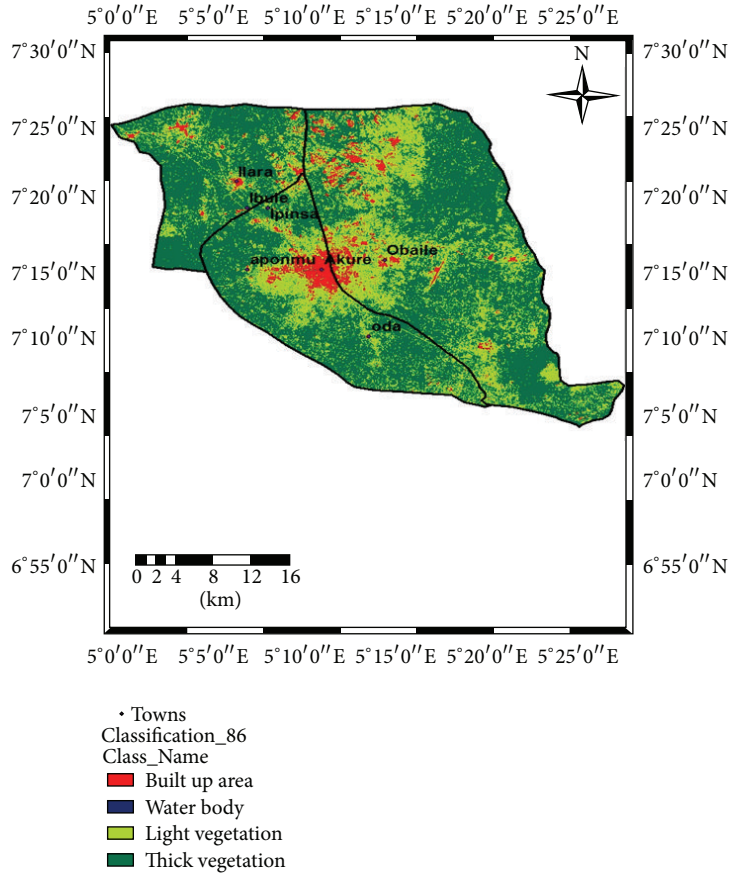


Figure 4: Land use classification of Akure as of 1986. Source: Landsat 4 Thematic Mapper (TM) Imagery (1986).

Figure 6 illustrates the LULC classifications for the year 2007. In the figure, the built-up area further increased to about 22,985 ha. (18.36%) and light vegetation occupied 82,415 hectare (65.82%) while areas covered by thick vegetation and water body reduced to 19,002 ha. (15.18%) and 811 ha. (0.64%), respectively. The land use for the built-up area continues to increase up to date while that of thick vegetation, light vegetation, and area covered by water reduces.

In 2014, land use for built-up area (as shown in Figure 7) increased from 22,985 (in 2007) to 34,303 ha. (27.40%) while light vegetation (the cultivated area) reduced from 82,415 ha. (in 2007) to 72,675 ha. in 2014. The reason for this might be because of drastic reduction in number of farmers since the majority of people working on the farms had been taken over by civilization and quest for white-collar jobs while some land areas meant for cultivation were acquired for provision of public utilities.

The implication of this analysis is expressed in the rate of urban expansion as illustrated by the trend of increase in the built-up area and light vegetation (cultivated land areas). The drastic reduction in the percentage of area covered by thick vegetation shows there was a phenomenal growth within the studying period. For instance, the built-up area increased by 22.3% between 1986 and 2014 and light vegetation (cultivated land areas) by 27.71%. This is likely to be the result of much encroachment into the thick vegetation and rocky and undulating land areas for the purpose of building construction, quarry, blasting and mining activities. Besides, the economic situation in the state around the time (especially in the ealier years of the millenium) was favourable for individuals, government, and various establishments to embark on massive developments. For example, in 2002, various projects were embarked upon as a consequence to the discovery that the state falls within the mineral endowed region, which resulted in the tremendous increase in the built-up areas. This accounted for the massive physical expansion of the region. Again, Akure gained a great influx of people seeking greener pastures being the state capital while the discovery of bitumen in the state attracted many investors and other immigrants within the studying period.

4.2. Land Use Land Cover Change (LULCC) Detection Analysis for the Years 1986–2014. The LULC Classifications of Akure and the change detection analysis for the 1986–2002, 2002–2007, and 2007–2014 are presented in Table 1 and Figure 8. From the table and figure, the percentage increase of built-up area, light vegetation (i.e., cultivated land areas), and water body, as shown by its positive index, was higher between 1986 and 2002 than between 2002 and 2007. The percentage difference for built-up area was much higher between 2007

Table 1: LULC change detection analysis in Akure for the years 1986–2014.

The LULC	2002–1986		2007–2002		2014–2007	
	Difference in area (ha.)	Difference in area (%)	Difference in area (ha.)	Difference in area (%)	Difference in area (ha.)	Difference in area (%)
Built-up area	14441	11.53	2160	1.73	11318	9.04
Thick veg.	−47818	−38.19	−13976	−11.16	−1379	−1.11
Light veg.	30963	24.73	13475	10.76	−9740	−7.78
Water body	2413	1.93	−1658	−1.33	−199	−0.15

Sources: Landsat Satellite Imageries (1986, 2002, 2007, and 2014).

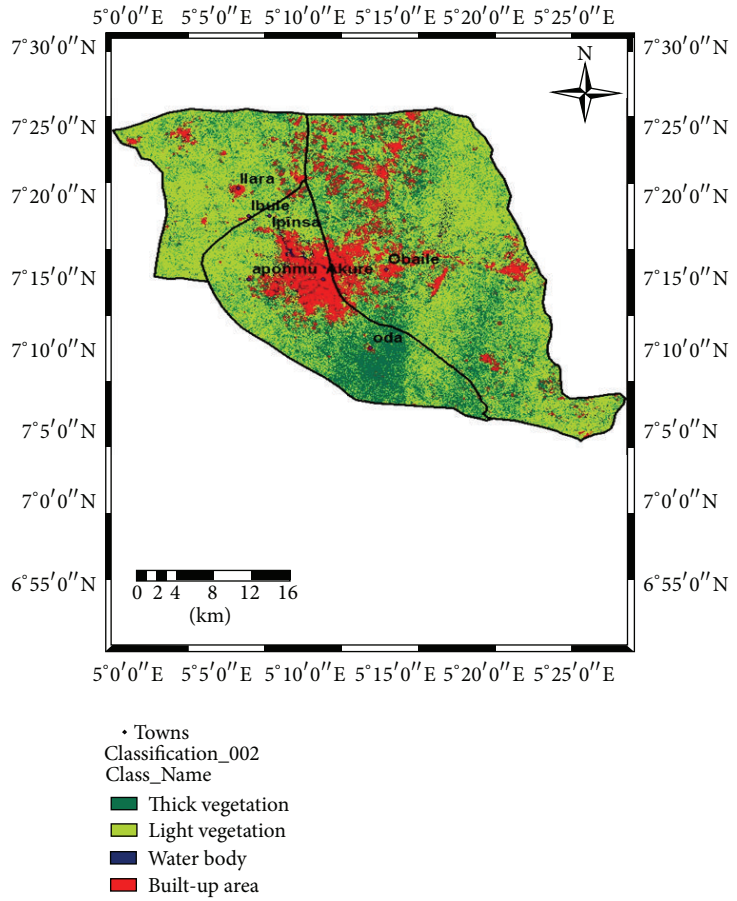


Figure 5: Land use classification of Akure as of 2002. Source: Landsat 7 Enhanced Thematic Mapper (ETM$^+$) Satellite Imagery (2002).

and 2014 while other land classifications have 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 is an evidence of consistent growth and rapid development witnessed in the city.

4.3. Urban Built-Up Change Detection Analysis and Predictive Model for Future Expansion. The spatial pattern of sprawling in Akure over a period of three decades (1985–2014), as shown in Figures 4–7, expresses the direction and extent of growth in the period examined. For instance, between 1985 and 2002, the growth navigates towards the northern and the eastern parts of the region more than any other direction. These areas were earmarked for the construction of Government Residential Areas (GRAs) and government ministries. Besides, the area was the location of Ijapo Estate, a notable residential estate in the city which attracted much influx into the area. The construction of Ilesha-Akure-Owo highway which passes through the north-eastern part of the city was anosther notable factor that plays a prominent role in attracting people to the area. But the direction of growth thereafter diffused to other directions, probabily due to congestion in this area and availability of cheap lands and good topography which favours construction in other parts of the city.

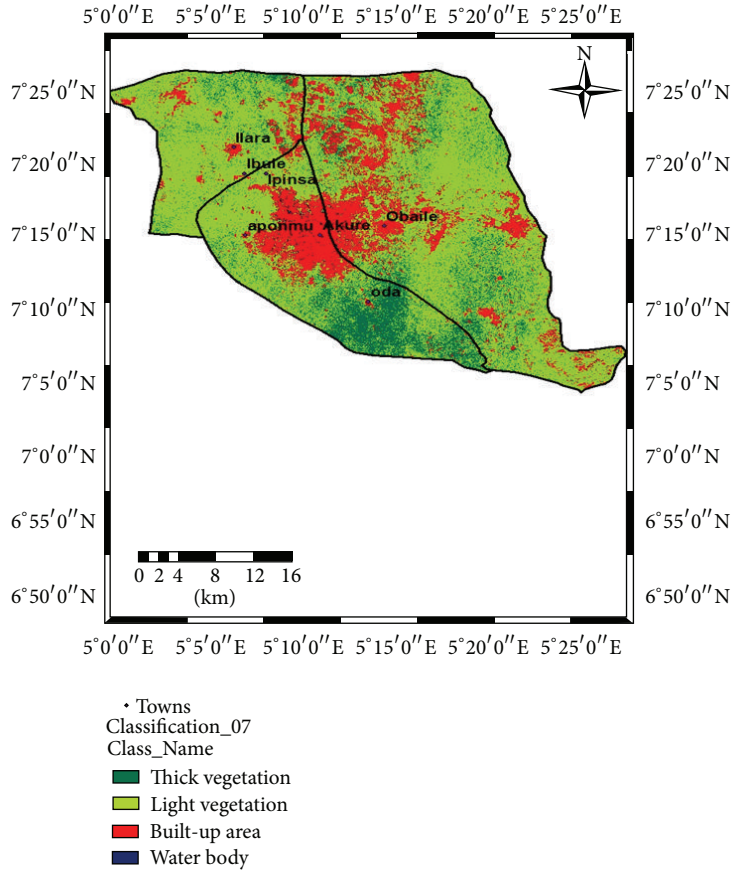


Figure 6: Land use classification of Akure as of 2007. Source: Landsat 7 Enhanced Thematic Mapper (ETM$^+$) Satellite Imagery (2007).

The location of Federal University of Technology, Akure (FUTA), in the north-western part of the city has much influence in attracting huge population of people into the area. Most staff of the institution and students prefer to live close to it, thereby making the growth an institutional attraction. Currently, the growth around this institution has almost captured Ipinsa and Ibule (the two nearest settlements) as high percentage of students of the institution find cheaper accommodation there as well as cheaper lands for staff and people from Akure to build houses and hostel accommodation for students. This and other important developments that parade the city revealed significant difference in stages of expansion and land uses within the studying periods. These findings corroborate the work of Oyinloye [7] and Balogun et al. [2] who observed significant difference in stages of development and growth in Akure since its inception as a state capital.

The use of GIS to predict future expansion of the study area and possible changes in land uses was modeled with the aid of Markov Chain technique to guide policy makers in the management of land use activities in Akure and its environs. Adopting the 3.6% growth rate used in Oyinloye [7] for Akure projected population, the predicted future expansion for the built-up area for a period of 20 years (i.e., 2014 to 2034) is estimated at 66881.02 ha. This was done using the exponential model of Hofstede and Brussels [21], stated as follows: $P_f = P_0(1 + r/100)^n$, where P_f is future (projected) population (or growth area), P_0 is present population (or growth area), r = growth rate, and n = number of years for the proposed projection. The pictorial representation of the built-up change detection analysis and future prediction is shown in Figure 9. As shown in the figure, there is every possibility of Akure becoming a full grown conurbation by 2034 when it would have subsumed many of its adjoining communities.

5. Summary of Findings and Policy Implications

The study gives a clear indication of unguided expansion in the growth of Akure which affects the pattern of land uses in the city and its surrounding settlements. There were incompatible conversions of land uses and undue encroachment into green areas in the adjoining settlements due to favourable economic situation in the state around the period. In the early year of the millenium, Akure gained much influx of people being the state capital. Besides, the discovery of bitumen in the state attracted much investors and other immigrants in quest of greener pastures for job opportunities. Its administrative status and concentration of establishments were the key indices for this attraction. With this, the thick vegetation was massively encroached which consequently gave way to further developments and expansion from the

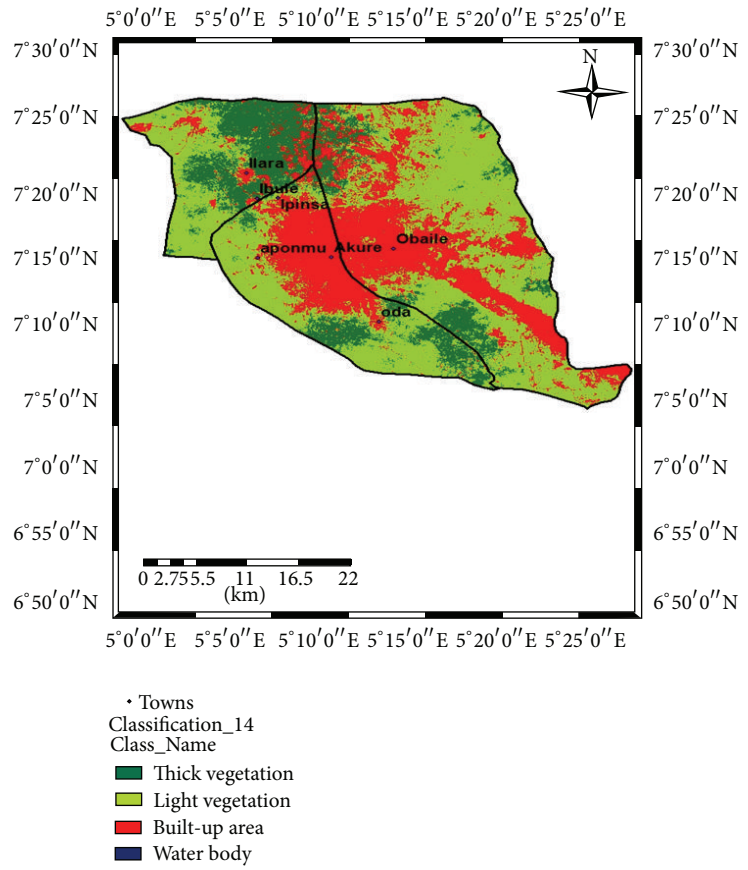


Figure 7: Land use classification of Akure as of 2014. Source: Landsat Operational Land Imager (OLI) Satellite Imagery (2014).

city into various sorrounding communities. Also, the regional setting of Akure has naturally influenced the direction of the expansion. Findings revealed that the city spread out along the fairly flat areas of the north-western part of the city which appear to be more favourable to human settlements. Thus, the expansion first tends towards this direction before it began to diffuse to other areas.

Based on major findings in this study, it has become pertinent to put up some policy recommendations. In the first instance, the unguided nature of Akure urban development whose effects on land use pattern are well noticed in the study area needs adequate attention. The check on this should commence with land acquisition and allocation procedures for various uses so as to guide against incompatible land uses. It is therefore recommended that ministries in charge of land management should employ resourceful control measures over private and public land uses through effective zoning strategy. In view of this, the Development Control Department (DCD) in the Ministry of Urban Development and Physical Planning should be reinforced with strong tools to carry out their duties, particularly in the area of effective monitoring for sustainable development.

The existing land use in the study area is predominantly residential. Most of the buildings have aged and are in deplorable conditions. In some parts of the city, especially at the urban core, most of the old buildings are being removed and changed over to new ones. In the course of changing some of these buildings, the usages are always at variance with compatibility standard. They constitute nuisance rather than complementing the planning and environmental standards. In this regard, it is recommended that adequate monitoring be made by Development Control Department (DCD) and other stakeholders in urban planning, right from plan approval stage to erection of structures to forestall such occurrences and to achieve a sustainable environment. Besides, property vis-à-vis facility rehabilitation strategy should be adopted on degraded landed properties rather than arbitrary removal and rambling replacements. This should involve improving the existing infrastructural facilities as well as providing new ones with a view of making their services functionally accessible and adequate. To reduce the level of encroachment into natural vegetation in the course of expansion, it is also suggested that vertical expansion should be encouraged in the form of story buildings, high scrappers, and the like. Also, the concept of Smart Growth and Compact City via Urban Growth Boundaries policy that has been implemented in most European and American cities can as well be adopted in the study area. It is believed that this will reduce the rate of land consumption and indiscriminate uses and improve the aesthetic value of the environment.

The existing Master plan of Akure was produced in 1980 and has become inactive, old, and superseded. Thus, there is a need for its review and provision for a more comprehensive regional plan to guide the development and spatial growth

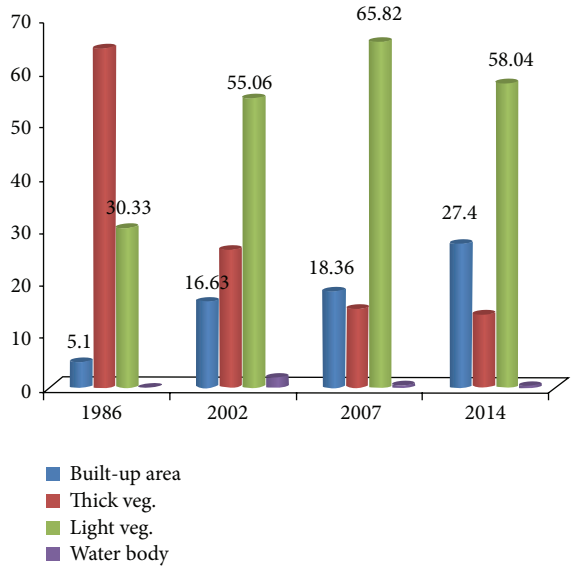
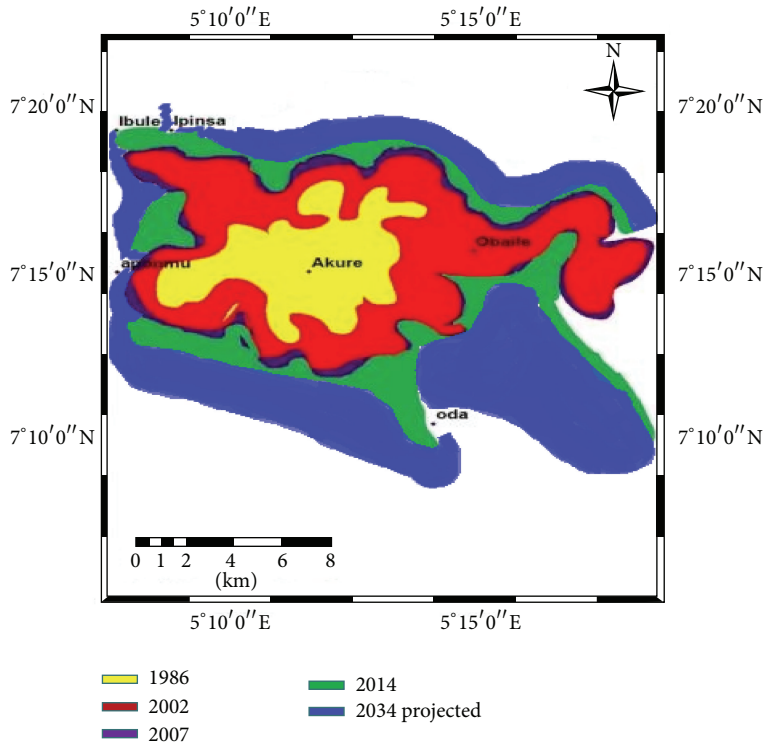


Figure 8: LULC classification and change detection in Akure urban land use. Sources: Landsat Satellite Imageries (1986, 2002, 2007, and 2014).



Year of growth	Growth area (in hectare)	Cumulative area (in hectare)	Area (%)
1986	6383.65	6383.65	5.10
2002	20825.33	27208.98	16.63
2007	22984.57	50193.55	18.36
2014	32969.15	83162.70	26.33
2034 projected	66881.02	150043.72	53.41

Figure 9: Urban built-up change detection analysis and predictive model to the year 2034. Sources: Landsat Satellite Imageries (1986, 2002, 2007, and 2014).

of the entire region. These plans are to be administered by a constituted board which is to be saddled with responsibility to maintain an orderly and aesthetic environment in the region. The board is to be made responsible for the preparation and implementation of planning schemes as well as local, area, and structural plans in conformity with the state and national plans. This will go a long way to assist in regulating land use for sustainable development in the area.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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