

*Full Length Research Paper*

# Analysis of urban expansion and land use changes in Akure, Nigeria, using remote sensing and geographic information system (GIS) techniques

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Akure has since it became the administrative headquarters of Ondo State in 1976 been witnessing rapid developmental changes in terms of physical landscape, city growth and urban sprawl. These agents of landuse landcover changes are capable of creating environmental and climatic problems. In view of this, We multi temporal remote sensing data and geographic information system (GIS) techniques with field survey were used to detect the land use and land cover change in Akure (Lat: 7.25 °N; Lon: 5.20 °E), a south-western city in Nigeria between 1986 and 2007. The main objective using this approach is to examine the landuse landcover changes (LULCC) in Akure at different epochs in order to detect the changes that have occurred and subsequently project the likely changes that might occur over a given period. We found changes in land use and land cover of Akure through our different classification scheme (arable land, bare-surface land, built-up/settlement, dense forest and water bodies with a percentage change of 11.24, -5.86, 28.36, -33.87 and 0.13, respectively between 1986 and 2007). Results further revealed through projection that change by 2020 may likely follow the trend observed between 1986/2007.

**Keywords:** Urban expansion, land use, remote sensing, geographic information system (GIS), Akure.

## INTRODUCTION

Landuse landcover change (LULCC) is urbanization induced. Rapid pace of urbanization has been shown to be a global problem present in most of the developing countries. For instance, the urban populations in these countries have grown by 40% between 1900 and 1975. Furthermore, there is every indication that the trend will continue, adding approximately two billion people to the urban population of the presently less-developed nations for the next 30 years of the period of study (United Nations Environment Programme, 2002). Arnfield (2003) stated that the world is becoming increasingly urbanized

with 45% of the population already living in the urban areas in the year 2000, with the projections as at then that half of the world will live in urban areas by 2007. It is also estimated that by the year 2025, 60% of the world's population will live in cities (UNPF, 1999). Akure is not in any way going contrary to this as the population has been more than tripled what it used to be before it became administrative headquarters of the state and local government.

Globally, land cover today is altered principally by direct human use: agriculture and livestock raising, forest harvesting and management, and urban and suburban construction and development. Hardly can we find any vegetation that has not been affected by man in the world. About 400,000 hectares of vegetation cover has been confirmed to be lost annually (Adesina et al., 1999). Due to anthropogenic activities, the earth surface is being significantly altered in some manner and man's presence on earth and his use of land has had a profound effect on rather all meteorological/climate parameters. Land transformation has been asserted to be one of the most

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**Abbreviations:** LULCC, Landuse landcover changes; RS, remote sensing; GIS, geographic information system; NPC, National Population Commission; MDG, Millennium Developmental Goals; UNDP, United Nations Development Program; NASRDA, National Space Research Development Agency; GPS, Global Positioning System.

important fields of human induced environmental transformation (Fasal, 2000). Environmental protection has faced critical problems due to several factors ranging from increasing population, demolishing of natural resources, environmental pollution, unplanned land use and several others. Several research works, has shown that unplanned changes of land use due to urbanization have become a major problem (Zhao, 2003; Nanda, 2005). Most land use changes occur without a clear and logical planning without attention to their environmental impacts. Major flooding, air pollution in large cities as well as deforestation, urban growth, soil erosion, desertification, are all consequences of a mismanaged planning without considering environmental impacts of development planes. The rapid land use changes by the growing population have reduced natural vegetation cover in most countries of the world (Nicholson, 1987).

GIS-based multi-temporal land use data provides a historical vehicle for determining and evaluating long-term changes in land use due to urbanization. Remote sensing (RS) and GIS are now providing new tools for advanced land use management. The collection of remotely sensed data facilitates the synoptic analyses of Earth - system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity (Wilkie and Finn, 1996).

Land use changes arising from urbanization, agriculture; pasturing and deforestation are some of the contributing factors to land cover changes in Akure. These changes in LULC reflect on the population growth, land consumption rate and local climate. Expansion of Akure has resulted not only in depletion of natural resources, but deterioration of the environment. Agriculturally productive land and forestland have been converted into residential and other uses. The land use pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. The uncontrolled growth of urban development has adversely affected Akure's ecosystem which has potency to indirectly reflect on weather parameters and eventually leads to local climate modification (Balogun et al., 2009; Akinbode et al., 2007; Kalnay and Cai, 2003; Voogt and Oke, 1997).

However, the objective of this phase of the study is to attempt mapping out the LULC status of Akure between 1986-2007 with a view of detecting the land consumption rate and the changes that has taken place using GIS and RS techniques; serving as a precursor to our further study on urban induced variations or change in weather pattern of the city.

### Study area

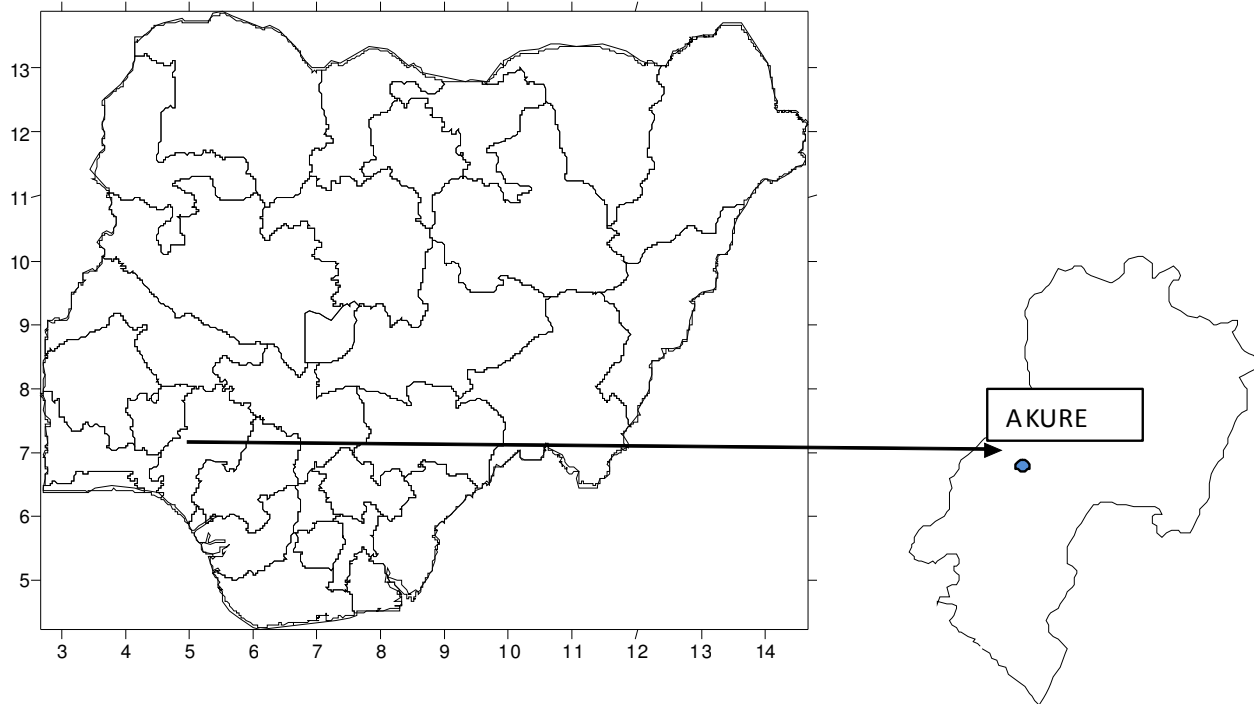
Akure, the capital city of Ondo State, Nigeria is located

on latitude 7°25'N and longitude 5°20'E (Figure 1). The rapid growth of the city, particularly within the last 25 years, has made it one of the fastest growing metropolitan areas in the South-western Nigeria. Its population has more than tripled from 157 947 in 1990 to ~500 000 in 2006 [National population Commission (NPC) reports, 2006]. It became an administrative and economic seat to Akure South Local Government Authority, and Ondo State with the latter's creation in 1976 from the old Western Region. Since then, the city has witnessed immense growth in the size of built-up areas, number of immigrants, transportation and commercial activities. It experiences warm humid tropical climate, with average rainfall of about 1500 mm per annum. Annual average temperatures range between 21.4 and 31.1 °C, and its mean annual relative humidity is about 77.1% (based on 1980-2007 data from the Nigerian Meteorological Agency). Its vegetation is the tropical rainforest type. Akure lies on a relatively flat plain of about 250 m above sea level within the Western Nigerian plains. As at 1982, the pattern of land use distribution shows that about 65.7% is used for residential purposes while the remaining portions are shared for industrial (2.1%), commercial (1.6%), public offices (14.4%), cultural or recreational (0.2%) and educational purposes (14.8%). Unused or vacant land was 1.1% (Ayoade, 1993). This is however expected to have changed but no published research result to justify our expectation. Incidentally, Akure is one of the Millennium Cities Initiative Project of the Columbian University and Columbian national investment working with Millennium Development Goals (MDG) support team of the United Nations Development Program (UNDP). This suggests the need for research on issues relating to its growth and likely environmental and climatic responses that are associated with urbanisation.

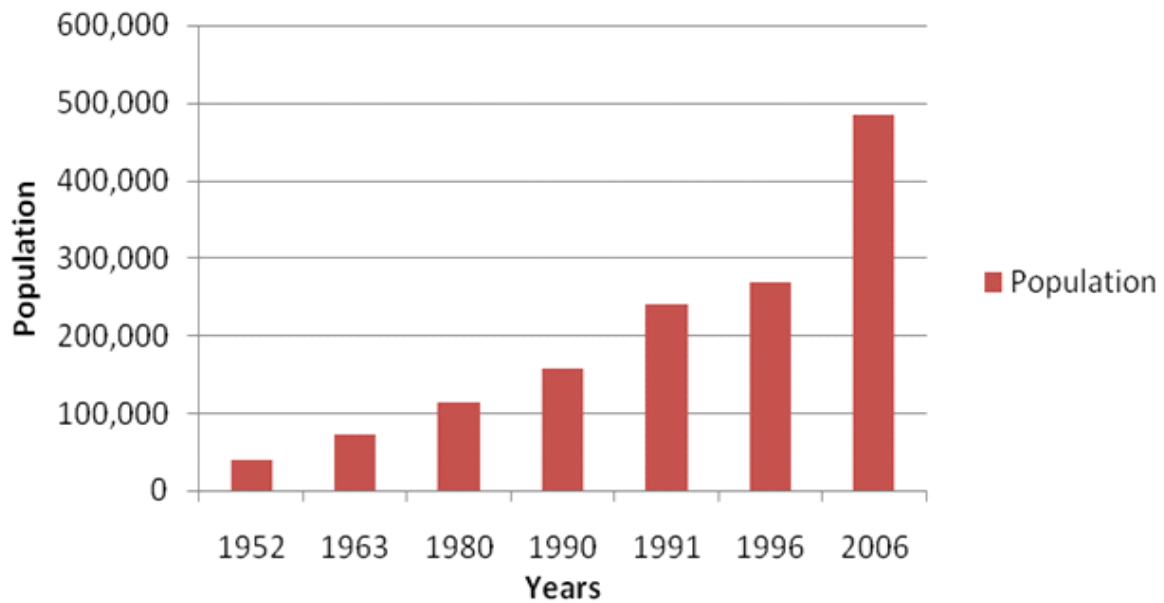
### METHODOLOGY

This study utilizes diverse forms of data. Remotely sensed data - Landsat TM satellite imageries of Akure 1986, 2002 and 2007 (a 21-year time span) was obtained from Global Land Cover Facility.. Akure and its environs were carved out using the local government boundary map and Nigerian Administrative map obtained from National Space Research Development Agency (NASRDA). These were brought to Universal Transverse Mercator projection in zone 31. We also obtained the population census data of Akure for 1952, 1963, 1980, 1990, 1991 population figure, 1996 population projection figure and Growth rate (1991/2006) from Nigerian Population Commission (NPC). The trend of the population growth is presented in Figure 2.

Before the preprocessing and classification of satellite imagery, an extensive field survey was performed throughout Akure using global positioning system (GPS). The GPS has developed into an efficient GIS data collection technology which allows for users to compile their own data sets directly from the field as part of 'ground truthing'. The field work was conducted in December, 2007, this was planned to tally with the season during which the imageries were obtained with a view of obtaining representative cover type characteristics of the spectral zonation in the area during the period



**Figure 1.** Location map of Nigeria and Akure (7.25 °N, 5.20).



**Figure 2.** Population growth of Akure from 1952 to 2006.

of coverage.

**Development of classification scheme**

Remotely sensed images are major sources of data and information that are used in various fields such as environmental studies, forest

management, and urban change detection. One of the products of the images is a thematic map. So far many efforts have been performed to extract information from remotely sensed images and various methods have been developed in this field. One of the main approaches is quantitative analysis (digital interpretation). Among digital techniques, classification is a common and powerful information extraction method, which is used in remote sensing.

**Table 1.** Land use-land cover distribution (1986, 2002 and 2007).

Classification category	1986		2002		2007	
	Area (m <sup>2</sup> )	Area covered (%)	Area (m <sup>2</sup> )	Area covered (%)	Area (m <sup>2</sup> )	Area covered (%)
Arable land	47717.00	29.43	66208.93	40.84	65941.23	40.67
Bare surface	17332.48	10.69	8299.571	5.12	7831.231	4.83
Built-up/Settlement	16505.58	10.18	52703.65	32.51	62487.71	38.54
Dense forest	79755.33	49.19	33908.19	20.91	24839.43	15.32
Water bodies	826.90	0.51	1016.937	0.63	1037.679	0.64
Sum	162137.3	100	162137.3	100.00	162137.3	100

There are many classification methods that have their own advantages and drawbacks. Between classification methods, maximum likelihood approach has been used more frequently. Standard classification methods usually concern pixels as main elements and try to label the pixels individually. But, their results are not perfect and always are erroneous, since many steps are introducing errors in the classification process. Hence maximum likelihood approach is adopted for this work.

The analysis of the work is predicated basically on the use of remote sensing and GIS techniques. Ilwisi 3.1 was used in carving out Akure and its environs out of the whole image within the path/row. Also, the classification of imagery was done using this software and other image processing and enhancement. ArcView3.2a was also used in displaying, subsequent processing and enhancement of the image. Future land use projection was based on statistical trend analysis.

## RESULTS AND DISCUSSION

### Land use-land cover change: Trend, rate and magnitude

Results in Table 1 and Figure 3(a, b & c) makes evident that the older traditional central district of the city has become increasingly congested and the city has haphazardly expanded outwards depleting cultivated land and vegetation in the fringe, particularly towards the north western part of the city. There is a negative change in bare lands between 1986 and 2007. This is most likely due to the fact that people are encroaching into the rocky/undulating areas for purposes such as building, quarry, construction, blasting and mining. Within these period, the built up land has increased by 28.36%, consequent upon the various project that were embarked upon after the discovery that the state falls within the mineral rich (oil, bitumen among others) region. Again, Akure being the capital city has definitely attracted investors, people seeking for greener pastures and others immigrants because of its improved status. This has however led to the physical expansion of the city as evident in the increased land consumption rate from 0.083 to 0.160 and already having land absorption coefficient of 0.277 between the periods of study. Some of the major land consuming projects which would have

endeared immigrants into the city, include various housing estate schemes like Aule Housing Estate, Alagbaka Quarters, Owena River Basin Development Authority, establishment of the Federal University of Technology, Akure (FUTA) in 1982 and other tertiary institutions, Akure Airport, the Ondo State Oil Producing Area Development Commission (OSOPADEC), Okitipupa Oil Palm factory amongst others.

Although the arable lands appears to have increased in this study primarily because of the vast devastation done to the forested lands at the outlying extremes of the city for subsistence agricultural purposes, having lost out the existing arable lands to building and other construction purposes.

The dense forest has reduced by 33.8%, as a result of the increased deforestation rate, land degradation, farming and encroachment of people for building purposes. The advantageous roles of these depleted forests cannot be underestimated in terms of carbon management and implication for regional climate change at large.

### Change detection and analysis

LULCC of Akure between 1986 -2002 and 2002-2007 as well as the change detection respectively is presented in Table 2 and Figure 4 where a rapid change in built up and arable land is noted to have increased by more than 30% and the dense forest terribly depleted. Their individual approximate rates of change were also presented.

From the classification of imagery from the individual years, a post-classification, approach of subtracting the generated percentage cover of each category via the classification maps, 1986 – 2002 and 2002 - 2007 was applied.

This is perhaps the most common approach to change detection and has been successfully used by Yang et al (2003) to detect land changes in the Atlanta, Georgia area. An advantage of the approach is that it provides the "from-to" change information.

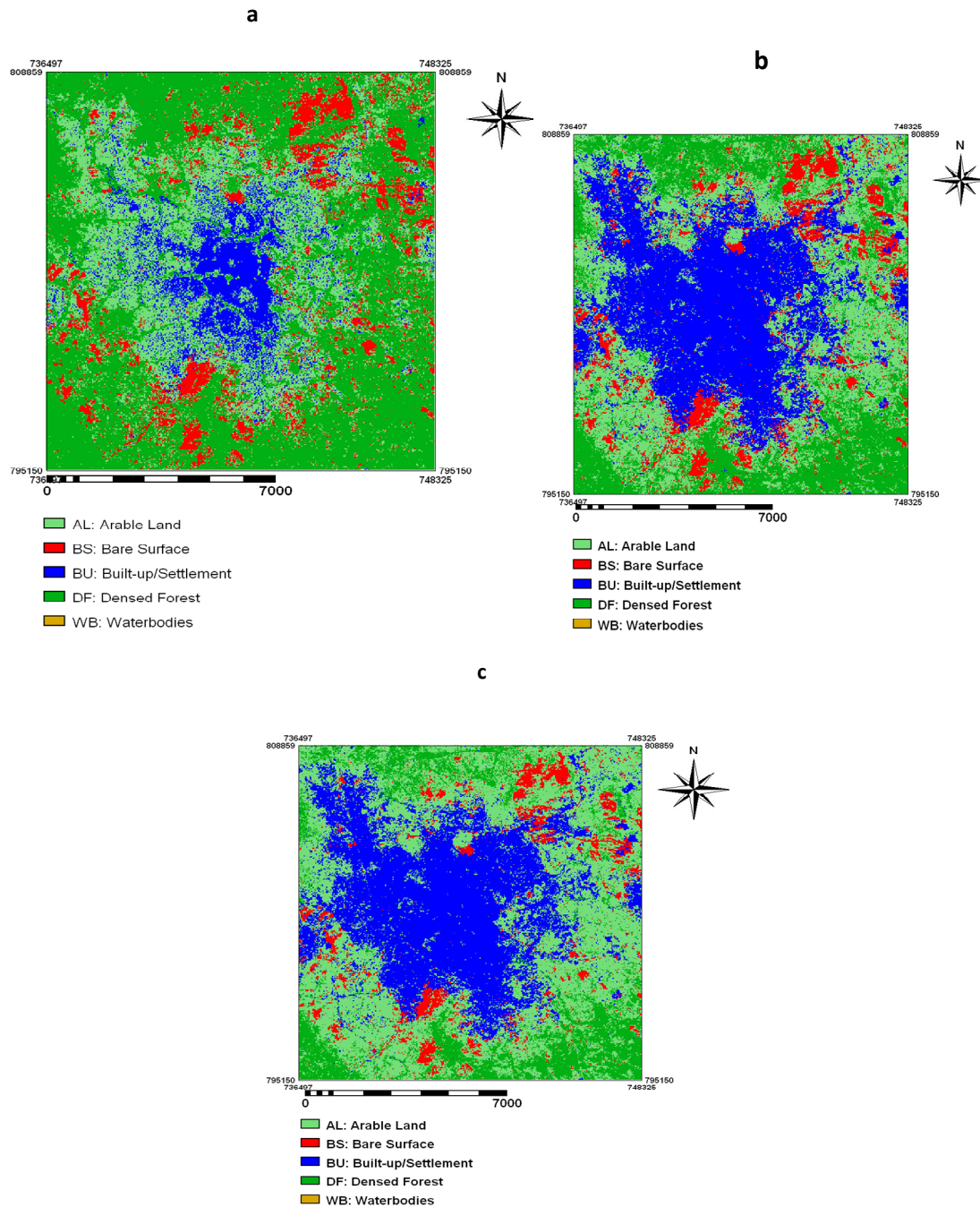


Figure 3(a, b & c). Landuse landcover map of Akure in 1986, 2002 and 2007 respectively.

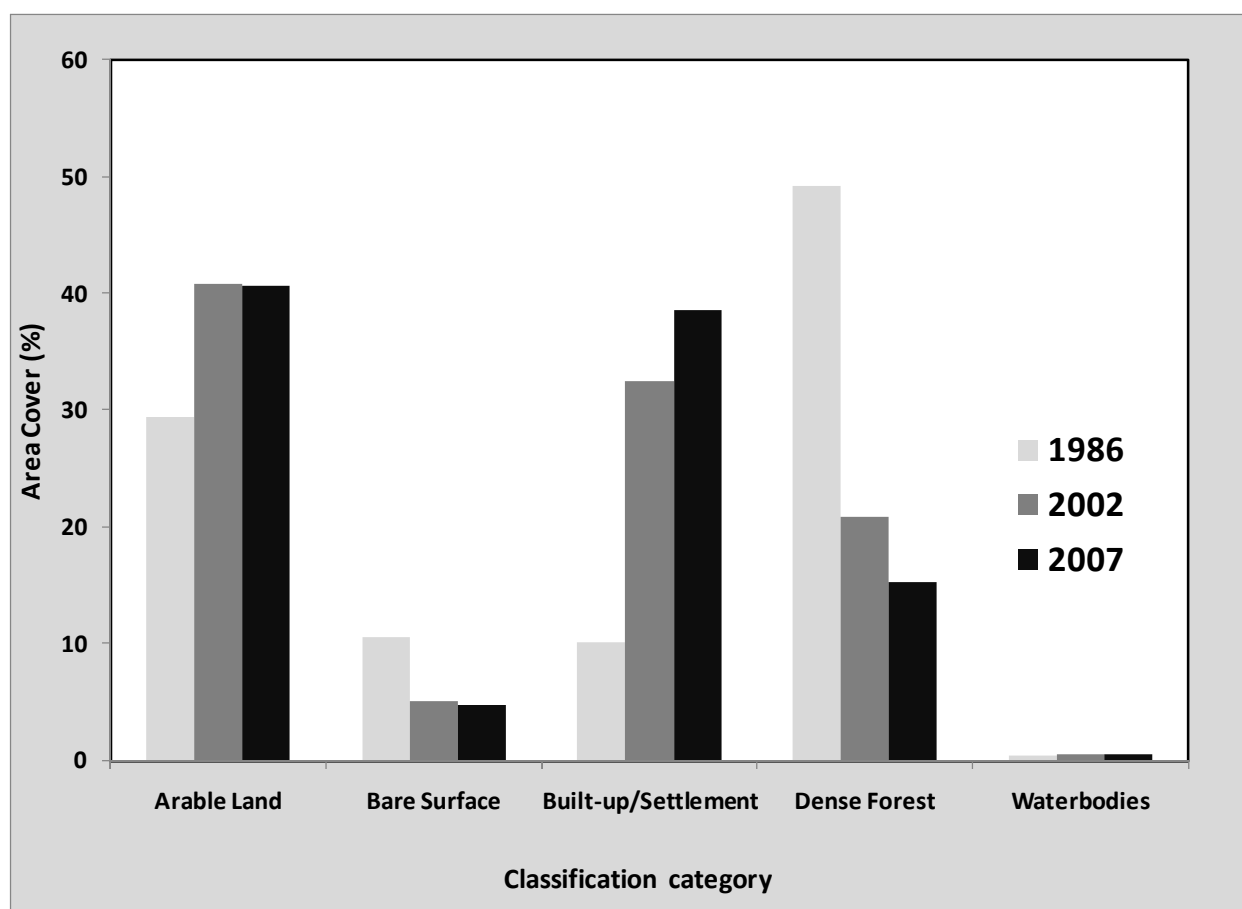
### Nature and location of change in LULC

An important aspect of change detection is to determine what is actually changing to what, that is, which landuse is changing to the other. Location of change can be accessed from the overlay map whereby both year of study's image were overlaid to see what has changed. Figure 5 shows that almost all classes are changing to one another but more significantly to built-up, followed by

arable land. Considering the map, at the NW there is a significant conversion to built-up, attributed to the establishment of Federal University of Technology, Akure which causes rapid expansion as there is continuous construction of both residential and commercial buildings to serve the community. The observation here is that there exists a growth from the city core following the theory of city growth postulated by Burges, 1925. Similarly, the pattern seems to be uniform for the SE

**Table 2.** Land use–land cover change of Akure and its environs: 1986 -2002 and 2002-2007.

Classification category	1986/2002		2002/2007	
	Difference in area (m <sup>2</sup> )	Difference in area (%)	Difference in area (m <sup>2</sup> )	Difference in area (%)
Arable land	18491.93	11.41	-267.701	-0.17
Bare surface	-9032.91	-5.57	-468.34	-0.29
Built-up/settlement	36198.08	22.33	9784.056	6.03
Dense forest	-45847.14	-28.28	-9068.76	-5.59
Water bodies	190.04	0.12	20.74162	0.01

**Figure 4.** Change detection between 1986, 2002 and 2007.

where residential and administrative wing are located. Generally speaking, a lot of dense forest has transformed into arable due to the fact that previous arable lands have been converted to built-up land.

#### Landuse landcover projections by 2020

This projection is deemed necessary considering its relevance to the Nigerian Federal Government Vision

2020:20 program and Akure being named among the Millennium Cities initiative projects of the Columbian University and Columbian national investment working with MDG support team of the UNDP. Figure 7 presents the histogram for the spatial extent projection. This step is taken with the intention of giving an insight to what LULC situation of Akure will look like by the year 2020. It projected that about 56% of the total landcover will be built-up and about 48% will be arable land although with reservations. It also indicated that dense forest would



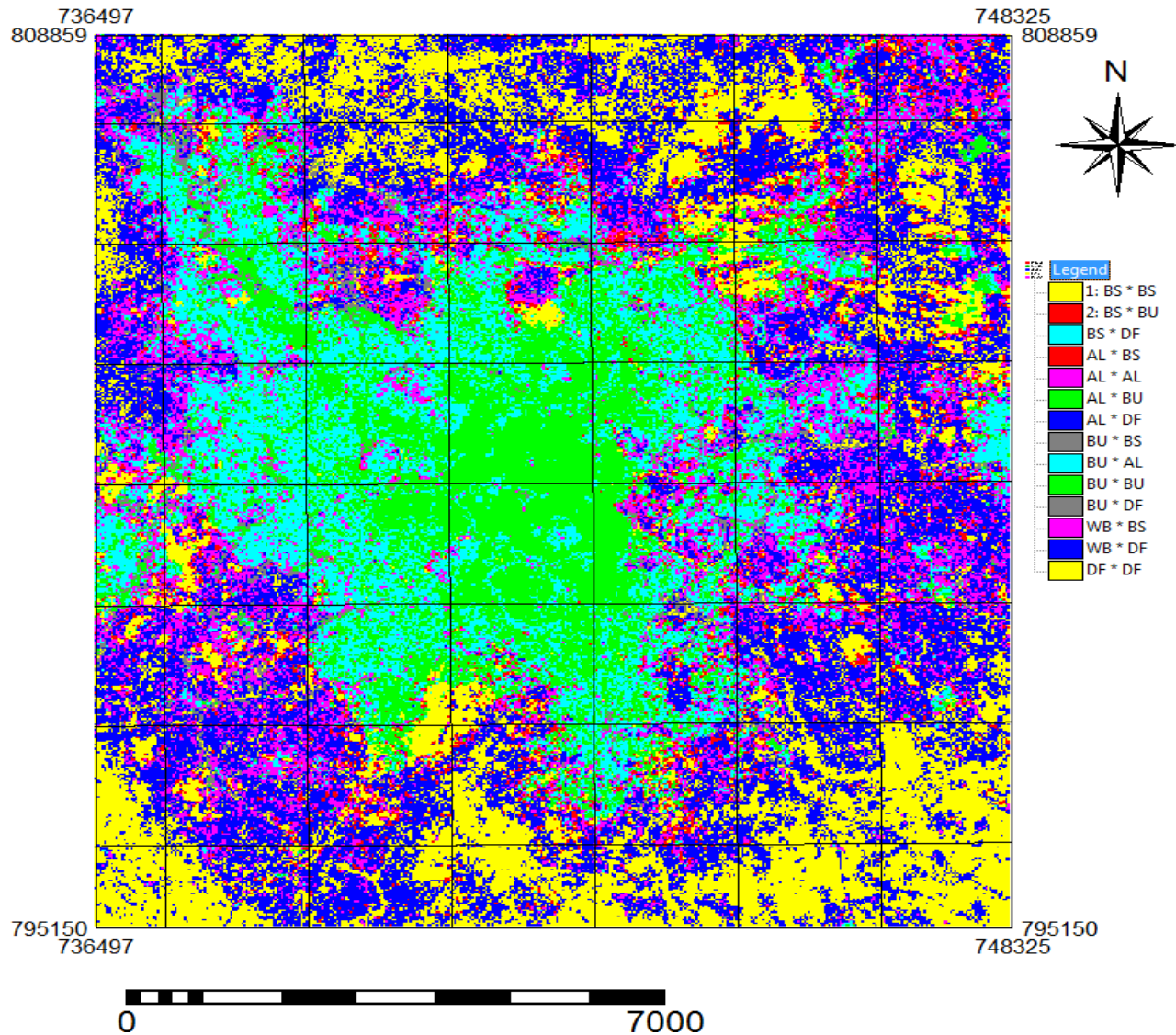


Figure 5. Overlay map of both 1986 and 2007 imageries.

have been drastically reduced by the year 2020 (Table 4). These will have serious implication on the local climate of the city (Balogun et al., 2009) and also contributes to greenhouse gases emission due to the destruction of the forests which are carbon sinks. Results of our projection based on statistical trend analysis are presented in Figure 6.

The equations presented in Table 3 were generated from trend analysis, and subsequently used to project for 2020

**Conclusion**

In this study, we have indicated the potential use of Remote sensing data and GIS techniques in investigating

LULCC of Akure. Remote sensing data were analyzed in GIS environment using Maximum Likelihood Approach to produce LULC map in each study year and further project for the year 2020 in accordance to Nigeria’s Vision 2020 program. The five classes were distinctly produced for each study year but with more emphasis on built-up land as it is combination of various anthropogenic activities that make up this class; and indeed by its nature affect other classes.

Results indicated a rapid increase in built up and arable land but terrible depletion of the dense forest. It was also observed that future changes by the year 2020 may likely follow the trend observed between 1986 and 2007 as the projection results indicated that built-up and arable land will increase rapidly and the dense forest would have been drastically reduced by the year 2020. These will

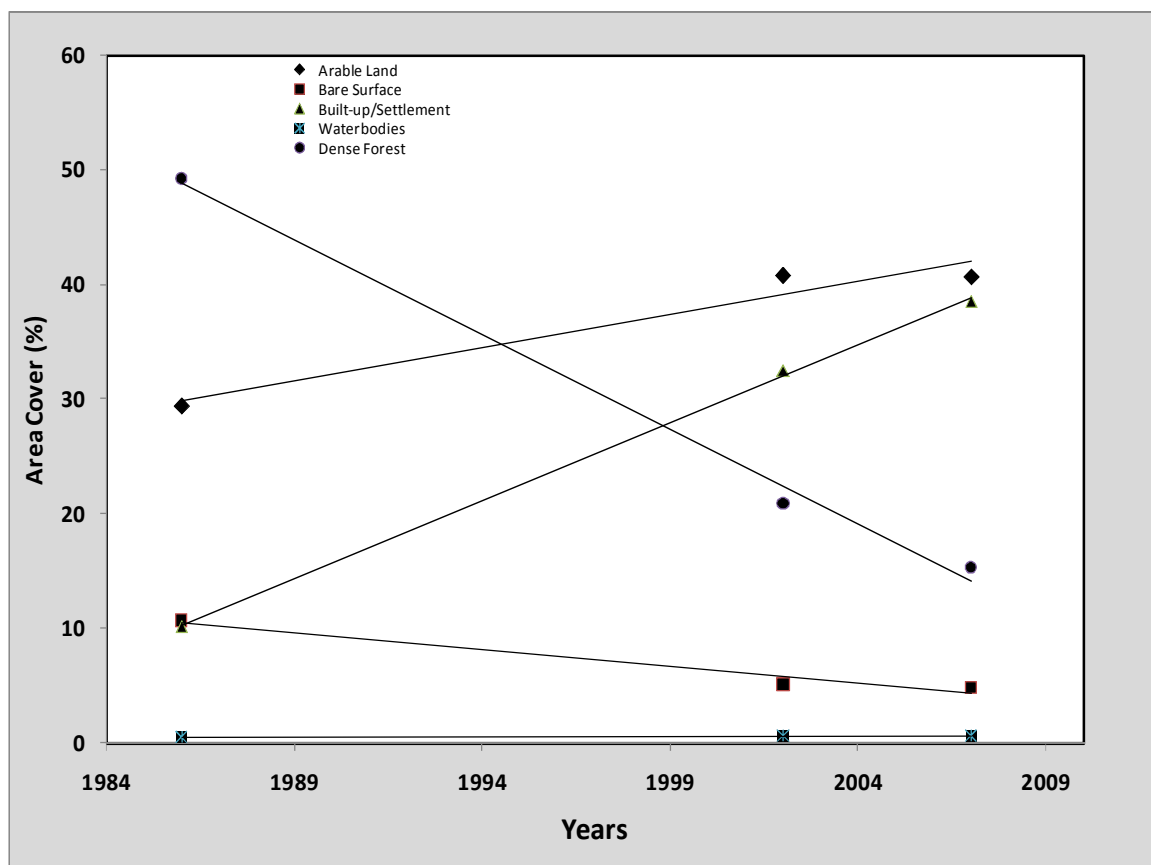
**Table 3.** Statistical projection model for each classification category.

Classification category	Generated Equation
Arable land	$Y=0.578x-1119$
Bare surface	$Y=-0.295x+598.1$
Built-up	$Y=1.361x-2693$
Dense forest	$Y=-1.605x+3326$
Water bodies	$Y=0.006x-12.33$

The equations were generated from trend analysis, and subsequently used to project for 2020.

**Table 4.** Land use –land cover projection by 2020.

Year	LULC category	Arable land	Bare Surface	Built-up/settlement	Dense forest	Water bodies
2020	Area (m <sup>2</sup> )	78733.87	3567.02	91153.58	-11349.61	-340.49
	Area (%)	48.56	2.2	56.22	-7	-0.21

**Figure 6.** Trend chart of classification category against years.

have serious implication on the local climate of the city and also contributes to greenhouse gases as the carbon sinks would have been terribly depleted. This projection

calls for improved urban planning, agricultural enhancement to improve food security and quick afforestation considering the mitigating roles of the forest on global



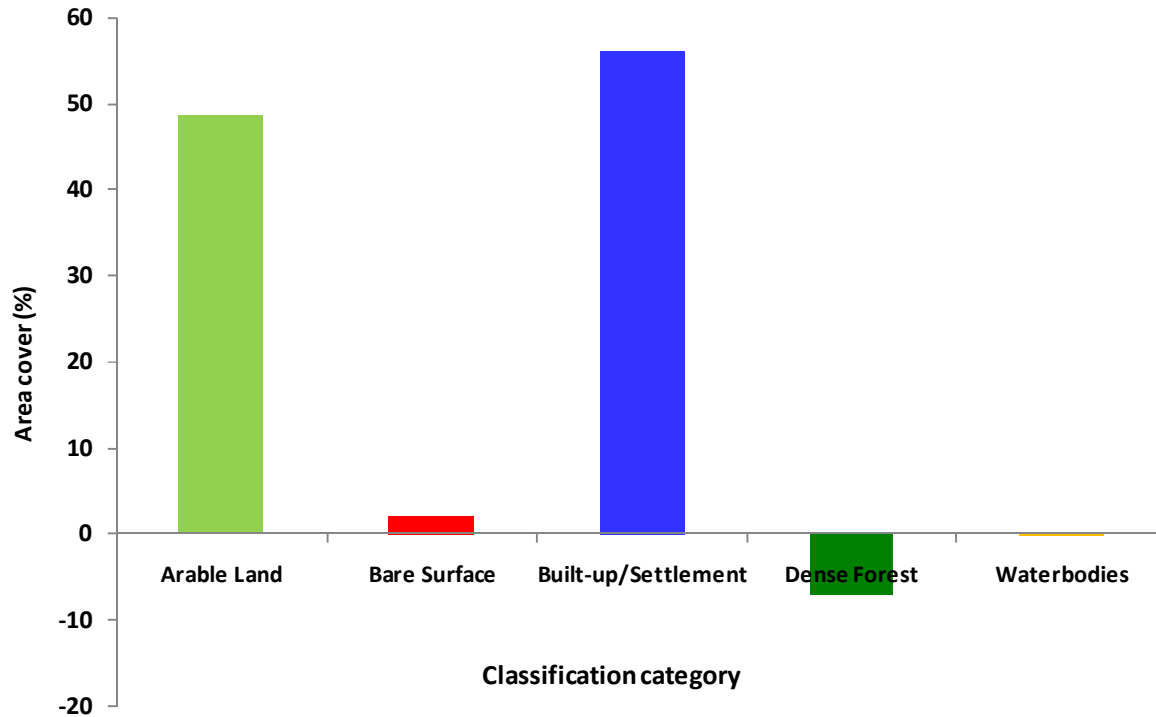


Figure 7. Spatial extent of projection for year 2020.

warming and climate change.

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