Spatial Growth in a Traditional Urban Settlement of Ile-Ife, Nigeria: A Spatio-Temporal Approach for Sustainable Development

***Tunji Akinlotan; *Omotosho B. O. **Odegbenro F.J. and ***Okubena Modupeola R**

*Department of Urban and Regional Planning, The Oke-Ogun Polytechnic, Saki Oyo State Nigeria
**Center for Human Settlement and Urban Development (CHSUD), Federal University of Technology, Minna
***Abraham Adesanya Polytechnic, Ijebu-Igbo Ogun State Nigeria
tunjiakinlotan@gmail.com

Abstract

The desire for development of any human settlement is as important as the safety of its environment for both economic growth and development without which any growth cannot be said to be sustainable. The paper analyzed the rate and trend of urban development in the last thirty years with a view to predicting the future rate and trend of development in Ile-Ife which could serve as a veritable planning tool for a sustainable development. Primary and secondary data were used. The primary data was obtained, using GPS receiver to obtain the geographic coordinates of strategic locations for the purpose of geo-referencing. The secondary dataset includes the use of Landsat imageries of 30m resolution, (1986, 1996 and 2006) and SPOT V imagery of 5m resolution was used to map the land use land cover of the study area, the major roads, minor roads and major landmarks. The land use-land cover maps were created for different identified land use classes as well as attribute tables for each spatial entity. GIS analyses in form of spatial and non-spatial queries were carried out to determine the rate, trend and magnitude of urban development. In addition to this, the future rate and trend was also predicted using Cellular Automation within the GIS, the map output shows the trend of urban development. The results showed that there is physical expansion of the Ile-Ife with a land consumption rate of 0.024 in the 1980's, 0.026 in the 1990's, 0.029 in 2000's and an increased land absorption coefficient from 0.029 to 0.034 in the last three decades. This is evident in a positive change trend rate for the major (0.8) and minor (0.4) urban centre while both disturbed forest (-0.8) and intensive agriculture (-0.4) has negative change trend rate. Besides, the trend of urban development to the year 2020 was predicted with the major and minor urban centre still leading with a positive change trend of 1.7 and 0.9 respectively. The study concluded that with such an increase in land consumption rate and land absorption in Ile-Ife, there are needs for development control, land readjustment and appropriate regulations in growth development, in order to maintain a balance between preventing urban sprawl and providing land for sustainable housing development, without jeopardizing the future need.

Keywords: Urban growth pattern, Land-use/cover, GIS and remote sensing, Ile-Ife, Nigeria

Introduction

Urbanization has been a universal and important social and economic phenomenon taking place all around the world. This process, with no sign of slowing down, could be the most powerful and visible anthropogenic force that has brought about fundamental changes in land cover and landscape pattern around the world (Krishna, 2009). As a result, cities and towns are growing faster than ever, being a huge center for residence, industry, trade and investment, communications, infrastructure and social services among others. However, this growth also triggers numerous problems, environmental pollution and degradation, increased environmental hazards such as flooding, population explosion, insufficient sanitation and water supply, transport problems, poor housing conditions, rising cost of living and wealth inequality, and increase in crime, and loss of fertile agricultural and wetlands are some of the most prominent negative effects of rapid urbanization and urban growth (UN-Habitat 2011). If not managed properly, these may intimidate sustainable development of cities in the long run (Dubovyk *et. al.* 2011).

Urban growth patterns are characteristics of spatial changes that take place in metropolitan areas, the spatial configuration and the dynamics of urban growth are important topics of analysis in the contemporary urban studies. Several methods and techniques have been developed and applied to quantify and characterise the urban growth processes and patterns. Traditionally, visual interpretations of high resolution aerial photographs were used to acquire comprehensive information for mapping of urban areas. This mapping technique is expensive and time consuming for the estimation of urban growth. However, with the gradual advancement and availability of high temporal and spatial resolution remote sensing imagery, the possibilities of monitoring urban problems with a better accuracy have become more promising. Hence, accurate mapping of urban environments and monitoring urban growth is becoming increasingly important at the global level.

Statement of Problem

Rapid urban growth is normally accompanied by high population growth, dramatic land use/cover change and social transformations. Such rapid demographic and environmental changes in the past decades have resulted in environmental degradation, haphazard physical development, informal developments on wetlands, and poor land use planning practices (Jiboye 2005). Urban area is a social, economic and natural compound ecosystem with human activity at the centre and with the speeding up of the development of modern industry and urbanization, as the core of regional system, the population of this area increase quickly and urban size also grows. Basically, according to Klosterman (1999), planning and management of urban spaces requires a comprehensive knowledge of the development process and physical dimension of cities. Most literature on the analysis of the spatial characteristics of cities growths highlight the temporal dynamics, meanwhile Seto (2005) argue that, most of these studies focus on cities in the USA. Recently though, few studies have been conducted in Europe and some Asian countries, however, less is studied in relatively fast growing cities of Africa using remote sensing and GIS techniques. Thus it is worthwhile to expand the application of GIS and remote sensing to traditional fast growing African cities. This study therefore filled this gap with a detailed and comprehensive attempt, adopted to evaluate growth rate in the study area as it changes over time with a view to detecting the land consumption rate and also make attempt to predict same and the possible changes that may occur in the future for its sustainability.

Study Area

The study area, Ile-Ife as a developing city has being experiencing the gradual transformation that is taking it from been a regional cultural centre, through a secondary-urban-centre status, to a city displaying the hallmarks of progressive urbanization and which, in recent times, has being rapidly modernizing (Osasona *et al.* 2006). Ile-Ife covers the whole of Ife Central Local Government Area, few parts of Ife North and most parts of Ife East Local Government Area of Osun State, Nigeria. Ile-Ife is located between latitude $7^0 31^1$N and $7^0 34^1$N of the equator and between longitude $4^0 30^1$E and $4^0 34^1$E of the prime meridian. The study area is bounded in the North by Atakumosa West

Local Government Area, in the North West by the Ede South Local Government Area, in the East by Atakumosa West Local Government Area, in the West by Ife North Local Government Area and in the South by Ife North and South Local Government Areas.

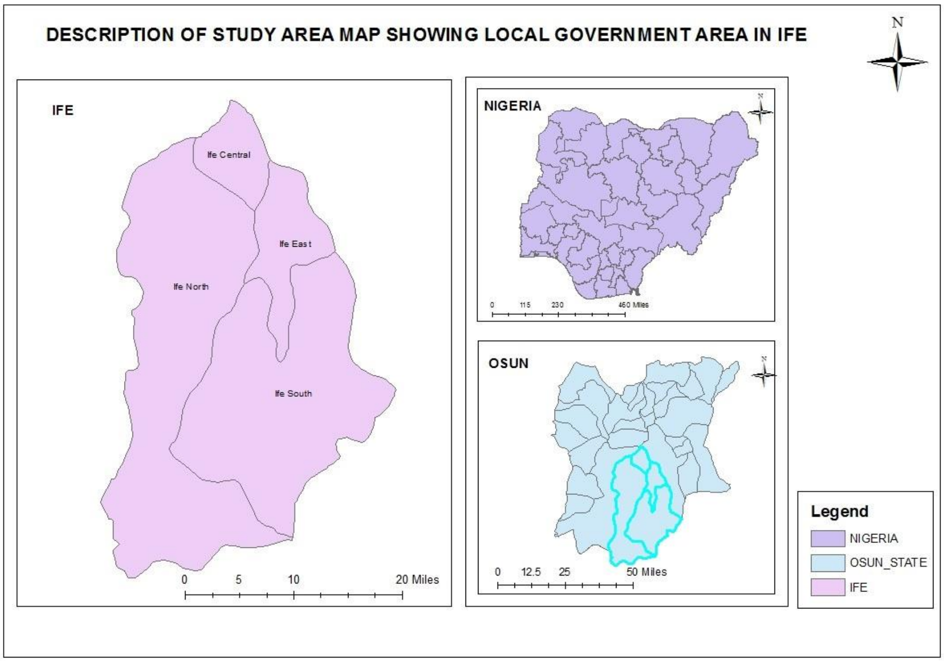

Fig. 1. Ile-Ife in the regional setting

Literature Review

Human intervention and natural processes are responsible for the constant change in land cover all over the world. Land cover change is determined by the interaction in space and time between biophysical and human influences. Land use and land cover is dynamic in nature and is an important factor for the comprehension of the interaction and relationship of anthropogenic activities with the environment. Knowledge of the nature of land use and land cover change and their configuration across spatio-temporal scales is consequently indispensable for sustainable environmental management and development (Turner, 1994). Accordingly, Long *et.al* (2008) stress that urban landscapes are exemplified by the large concentration of population, and fast expansion of urban zones which lead to alteration in the land use and land cover configuration that consequently impact the landscape. Remote sensing technology is principally appropriate for mapping environmental phenomena such as land use change and land cover as field-based mapping is practically difficult. Remote sensing observations provide continuous monitoring across varied spatial and temporal scales (Gibson, 2000). The spatial, temporal and spectral characteristics of the remote sensing data are effectively used in land use and land cover change mapping, hence helping in decision making for sustainable land resource management Berlanga-Robles, (2002). Remote sensing and Geographic Information Science (GIS) technologies have been utilised productively to detect and quantify changes in the landscape and the consequential environmental impacts.

Long (2008) observed that studies have utilised remote sensed data to examine urban land changes in modern times with conclusions showing varying degree of different patterns of urban expansion and development in which could be associated with specific environmental factors. A review show that Prakasam (2010) studied the land use and land cover change in Kodaikanal region of Western Ghats in Tamilnadu State of India and observed changes during a span of 40 years from 1969 to 2008. Using Landsat satellite data and performing supervised classification techniques, he found that 70% of the region was covered in forests in 1969 but has decreased to 33% in 2008. The built-up lands also increased from 3% to 21% showing that the region is affected by rapid urbanisation which is leading to adverse environmental effects for the identified bio-diversity rich region of Kodaikanal. Meanwhile, Krishna (2009) utilised Landsat TM imageries to study the land use change in Bombay (Mumbai), India, which is the highest populated metropolis of India and found a remarkable increase in built-up land by 300% and a reduction in forests by 55%, due to the increasing pressure of urban expansion to cope up with the population rise. He carried out a study using land use maps for 1925 and 1967 and compared them with Landsat imagery in 1994 to quantify a change spanning from 1925 to 1994.

Zubair (2006) utilised remote sensing and GIS technologies to detect the land use and land cover changes in Ilorin, Nigeria from 1972 to 2001 through Landsat TM images of 1972, 1986, and 2001, using Maximum likelihood algorithm of supervised classification method to delineate five land use and land cover classes for the study, namely: farmland, wasteland, forest, built-up and water-bodies from the imageries. He concluded that there is likely going to be denseness brought by compactness in Ilorin in the very near future.

Many scientists, resource managers, and planners agree that, the future development and management of urban areas entail comprehensive knowledge about the on-going processes and patterns. As a result, understanding the urban growth patterns, dynamic processes, and their relationships and interactions is a key objective in the contemporary urban studies as quoted by Long (2008). Remote sensing is helpful tool to better understand the spatiotemporal trends of urbanization and monitor the spatial pattern of urban landscape compared to traditional socioeconomic indicators such as population growth, employment shifts. However, Zubair (2006) opined the availability of multi-temporal data is important to analyse the dynamics of land cover change over time and space.

Methodology

The data used for this work were obtained from both primary and secondary sources. The primary data were collected through field observation with the use of GPS receiver to collect co-ordinates of places and landmarks in the study area which was integrated into the GIS environment for the user requirement survey and analysis. The study period covered thirty (30) years from 1983 – 2013 and the satellite imageries over the study area were obtained and analysed. The method of processing and analysis was a multi-stage approach. The first stage involved determining the trend and pattern (land use/land cover) of urban development in Ile-Ife between 1983 and 2013. The data used were mainly the Landsat imageries for different time periods and the road map of Ile-Ife, creating 3 epochs of ten years interval (1983-1992, 1993-2002, and 2003-2013). The second stage entailed the use of processed data from the first to forecast the trend of change in the land use for 2020. Markov Chain and Cellular Automata Analysis were used for predicting the change. This was achieved by developing a transition probability matrix of land use change in between epochs, which showed the nature of change and also served as the basis for projecting to a later time period of 2020 .The transition probability may be accurate on a per category basis, but there is no knowledge of the spatial distribution of occurrences within each land use category. Hence, Cellular Automata (CA) was used to add spatial character to the model.

Results and Discussion

Land Use-Land Cover Distribution

The static land use-land cover distribution for each study year as derived from the maps are presented in the table below:

The figures presented above represents the static area of each land use-land cover category using Formecu Classification Scheme for each study year. Intensive Agricultural Land in the years between 1983 and 1992 occupies the most class with 70% of the total classes. This may be due to the fact that the town is known for its credibility in agricultural activities where farming (crop cultivation) seems to form the basis for living i.e. Ife can be described as an agrarian town (Jiboye 2005). The disturbed forest can be said to be moderate as it was occupying about 25% of the total land area. This is connected to the fact that the town (Ile-Ife) was made to be the host community to the University of Ife which consumed a vast expanse of land for its construction activities in which a lot of thick forest as at the eighties were already been cut down to allow for the construction of its physical structures. For the built up areas, the major urban center; Ile-Ife made 3% of the total land coverage while minor urban center (which was at then purely of rural characteristics) was 1% this also could be attributed to the development that the siting of the university has brought on the host town of Ile-Ife. Water body and Rock Out crop are of least coverage of 0.37% and 0.1% respectively.

Table 1. Land Use-Land Cover Distributions (1983-1992, 1993-2002, and 2003-2013)

	1983-1992		1993-2002		2003-2013	
	Area (Ha.)	**Area (%)**	**Area (Ha.)**	**Area (%)**	**Area (Ha.)**	**Area (%)**
Dam & Water Bodies	84.80	0.1	47.6	0.04	44.4	0.04
Disturbed Forest	24,908.50	25	15,712	16	7,275.2	8
Intensive Agric. Land	68,828.80	70	74,483.6	75	72,264.4	71
Major Urban	3,154.80	3	6,001.6	6	13,374.0	14
Minor Urban	1,327.90	1	2,062.8	2	5,332.0	6
Rock Outcrop	368.00	0.37	365.2	0.37	382.8	0.38
Total	98,672.80	100	98,672.80	100	98,672.80	100

Between 1993 and 2002, intensive agricultural area still maintained its highest class with 75% while built up area i.e. the major urban centre claimed a percentage of 6%. Disturbed forest has percentage coverage of 16%. The minor urban center, rock crop out has 2%, 0.37% respectively. While Dam and Water bodies take up the least percentage of 0.04% of the total class.

In essence, the town experienced a gradual development in which the size of the thick forest was cut down for more agricultural functions most especially cropping. This also made room for urban expansion especially given the percentage gain of urban land use of the period.

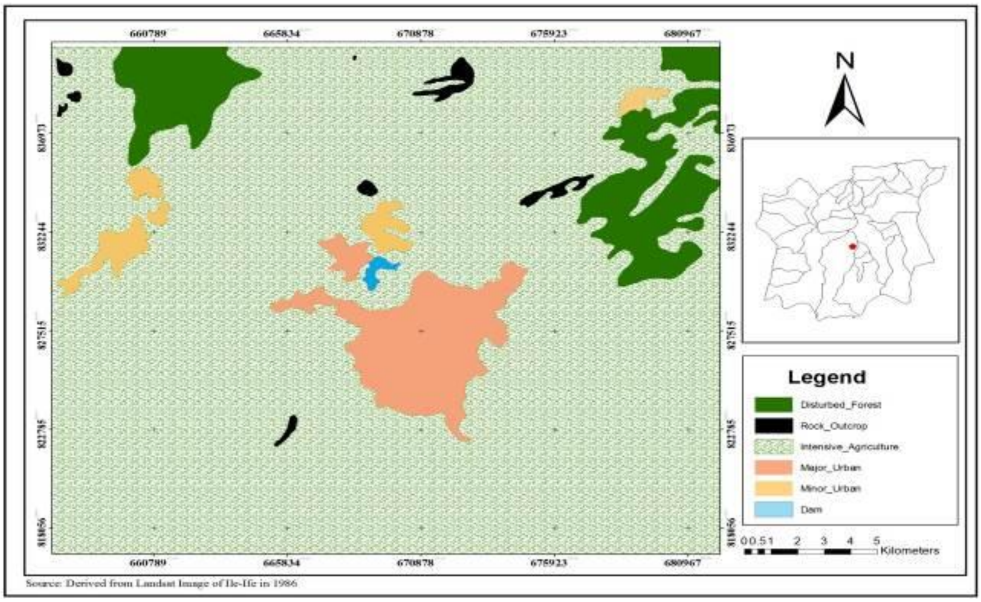

Figure 2. Land Use-Land Cover Map of Ile-Ife between 1983 and 1992

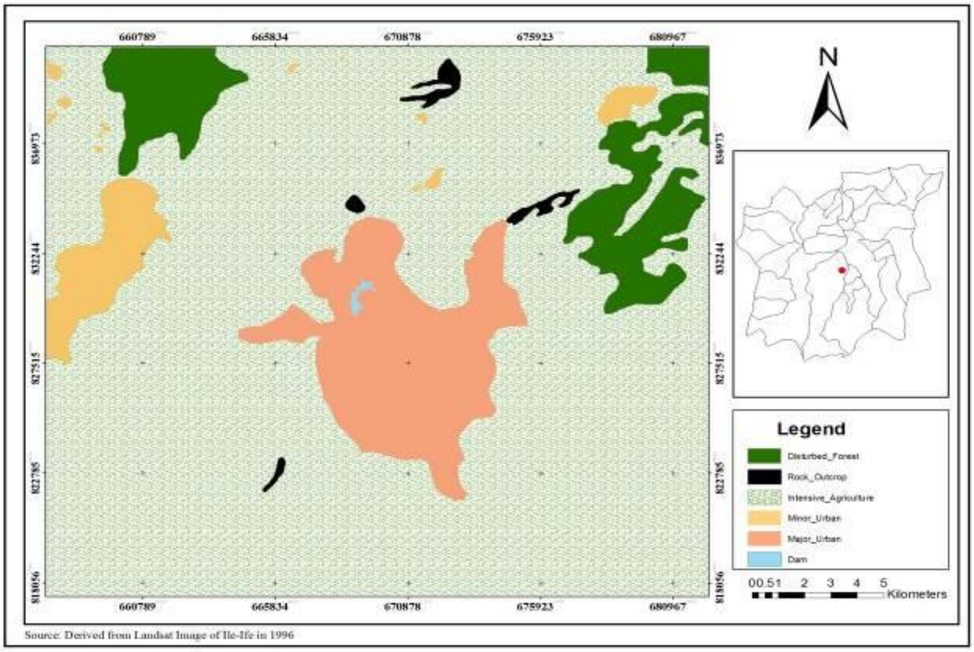

Figure 3. Land Use-Land Cover Map of Ile-Ife between 1993 and 2002

In epoch 2003-2013, Disturbed Forest covered 8% and Intensive Agriculture covers 71% compared to that of 1993-2002 which is 16% and 75% respectively. While Major Urban and Minor Urban is 14% and 6% as compared to the 6% and 2% respectively between 1993 and 2002, (see fig. 3). The difference in rate of development during this period can be described has more than twice which caused drastic reduction that was experienced in the disturbed forest and intensive agriculture while the major and minor urban centers picked up fast. This could largely be attributed to the vast clearance of bushes or forest for construction activities like the construction of the Ilesa/Ibadan by pass, which has made the area around the road to be prone to development because it opened up Ede/Ibadan Road which host lots of commercial activities to spring up along the route. This is evident in activity sites like filling stations, road safety office, trailer parks, and food centers, even the presence of Oduduwa University, Foreign Links College and OAU Distance Learning Centre.

Also along Ilesa Road in the town, due to the influence of OAUTHC, there has been a lot of private residential buildings. Even within the OAU community, this vast development is evident in the construction of the link road from the OAU Main Campus to OAUTHC alongside the construction of OAUTHC Phase III. The pattern of land use and land cover distribution between 2003 and 2013 is different from other previous years as intensive farm land still occupies a major part of the total land but there exist a decrease by half in the disturbed forest. Still, water body maintains the least position in the classes whilst built-up occupies 20% of the total class.

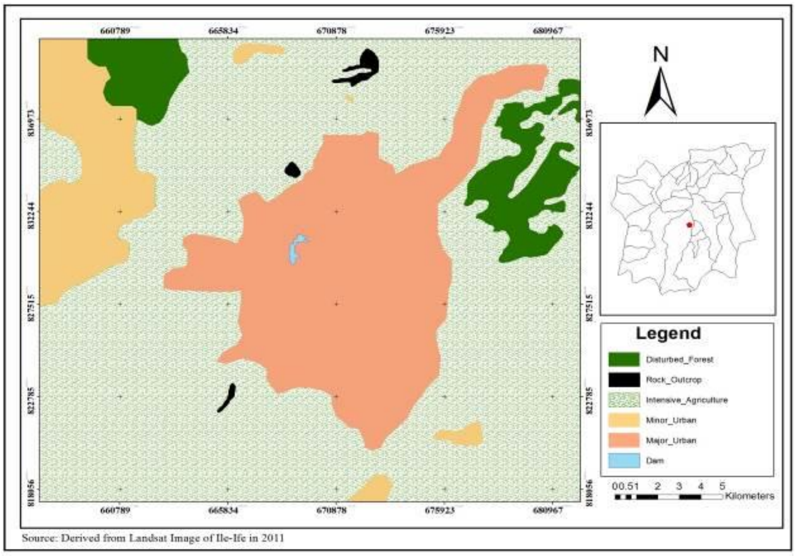

Figure 4. Land Use-Land Cover Map of Ile-Ife between 2003 and 2013

Land Consumption Rate and Absorption Coefficient

It should be noted here that the closest year's population available for each study epoch as shown above were used in generating both the Land Consumption Rates and the Land Absorption Coefficients as given above. In essence, considering Ile-Ife in a regional context, the difference in the population of the minor built up areas and major built up area is large and according to ranking, it can be said that the effect of this is evident in their spatial representation of these land uses. Considering the difference in population figure of Ile-Ife over time and the structure of development economically, politically and socially, the growth trend of the city is evident in its land consumption rate and absorption coefficient i.e. measure of change in consumption of new urban land by each unit increase in urban population and measure of compactness which indicates a progressive spatial expansion of a city that is on the increase.

Table 2. Land Consumption Rate and Absorption Coefficient

Year	Land Consumption Rate	Year	Land Absorption Coefficient
1980's	0.024	1983-1992/1993-2002	0.034
1990's	0.026	1993-2002/2003-2013	0.029
2000's	0.029		

Table 3. Population figure of Ile-Ife in the 1980's, 1990's and 2000's

Year	Population figure	Source
1984	185,975	Encyclopedia Americana 1984
1991	289,500	National Population Council 1991
2006	644,373	National Population Council 2006

Land Use-Land Cover Change: Trend, Rate and Magnitude

There seems to be a negative change i.e. a reduction in disturbed forest and a positive change in intensive agriculture between 1983-1992 and 1993-2002. This can be said to be largely due to increase development in the city during these epochs, there was more influx of people attributed to better job opportunity in OAU and OAUTHC but there was a general hardship imposed by the Nigerian Military Government in the country which made people to use subsistence farming to complement their means of livelihood. During this period a lot of civil servants had a farm to sustain their family alongside their job. Teachers are well known for their strike action during this period on the government owing them their wages.

The period between 1993-2002 and 2003-2013 witnessed a drop in the rate of intensive agriculture practice.

Table 4. Land Use-Land Cover Change: Trend, Rate and Magnitude

	Trend of Change				Annual Rate of Change	
	1980's and 1990's		1990's and 2000's			
	Area (Ha.)	Percent age Change	Area (Ha.)	Percent age Change	80's – 90's	90's - 2000's
Dam and Water Bodies	-37.2	-0.06	-3.2	0	44.4	0
Disturbed Forest	-9196.0	-9	-8436.8	-8	7,275.2	-0.8
Intensive Agric. Land	5654.8	6	-2219	-4	72,264.4	-0.4
Major Urban	2846.8	3	7372.4	8	13,374.0	0.8
Minor Urban	734.9	1	3269.2	4	5,332.0	0.4
Rock Outcrop	-2.8	0	17.6	0.01	382.8	0.001

Transition Probability Matrix

The transition probability matrix records the probability that each land cover category will change to the other category. This matrix is produced by the multiplication of each column in the transition probability matrix be the number of cells of corresponding land use in the later image.

For the 5 by 5 matrix table presented below, the rows represent the older land cover categories and the column represents the newer categories. Although this matrix can be used as a direct input for specification of the prior probabilities in maximum likelihood classification of the remotely sensed imagery, it was however used in predicting land use land cover of 2020.

Row categories represent land use-land cover classes in 2013 whilst column categories represent 2020 classes. As seen from the table, disturbed forest has 0.8360 of remaining disturbed forest while it has a 0.8878 of changing to intensive agricultural land in 2020. This therefore shows an undesirable change (reduction) in forest, with a probability of change which is much higher than stability. Intensive agricultural land during this period will change to major urban area with a probability of 0.1344; there are tendencies of expansion of the town at the edge of major urban area cutting down the intensive agricultural lands. Minor urban area has high tendencies of becoming a major urban area with a probability of 0.6871 which signifies a lot of growth in the surrounding suburban areas or minor urban areas. Major urban land also has a probability 0.4021 to remain as built-up land in 2020 which signifies stability.

Table 5. Transitional Probability table derived from the land use-land cover map of 1983 and 2013

Classes	**Dam**	**Disturbed Forest**	**Intensive agric. land**	**Major Urban**	**Minor Urban**	**Rock Outcrop**
Dam	0.6074	0.0000	0.0000	0.3926	0.0000	0.0000
Disturbed forest	0.0000	0.8360	0.8878	0.0000	0.0296	0.0000
Intensive Agricultural land	0.0001	0.0030	0.0621	0.1344	0.0469	0.0001
Major urban	0.0000	0.0000	0.0000	0.4021	0.0000	0.0000
Minor urban	0.0000	0.0000	0.0038	0.6871	0.3092	0.0000
Rock outcrop	0.0000	0.0000	0.0318	0.1936	0.0000	0.7745

Land Use-Land Cover Projection For 2020

The Table 6 shows the statistic of land use-land cover projection for 2020. Comparing the percentage representations, there exist similarities in the observed distribution particularly like it has been expected. For the Dam reduced with a difference of 0.02%. The intensive agriculture, experienced a little change of just 1%, suggesting no growth in the intensive farming with a lot of development in the major and minor urban, this is also evident in the transition probability matrix. Agriculture maintains the highest position in the class whilst dam retains its least position. Major Urban takes up the next position, followed by Minor Urban and finally, Disturbed Forest and Rock-out Crop. There is no likelihood that there will be compactness in Ile-Ife by 2020 but instead the town continues to expand until the major and minor urban areas get to their expansion limit before compactness sets in, which by then might be due to crowdedness because of the rate at which influx of people to the town is increasing

Table 6. Projected land use-land cover for 2020

Land Use Land Cover Classes		**Dam**	**Disturbed Forest**	**Intensive Agriculture**	**Major Urban**	**Minor Urban**	**Rock Out Crop**
	Area in Hectares	24.4	3,338.0	69,888.4	16,864	8,370.4	187.6

	Area In Percentage	0.02	3	70	17	9	0.98

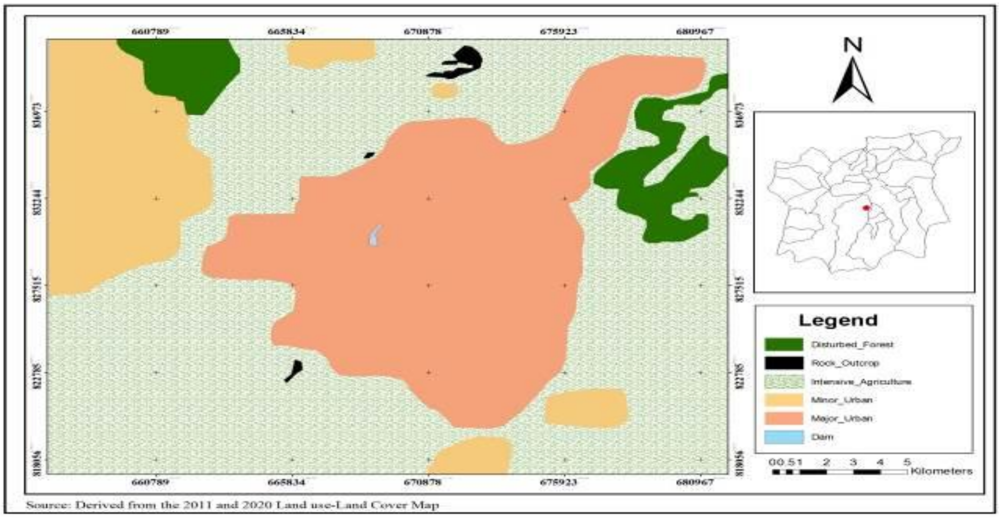

Figure 5. Projected Land use-Land Cover of Ile-Ife by 2020

Conclusion

The paper demonstrates the ability of GIS and Remote Sensing in capturing spatial-temporal data. Attempt was made to capture as accurate as possible six land use land cover classes as they change through time. The six classes were distinctly produced for each study year but with more emphasis on major urban land as it is a combination of anthropogenic activities that make up this class; and indeed, it is one that affects the other classes. In achieving this, Land Consumption Rate and Land Absorption Coefficient were introduced into the work to determine the compactness form of development in the study area. It was observed that change by 2020 will follow the trend in 2003/2013 accompanied by continuous increase in city expansion following the past and present trend. The work has revealed the direction and trend of growth for the city, which will serve as a viable prospect for the town planners to ensure adequate development control measures, and become a major input in the development of a working master plan for the city. Measures to curb abrupt encroachments into the green areas (intensive agriculture and disturbed forest) should be put in place, in order to maintain a balance between preventing sprawl and providing sufficient land for housing development.

References

Berlanga-Robles, C., and Ruiz-Luna, A.,(2002): Land Use Mapping and Change Detection in Coastal Zone of Northwest Mexico using Remote Sensing Techniques: Journal of Coastal Research, 18(3), p.514 –522: Available from http://www.jstor.org/stable/4299098 [Accessed 03/09/2010]

Dubovyk, O., Sliuzas, R., and Flacke, J. (2011). Spatio-temporal analysis of ISs development: A case study of Istanbul, Turkey. ISPRS Journal of Photogrammetry and Remote sensing, 66 (2), 234-246

Gibson, P., and Power, C., (2000): Introductory Remote Sensing: Digital Image Processing and Applications, Routledge, p. 92 – 112

Jiboye A. P. (2005) *Globalization and the Urban Growth Process in Nigeria* In: Fadare et.al editors. Globalization, Culture and Nigerian Built Environment. Faculty of Environmental Design and Management, OAU, Ile-Ife, Nigeria. 2, 342 – 345.

Klosterman, Richard (1999). "The What if? Collaborative Planning Support System." *Environment and Planning, B: Planning and Design. 26(1999): 393-408*

Krishna V.B. (2009) Determinants of the Patterns of Settlements in the Province of Tarlac. U. P. School of Urban and Regional Planning.

Long, H., Wu, X., Wang, W., and Dong, G., (2008): Analysis of Urban-Rural Land Use Change during 1995-2006 and its Policy Dimensional Driving Forces in Chongqing, China, Sensors 2008(8) Available from http://www.mdpi.com/1424-8220/8/2/681/pdf [Accessed 03/09/2010]

Longley, P., Donnay, J., Barnsley, M., (eds.) 2001; RemoteSensing and Urban Analysis Taylor and Francis, London, p.117

Osasona, C. O. and Hyland, A. D. C. (2006). *Colonial Architecture in Ile-Ife, Nigeria.*

Osasona, Lee O. Cordelia O. Ogunshakin and David A. Jiboye (2009). *Ile-Ife: "A Cultural Phenomenon in the Throes of Transformation."* The African Inner City, African Perspectives 2009.

Prakasam, C. (2010): Land use and land cover change detection through remote sensing approach: A case study of Kodaikanal Taluk, Tamilnadu. International Journal of Geomatics and Geosciences, 2010, Vol. 1, No. 2, p 150-158: Available from ipublishing.co.in/jggsvol1no12010/EIJGGS1015.pdf [Accessed 03/09/2010]

Seto K. C., Fragkias M. (2005). Quantifying spatiotemporal patterns of urban land-use in four cities of China with time series landscape metrics. Landscape Ecology 20(7):871-888

Turner, B.L. II and B.L. Meyer, (1994):"Global Land Use and Land Cover Change: An Overview." In Changes in Land Use and Land Cover: A Global Perspective, eds. W.B. Meyer and B.L. Turner II, 3-10. Cambridge: Cambridge University Press.

UN-Habitat. (2011). World Population Prospects: The 2008 revision methodology of the United Nations population estimates and projections. New York

Zubair, A., (2006): Change Detection in Land Use and Land Cover using Remote Sensing Data and GIS: A Case Study of Ilorin and its Environs in Kwara State: GIS Development Journal: Available from http://www.gisdevelopment.net/thesis/OpeyemiZubair_ThesisPDF.pdf [Accessed 03/09/2010]