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Full Length Research Paper

Dynamics of urban land use changes with remote sensing: Case of Ibadan, Nigeria

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There are so many problems confronting most contemporary cities in the recent time particularly among the less developed countries around the world. These problems have been recognized to be the product of lack of urban planning by the authority in-charge as well as individual members of the society. However, the negative relationship between urban population and urban development has been identified using different methodologies. The prime objective is to apply the technique of Remote Sensing and GIS technology to examine the trend, pattern, the relationship between sprawl and population as well as the socio-economic implications of urban sprawl in Ibadan. However, the population is estimated to increase by 68.5% between year 2000 and 2020 (2,207,829 – 3,223,429) while the corresponding projected land consumption is also expected to rise by 58.5% (52,220.3 – 89, 192.3 ha) which implies that both would have doubled but the population is likely to double itself much faster than the land mass. Similarly, there was a significant change in the land use of land cover between 1986 and 2000 and a good example was the farmland which had decreased by 67.9% between this periods. The implication of this growth on the socioeconomic well being of the population is that urban development would have encroached on the urban fringe where urban and periurban agriculture is being practiced leading to acute shortage of fresh food supply to the urban populace, while similarly the sprawl is likely to result in slums development.

Key words: Urban, land use, remote sensing, fringe, population.

INTRODUCTION

Land use, land cover and its pattern of change is a major element that is very important in the history of global expansion and land use and cover change (LUCC) with its impacts on the environment has been one of the increasing focus of global changes (Chase et al., 2000). According to Anderson, urban area still takes up a very small part of the Earth's surface (Anderson et al., 1976). However, expansion of human settlements and its accompanying activities, especially the rapid urbanization occurring in the developing countries, play an important role in global land use and cover change, causing changes in the ecological processes at both local and global scales. Urbanization is therefore regarded as a major driving factor of land use changes. It is therefore referred to as a transformation process from a traditional agricultural society to a modern metropolitan society, associated with major changes in social and economic structures. As an important component of land use and land cover change, its significance will undoubtedly continue to increase as the majority of the world's population is swarming into cities (Ottensmann, 1977; Zhao et al., 2002). Furthermore, the US Bureau of the Census defines urban areas as those in which the human population reaches or exceeds densities of 186 people per km^2. However, an ecological understanding of urban systems goes ahead to include less densely populated areas because of reciprocal flows and influences between densely and sparsely settled areas. Comparisons along gradients of urbanization can capture the full range of urban effects as well as the existence of thresholds.

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Therefore, in the broadest sense, urban ecosystems comprise suburban areas, exurbs, sparsely settled villages connected by commuting corridors or by utilities, and hinterlands directly managed or affected by the energy and material from the urban core and suburban lands (Pickett et al., 2001).

One of the factors driving land-use change includes what can be called 'development attractors.' These are physical features that promote new residential and commercial development. For example, main roads, existing developed areas, and utilities such as electricity, postal services, industrial development and potable water supply are development attractors because new development is likely to occur in their vicinity. Land use and land cover change is perhaps the most prominent form of global environmental changes since it occurs at spatial and temporal scales and is very relevant to our daily existence. The changes in land use and land cover are likely to affect natural resources and ecosystems as well as urban human activities in complex ways. The National Research Council recently identified Land Use Dynamics as one of the grand challenges for environmental research (NRC, 2001). Determining the effects of land use and land cover change depends on an understanding of past land use practices, current land use and cover patterns, and projections of future land use and cover, as affected by human institutions, population size and distribution, economic development, technology, and other characteristics.

However, Thenkabail et al. (2011) stated that Global cropland mapping is possible by integrating agricultural statistics and census data from national systems and spatial mapping technologies involving geographic information systems (Ramankutty et al. 2008). He went ahead by saying that the availability of advanced remote sensing imagery along with secondary data and recent advances in data access, quality, processing, and delivery have made possible the estimation of croplands based on remote sensing at the global level (Thenkabail et al., 2009a, 2009c).

Studies have shown that there remains only few landscapes on the Earth that are still in their natural state (Riebsame, 1994). 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 into an observable pattern in the land use/land cover over time. Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes in which urban environment is included (Moshen, 1999). The advancement in the concept of environmental mapping has greatly increased research on land use land cover change thus providing an accurate evaluation of the spread and health of the world's forest, grassland, agricultural resources and urban development and this has become an important research priority. Viewing the Earth from space is now crucial to the understanding of the influence of man's activities on his natural resource base over time. In situations of rapid and often unrecorded land use change, observations of the earth from space provide objective of human utilization of the landscape. Over the past years, data from Earth sensing satellites has become vital in mapping the Earth's features and infrastructures, managing natural resources and studying environmental change.

According to Meyer (1995), the ability to forecast land use and land cover change and, ultimately, to predict the consequences of change, will depend on our ability to document and understand the past drivers of land use and land cover change. Historical land use and cover change has occurred primarily in response to population growth, technological advances, economic opportunity, and public policy. Patterns of human settlement are shaped by both the interaction of environmental (e.g., climate, geology, topography, and vegetation) and social (e.g., cultural customs and ethnicity) forces around the world. An improved understanding of historical land use and land cover patterns provides a means to evaluate variations in past causal factors and responses as well as a method for evaluating the trends of human activities present in the current baseline. The systematic evaluation of these historical and contemporary factors will improve the ability to develop projections of future land use and management decisions.

Remote sensing (RS) and geographic information system (GIS) are now providing dynamic tools for advanced ecosystem management and the projection of urban growth (Shoshany et al., 1994). 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). Therefore, attempt will be made in this study to examine the status of land use land cover of Ibadan and its environs between 1986 and 2000 with a view to detecting the rate of change, the land consumption rate and the changes that has taken place in concentrated areas particularly in the built-up land so as to predict possible changes that have taken place till date as well as the changes that might take place in the future, say the next 12 years (2020) using both Geographic Information System and Remote Sensing data. The rational for this is not connected to the fact that most urban centre in Nigeria are now engulfing agricultural land use at the peripheries without any adequate planning for such development. Most areas that were once designated for industrial activities have merged with the growing urban centre forming conurbation, which may have negative impacts on the health of the residents. It is therefore necessary to determine the rate and direction of urban growth so that necessary precautions would be considered when decision is being taken on urban land use planning.

LITERATURE

Every parcel of land on the Earth's surface is unique in the cover it possesses (Meyer, 1995). Land use and land cover are distinct yet they have closely linked characteristics of the Earth's surface. The use to which we put land could be grazing, agriculture, urban development, logging, and mining among many others. While land cover categories could be cropland, forest, wetland, pasture, roads, urban areas among others. The term land cover originally referred to the kind and state of vegetation, such as forest or grass cover but it has broadened in subsequent usage to include other things such as human structures, soil type, biodiversity, surface and ground water. Land use affects land cover and changes in land cover affect land use. This implies that both of them possess symbiotic relationship. A change in either however is not necessarily the product of the other.

Very central to urban land use changes is the development of sprawl which is seen today as a global phenomenon. According to Besussi et al. (2010), Sprawl is loosely associated with the tradeoff between the desire to live as close to the city as possible against the desire to purchase as much space as possible and still retain the benefits of "urban" or "suburban" living. Sprawl thus comes about through rising wealth and transportation technologies that allow such suburban development and urban morphologies to reflect this tradeoff. The dynamics of the processes defining such spatial interaction and land development are thus central to an understanding of urban form and structure.

It has however been posited that changes in land cover by land use do not necessarily imply degradation of the land if the land is put into proper use. However, many shifting land use patterns driven by a variety of social causes, result in land cover changes that affects biodiversity, water and radiation budgets, trace gas emissions and other processes that come together to affect climate and biosphere (Riebsame et al., 1994). Land cover can be altered by forces other than anthropogenic. Natural events such as weather, flooding, fire, climate fluctuations, and ecosystem dynamics may also initiate modifications upon land cover. Globally, land cover today is altered principally by direct human use: by agriculture and livestock raising, forest harvesting and management, urban and suburban construction as well as other developmental activities.

Hence, in order to use land optimally, it is not only necessary to have the information on existing land use land cover but also the capability to monitor the dynamics of land use resulting out of both changing demands of increasing population and forces of nature acting to shape the landscape. Conventional ground methods of land use mapping are labor intensive, time consuming and are done relatively infrequently. These maps soon become outdated with the passage of time, particularly in a rapid changing environment. In fact according to Olorunfemi (1983), monitoring changes and time series analysis is quite difficult with traditional method of surveying. In recent years, satellite remote sensing techniques have been developed, which have proved to be of immense value for preparing accurate land use land cover maps and monitoring changes at regular intervals of time. In case of inaccessible region, this technique is perhaps the only method of obtaining the required data on a cost and time – effective basis. A remote sensing device records response which is based on many characteristics of the land surface, including natural and artificial cover. An interpreter uses the element of tone, texture, pattern, shape, size, shadow, site and association to derive information about land cover.

However, the use of remote sensing to detect the growth of urban land use, its changes and the determination of the statistics was also demonstrated by many scholars among who is Thenkabail in his study of global cropland. According to him, the specific remote sensing advances enabling global cropland mapping and generation of their statistics include factors such as free access to well-calibrated and guaranteed data such as Landsat and Moderate Resolution Imaging Spectrometer (MODIS), frequent temporal coverage of data such as MODIS backed by high-resolution Landsat data, free access to high-quality secondary data such as long-term precipitation, evapotranspiration, surface temperature, soils, and global digital elevation map (GDEM), global coverage of data, Web-access and broad bandwidth, and advances in computer technology and data processing (Thenkbail et al., 2011). These advances have enabled better estimates of urban land use pattern, using unified and systematic frameworks. For instance, Ramankutty et al. (2008) estimated global croplands to be 1.54 billion hectares for the nominal year 2000. Thenkabail et al. (2009a) and Thenkabail et al. (2009c) also obtained a similar estimate (1.53 billion hectares). However, Portmann et al. (2009) estimates were lower (1.3 billion hectares).

Lastly, the effect of this unchecked urban growth and the implications on the socioeconomic activities cannot be under estimated. A major consequence is urban sprawl, which is defined by the combination of several factors. For instance, Anthony, in his study of urban sprawl reviewed different indices that were used to define urban sprawl; these are unlimited outward extension of development, low-density residential and commercial settlements, leapfrog development, fragmentation of powers over land use among many small localities. Others are dominance of transportation by private automotive vehicles, no centralized planning or control of land-uses, widespread strip commercial development, great fiscal disparities among localities, segregation of types of land uses in different zones, and reliance mainly on the

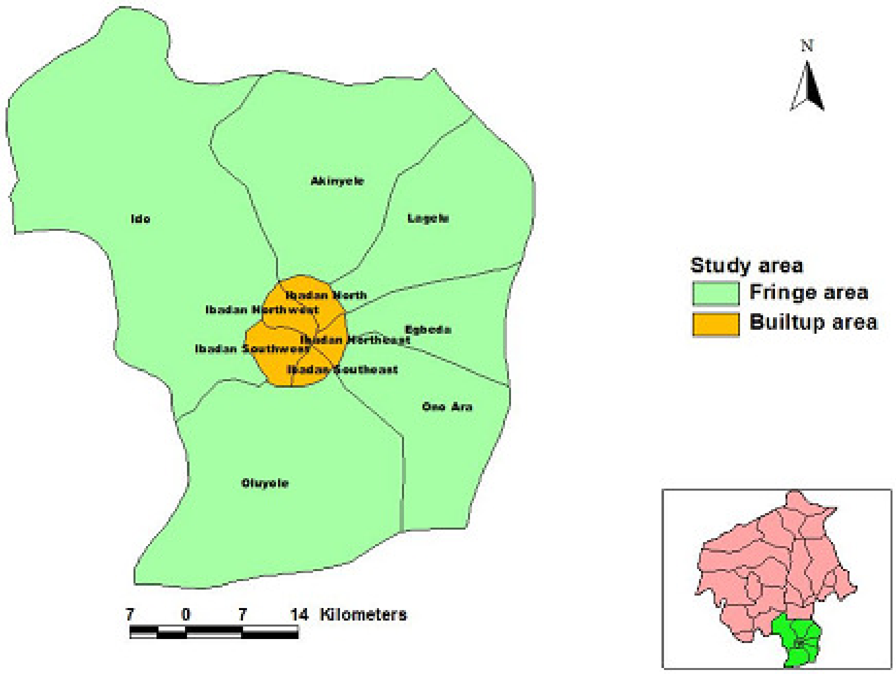

Figure 1. Ibadan region inset Oyo state.

trickle-down or filtering process to provide housing to low-income households.

STUDY AREA

The city of Ibadan is located in the southwestern part of Nigeria. It is located approximately on longitude 3^{o}5’ to 4^{o}36’East of the Greenwich Meridian, and latitude 7^{o}23’ to 7^{o}55’ North of the Equator. Ibadan is located at a distance of 145 km north of Lagos (Ayeni, 1994). As at early 80s, it had an aerial extent of about 30, 080 km^2 with the metropolis covering about 250 km^2 of the area. The 2006 census put the total population of Ibadan to 2,550,593 while the average population density was 828 persons per km^2 (NPC, 2006). The total population size of the wider Ibadan region was 1,258,625 in 1963 and 1,991,367 in 1991 (Afolayan, 1994). The population size of Ibadan urban was 627,379 in 1963 while that of Ibadan rural was 631,246. However, the development in the core area of the city has encroached and took over most of these villages that surround the area. As a result, any projection of the population of Ibadan urban should be based on a total size of the figure obtained by adding the population sizes of Ibadan urban with those for the former villages in the smaller Ibadan region (Afolayan, 1994). The population of the entire city increased to 1,222,187 while that of Ibadan urban only was 1,829,187 in 1991. Ibadan region encompasses eleven Local Government Areas, some of which are Ibadan North, Ibadan South, Ibadan Northwest, Ibadan Southwest and Ibadan Northeast local governments while the wider Ibadan covers the fringe areas which are Akinyele, Oluyole, Egbeda, Ido, Lagelu and Ono-Ara Local Government Areas (Figure 1).

THE GROWTH OF IBADAN CITY

The growth of Ibadan became more rapid when it was made the headquarters of the defunct Western Region of Nigeria in 1946. It became a major centre for the attraction of many more expatriates and other Yoruba sub ethnic groups due to the increasing range of opportunities that abound in the city. Consequently, more residential areas were needed to accommodate the teeming inflow of people and the city began to grow rapidly outside the city wall. The city continues to grow in all directions especially along the major routes, Lagos to the South, Ile-Ife to the East, Abeokuta to the West and Oyo the North, to cover a large expanse of land of over one hundred square kilometres.

Many new developments had taken place since 1973 to generate the outward growth of the city in almost all directions (Areola and Ofomata, 1978). These developments included the building of the Ibadan – Lagos express way, the establishment of the housing estate, the Wire and Cable Factory and the NNPC oil storage depot at Owode on Abeokuta road, the building of the new Airport and the commissioning of Ajoda New Town along Ife road, the building of the Leyland Motor Assembly Plant and the Triplex Glass Factory on Iwo road as well as the new army barracks at Odoogbo, near Ojoo to the north of the city. These developments led to the sharp reduction in the proportion of land devoted to non-urban land uses at the fringes of the city (Gbadegesin, 1981).

For instance in the 1980s, the expressway generated the greatest urban sprawl in the southern and southwestern sectors of the city where the traditional sector of the city has been spreading further and further into the countryside, especially along Akanran/Ijebu Igbo and old Ife roads. The development has led to the categorization of the city into two; the metropolis and the wider Ibadan. The metropolis comprised of the five local governments that are located at the city centre while the wider Ibadan is comprised of the five local governments and the six local government areas located outside the built up area.

Land use change of Ibadan in retrospect

The exact population of Ibadan is not known because the national census of 1991 undoubtedly underestimated the number of inhabitants. The current estimate today varies from 2 to 5 million inhabitants (Ayeni, 1994). Moreover, it is well known that population counts during the colonial period were more like estimates than real counts, and it is difficult to give even an evaluation of the percentage rate of growth. An approximation of the growth of the three main Nigerian cities (Lagos, Ibadan, Kano) in the 20th century reveals some unrealistic figures: a very low rate of growth (0.8%) for Ibadan between 1931 and 1952, whereas all the other West African cities grew at a higher rate; the population of Kano increased five-fold and the population of Ibadan only two-fold between 1960 and 1991; the population of Ibadan increased five-fold in only one decade (1991-2000). In 1981, another calculation based on the average population per housing unit gave an estimate of two million inhabitants (Ayeni, 1994). Ibadan was the largest city in sub-Saharan Africa (Lloyd, 1967). In 1952, it is estimated that the total area of the city was approximately 103.8 km^2. However, only 36.2 km^2 was built up. This meant that the remaining 67 km^2 were devoted to non-urban uses, such as farmlands, river floodplains, forest reserves and water bodies. These “non-urban land uses” disappeared in the 1960s: an aerial photograph in 1973 revealed that the urban landscape had completely spread over about 100 km^2. The land area increased from 136 km^2 in 1981 to 210-240 km^2 in 1988-89. It was estimated that Ibadan would covered 400 km^2 by the year 2000 (Onibokun, 1995). The growth of the built-up area during the second half of the 20th century (from 40 km^2 in the 1950s to 250 km^2 in the 1990s) shows clearly that there has been an underestimation of the total growth of the city. In the 1980s, the Ibadan-Lagos expressway generated the greatest urban sprawl (east and north of the city), followed by the Eleiyele expressway (west of the city). Since then, Ibadan city has spread further into the neighbouring local government areas of Akinyele and Egbeda in particular.

METHODOLOGY

Data sources

Two remotely sensed images were selected for this study. The first is a SPOT-XS of 1986 while the second is a Landsat Enhanced Thematic Mapper plus (ETM+) imagery of 2000. Accordingly, the study period covered about 14 years. The Landsat satellite imagery was obtained from Global Land Cover Facility (GLCF), an Earth Science Data Interface, while the SPOT-XS of 1986 was obtained from the Department of Geography, University of Ibadan whom also got it from the National Space Research and Development Agency (NASRDA), Abuja. The base map of Ibadan showing the area extent of the city was also obtained from the Department of Geography, University of Ibadan, Ibadan. The projection used for the image registration and final map production was Universal Transverse Marcator (UTM), zone 31.

Image processing

Prior to interpretation, the imageries were geometrically rectified on a common UTM coordinate system (WGS 1984 system). The imageries were resampled to 30 m using the nearest Neighbor algorithm to keep the original brightness values of pixels. The spatial and spectral characteristics of the imageries were examined. The image processing and data manipulation were conducted using ILWIS 3.1 and Erdas Imagine 9.1 version (ERDAS Field Guide 1999).

Image thinning was carried out through contract; contract generalizes an image by reducing the number of rows and columns while simultaneously decreasing the cell resolution. Contraction may take place by pixel thinning or pixel aggregation with the contracting factors in X and Y being independently defined. With pixel thinning, every nth pixel is kept while the remaining is thrown away.

Method of data analysis

Methods of data analysis used were included calculation of the land use area in hectares for each study year and subsequently comparing the results. It also included overlay operations; a situation whereby maps generated was superimposed on each other. The last was the land consumption rate (LCR) and land absorption coefficients (LAC). The comparison of the land use land cover statistics assisted in identifying the percentage change, trend and rate of change between 1986 and 2000. In achieving this, the first task was to develop a table showing the area in hectares and the percentage change for each year (1986 and 2000) measured against each land use land cover type. Percentage change to determine the trend of change can then be calculated by dividing observed change by sum of changes multiplied by 100 (Table 1).

Percentage change (Trend) = [(Observed Change)/ (Sum of Change)] × 100

In obtaining annual rate of change, the percentage change is divided by 100 and multiplied by the number of study year 1986 – 2000 (14 and 20 years for projection). Going by the second method (Markov Chain Analysis and Cellular Automata Analysis), Markov Chain Analysis is a convenient tool for modeling land use change

Table 1. Land use land cover classification scheme.

Code	Land use classification
1	Farmland
2	Built-up area
3	Urban fringe and hinterland
4	Secondary forest
5	Water body

when changes and processes in the landscape are difficult to describe. A Markovian process is one in which the future state of a system can be modeled purely on the basis of the immediately preceding state. Markovian chain analysis will describe land use change from one period to another and use this as the basis to project future changes. This is achieved by developing a transition probability matrix of land use change from time one to time two, which shows the nature of change while still serving as the basis for projecting to a later time period. However, there is no knowledge of the spatial distribution of occurrences within each land use category. Hence, only LAC and LCR techniques were used.

The Land consumption rate and absorption coefficient formula are give below;

L.C.R = A/P

A = aerial extent of the city in hectares
P = population

L.A.C = $(A_2 – A_1) / (P_2 – P_1)$

A_1 and A_2 are the aerial extents (in hectares) for the early and later years, and P_1 and P_2 are population figure for the early and later years respectively (Yeates and Garner, 1976).

L.C.R = A measure of compactness which indicates a progressive spatial expansion of a city.
L.A.C = A measure of change in consumption of new urban land by each unit increase in urban population.

Both the 2007 and 2020 population figures were estimated from the 1991 and the estimated 2006 population figures of Ibadan respectively (with 14 years interval each) using the recommended National Population Commission (NPC) 2.3% growth rate as obtained from the 1991/2006 censuses. The first task to estimating the population figures was to multiply the growth rate by the census figures of Ibadan in both years (1991, 2006) while subsequently dividing same by 100. The result was then multiplied by the number of years being projected for, the result of which was then added to the base year population (1991, 2006). This is represented in the formula below;

$n = r/100 * Po$ (1)
$Pn = Po + (n * t)$ (2)

Where;
Pn = estimated population (2008, 2020)
Po = base year population (1991 and 2001 population figure)
r = growth rate (2.3%)
n = annual population growth
t = number of years projecting for

Population data

Population of Ibadan city (1963): 627,379
Population of Ibadan city (1986): 959,262
Population of Ibadan city (2000): 2,207,829 (Projected from 2000 {9 years})
Population of Ibadan city (2008): 2,614,069 (Projected from 2000 {8 years})
Population of Ibadan city (2020): 3,223,429 (Projected from 2000 {20 years})

Population Growth Rate: 2.3

The population growth of Ibadan city has been on the increase especially in the recent time based on its locational advantage over other settlements within the region. For instance, it grew by 65.4% between 1963 and 1986, and by 43.4% between 1986 and 2000. Furthermore, it is projected to grow by 68.5% between 2000 and 2020, a period of 20 years.

DATA ANALYSIS AND DISCUSSION

This chapter is basically divided into two; the first is the analysis of the satellite imageries obtained for the study. The processes highlighted in chapter three were adopted, starting from the image rectification, resampling, thinning, and enhancement before moving on to classification. An unsupervised classification was performed to be able to have a better understanding of the signature of the used imageries. After the various analyses performed on the imageries, some population data obtained from literature and Federal Office of Statistics were also examined to be able to determine the pattern of relationship that exists between urban land use change and population growth.

The results of this work are presented inform of processed imageries, maps, charts and statistical tables. They include the static, change and projected land use land cover of each class. However, the imageries were subset from the entire imagery of part of the southwestern part of Nigeria with a Path and Row of 151 and 055 respectively. These subsets are shown in Figures 2 and 3.

Figure 4 shows the spatial development of Ibadan city (the built up area) between years 1984, 2000 and 2007. The green shaded area in the inset shows the fringe area that is gradually being consumed by the teeming urban population.

According to Table 2, Water body (dams) had reduced by -1.3% per year between 1986 and 2000 the total reduction was 20.8% for the period. On the other hand, the built up area was increasing at the rate of 0.07 per year while the percentage of increase between 1986 and 2000 was 1.05%. Going further, data revealed that urban fringe/hinterland was increasing at the rate of 1.95% per year while the total increase between 1986 and 2000 had rose to 27.34%. Change in farmland area was also on the negative side. The annual rate of change (decrease) was 2.8% while the total change between 1986 and 2000 was -4.3%. Lastly, though the proportion of secondary forest as at 1986 was very low which was confined to the northern part of the city, precisely IITA and its

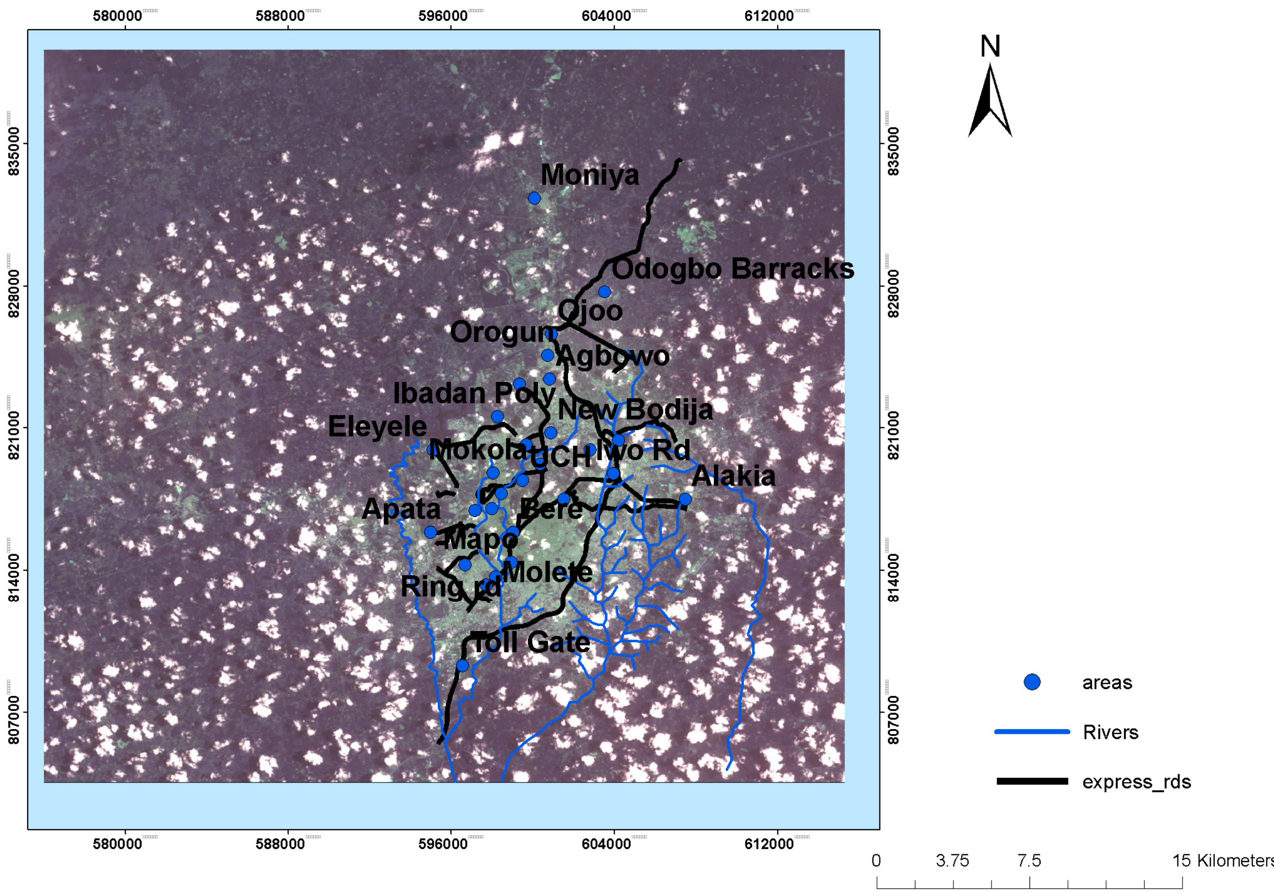

Figure 2. SPOT imagery of 1986 showing the aerial extent of Ibadan.

environment, it was discovered that almost the entire secondary forest had disappeared as at year 2000 leaving behind a pocket area reserved by the institute. Based on the data derived from the computation of this trend of changes in land use land cover of the study area, a projection was made as to what the trend of change is likely to be in the nearest future. As a result of this, both built up and the hinterlands were combined together to form a single built up urban center (wider Ibadan); the total growth for the entire region to year 2000 was therefore estimated to 22.0% at an annual rate of 1.7%. Based on this growth rate, it was concluded that Ibadan region would have increased to about 89192.3 hectares (892.00 km^2) of land by the year 2020 with a projected population of 3,049255.

The data presented in Table 3 shows the area of each land use land cover category for each study year. Water body in 1986 occupied just 1.9% of the total classes, and this value drastically reduced to 0.43% in the year 2000. Also, farming seems to be the major human activities outside Ibadan city and in other neighbouring villages that surround the town; it accounted for about 67.9% of the entire area covered in 1986 while it was also a little less (65%) in year 2000. This may be due to the changes in hydrological cycle and increase in water demand within the urban area as a result of urban expansion and population growth. The built up area was 5.8% in 1986 and it increased through a narrow margin of 5.9% in year 2000 while the hinterland otherwise called periphery or urban outskirt of Ibadan was 22.5% and 28.6% in both years 1986 and 2000 respectively. Though there were little secondary forest zone of just 1.9% in 1986; this had however disappeared completely by the end of year 2000. This is not surprising as the study is really focusing on urban land use and its neighbouring land covers.

According to Table 4, the metropolitan area of Ibadan had changed significantly between 1986 and 2007, while it was projected to still be on increase by year 2020. These changes are shown thus; 28.3% for 1986, 34.5% for 2000, 35.2% for 2007 while 59.0% was projected for 2020. This statistics only represents the built up area of the city while the hinterlands are excluded. What this implies is that by 2020, areas that are presently regarded as part of hinterland would have been engulfed by development.

However, Table 5 shows the percentage of change

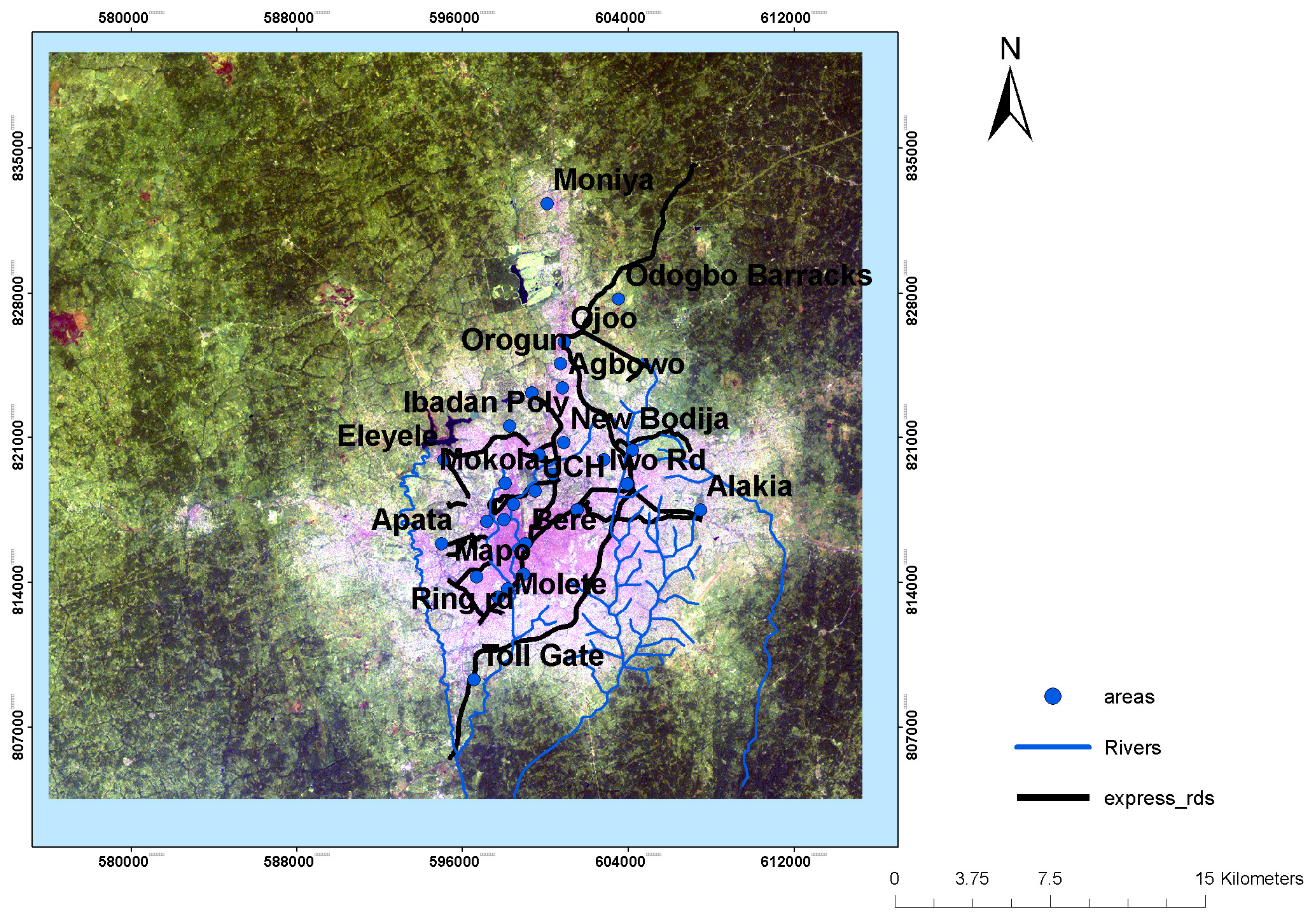

Figure 3. Landsat ETM+ imagery of 2000 showing the aerial extent of Ibadan.

between the aggregate hinterland and built up area. In this case, the entire city was classified into two according to their levels of development/congestion; these are built up and hinterlands. In 1986, the percentage of built up area was 79.4% while the hinterland was 20.6%. For the year 2000 on the other hand, the built up area covered 17.1% while the hinterland increased to 82.9%. Lastly in 2007, the built up had increased to 19.4% while the hinterland had also increased to 120.4% This showed that the proportion of built up area was greater than hinterland in 1986 while that of hinterland was greater in 2000. However, it had greatly increased by year 2007, with the hinterland taken a larger proportion. This simply implies that residents are massively moving out of the presently congested built up area to the hinterlands and this will ultimately affect the land use pattern especially farming and other socioeconomic activities in this region. It could also be deduced that in the earlier years of the development of Ibadan city, people were reluctant to move out of the core area and this was traceable to the traditional values the indigenes have for their traditional family compound, hence the high population and housing densities of the city centre at the time. It is therefore until recently that movement has started taking place as a result of improvement in socioeconomic status of the people, and thereby chasing agricultural land use away from the newly developing areas.

Computation of change detection

Land consumption rate (LCR) = (Aerial extent of the city in Ha) / (Population)

Land absorption coefficient (LAC) = $A_1 - A_2 / P_1 - P_2$

Aerial extent for year 1986: 42819.3 Ha.
Aerial extent for year 2000: 52220.3 Ha.
Projected aerial extent for year 2020: 89192.3 Ha.

Land consumption rate (LCR) is a measure of detecting the rate at which land is being consumed by the residing population. Through this measure, a prediction of land that is expected to be consumed by the teeming resident population could be determined, which could also be used to determine the rate of urban expansion. It could therefore be concluded that LCR is a function of increase

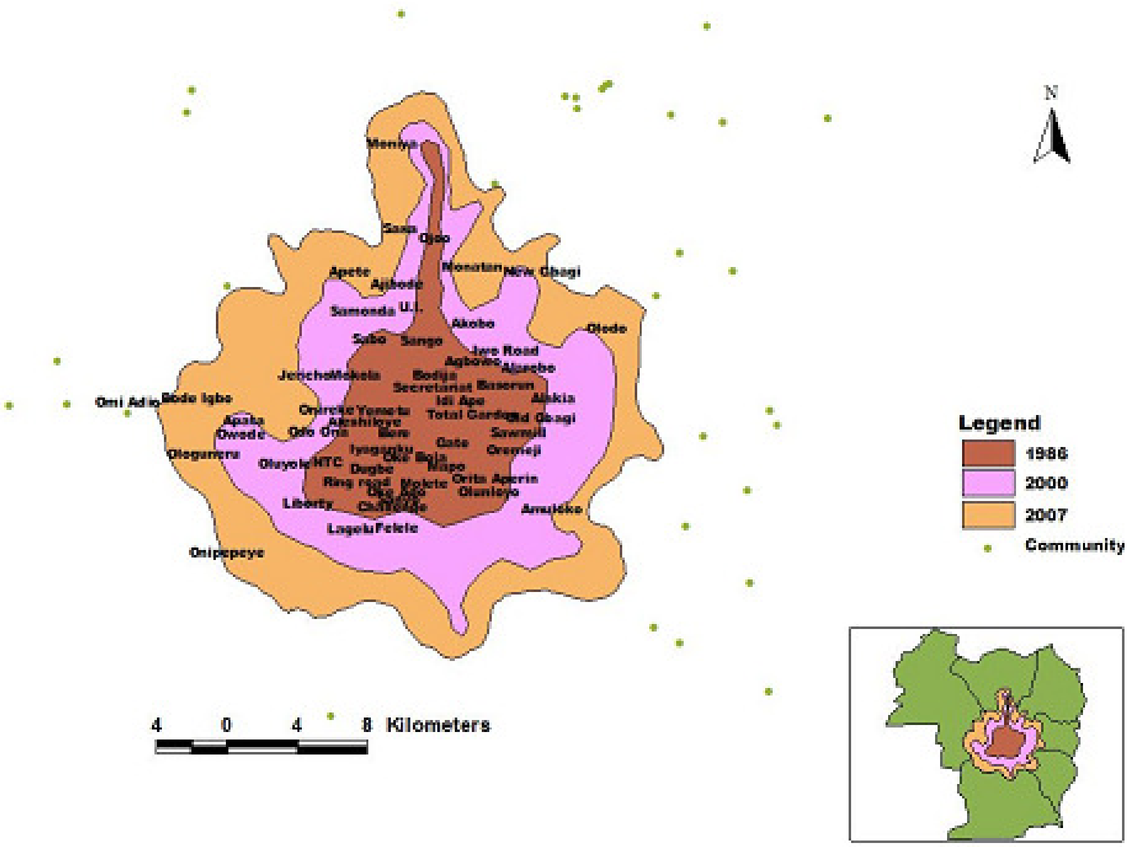

Figure 4. Urban built-up land use changes between 1984 and 2007.

Table 2. Trend and rate of changes in land use land cover between 1986 and 2000.

Class	Area 2007 (ha.)	Area 2000 (ha.)	Area 1986 (Ha.)	Annual rate of change	% Change btw 1986 - 2000	% Change/year
Water body	594.21	685.65	2739	-1.3	-20.8	**-1.3**
Built up area	10344.51	8920.86	8815.62	0.07	1.05	**0.07**
Urban fringe	64135.51	43299.4	34003.7	1.95	27.34	**1.95**
Farmland	79242.7	98323.3	102778.83	-0.31	-4.3	**-0.31**
Secondary forest	0	0	12293.06	0	0	**0**
Built up and fringe	**53276.35**	**52220.3**	**42819.3**	**1.7**	**22.0**	**1.7**

Table 3. Land Use land cover distribution of Ibadan and Environs (1986 and 2000).

LULC	2000		1986	
	Area (ha.)	% of area	Area (Ha.)	% of area
Water body	658.65	0.43	2739.0	**1.9**
Built up area	8920.86	5.9	8815.62	**5.8**
Hinterland	43299.4	28.6	34003.7	**22.5**
Farmland	98323.3	65.0	102778.83	**67.9**
Secondary forest	0	0	2857.06	**1.9**
Total	**151194.21**	**100**	**151194.21**	**100**

Table 4. Changes in land extent of Ibadan Metropolis in relation to mapped area.

Year	Metropolitan area (Ha.)	% of Ibadan Metropolis
1986	42819.3 (428.1 km^2)	28.3
2000	52220.3 (522.1 km^2)	34.5
2007	53276.35 (532.8 km^2)	35.2
2020	89192.3 (892 km^2)	59.0

Table 5. Distribution of Urban land-use changes in 1986 and 2000 in relation to successive metropolitan area.

Urban land	% in 1986	% in 2000	% in 2007
Built up area	79.4	17.1	19.4
Hinterland/fringe	20.6	82.9	120.4

Table 6. Land consumption rate (LCR) and land absorption coefficient (LAC) changes.

Year	Land consumption rate	Year	Land absorption coefficient
1986	0.05	1986-2000	0.01
2000	0.02	2000-2020	0.04
2020	0.03		

Source: Classified Landsat ETM+ of 2000 and SPOT Imageries of 1986.

in urban land use (that is change in urban land use). Similarly, Land Absorption Coefficient (LAC) is used to determine the rate at which the available land is absorbing the population. It is high when the rate of LAR is low and vice versa (that is it is low when the rate at which urban land use is expanding is greater than that of population and vice versa).

According to Table 6, the LCR was 0.05% in 1986, it drastically dropped to 0.02% in year 2000 and it is projected to rise a little to 0.03% by year 2020. On the other hand, analysis of the data revealed that Land absorption coefficient (LAC) between 1986 and year 2000 was 0.01 while that of year 2000 and 2020 was projected to rise to 0.04. This implies that LAR and LAC are inversely related to each other; the higher the LAR the lower the LAC and vice versa. It therefore suggests the rate at which urban land was expanding in 1986. There was a sharp drop in the rate of expansion around year 2000 while it had started rising from 2000, and it was estimated to continue rising to year 2020. This implies however that something must have responsible for the decline in urban land consumption around the 90s up to year 2000 while the new trend connotes that the consumption rate will be on increase at least till year 2020 though not as fast as in the 80s.

The population figures stated in Table 7 were obtained from the 1963, 1991 and 2006 Census Report of the National Population Commission, from which projections were made using the base year population provided by the commission. The projections were obtained using the population projection formula as provided earlier on. This shows that the population of the city has progressively being on increase. It was 627,379 in 1963, 959,262 in 1986 and 2,207,829 in 2000. It rose to 2614069 in 2008 and projected to be at 3,223,429 by year 2020. However, these teaming population are the basis of the growth the city is experiencing, though the population are unevenly distributed but their aggregate impact on the development of the city may be tremendous which if not properly controlled may be hazardous to the city. Another deduction that was made from the analysis was the change in population density of the city as it grows. Accordingly, the population density was 2240.7 per km^2 in 1986, it increased to 4228.7 per km^2 in 2000 while it was estimated to fall a little by year 2020. This shows the rate at which urban land is expanding as a result of increase in the population of the city. It implies that people now prefer leaving at the outskirt rather than the ever busy city centre as it were in other parts of the world. Lastly, a field observation was made to some of the outskirts of the city and surprisingly it was discovered that some quarters of the areas were occupied by people who acquired their lands through cooperative societies that were formed at various levels in their previous areas of residence located at the city centre as well as those created within their places of work. The trend in the

Table 7. Population figures for Ibadan Metropolis.

Year	Ibadan Population figure	Source
1963	627379	Afolayan 1994
1986	959262	Projected from 1963
2000	2207829	Projected from NPC,1991
2008	2614069	Projected from NPC, 1991
2020	3223429 (Projection)	Projected from NPC, 2006

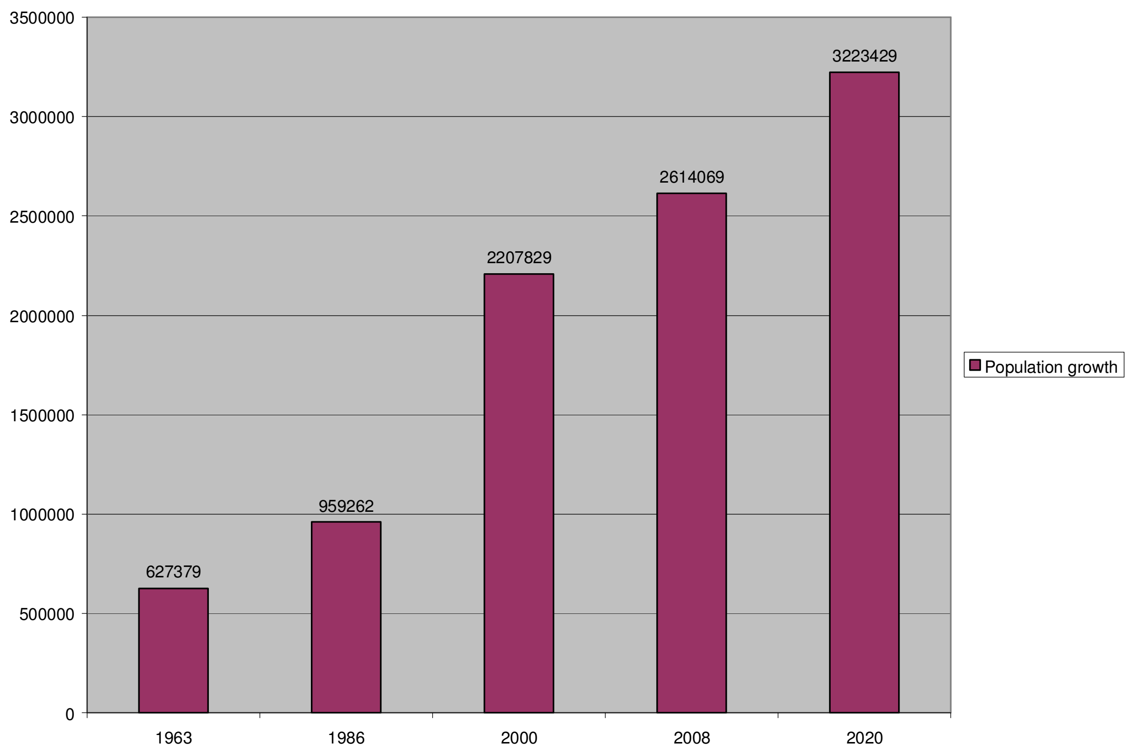

Figure 5. Chart showing thr trend of population growth of Ibadan city.

population growth is therefore shown in Figure 5.

Conclusion

From the analysis of the growth of Ibadan, it appears that the appropriate authorities have lost total control in the management of the city. Reason being that the green land had almost completely disappeared while development at the periphery has not been properly monitored. However, the study also revealed that water body had reduced significantly between 1986 and 2000, meaning that if the trend continues unchecked, there would be a time when there will be water crisis as already experienced in some parts of the city. Moreover, some parcels of wetlands that were previously used for fadama or urban agriculture in the early years have been wiped off with construction thereby denying urban farmers access to lands. At the same time, as lands are being converted to favour other secondary activities at the urban outskirt, farmers also lose their lands to development while the mentality and orientation of the younger ones gradually change from becoming a farmer to other secondary activities, which may lead to urban fresh-food crisis in the future. Lastly, the planning authority should endeavour to be carrying out regular urban audit on land use changes to be able to determine the trend and direction of development in the light of the booming urban population. If precautions are not taken, problems like urban food crisis, poor accessibility, sprawl development at the fringe and other environmental problems are imminent. In other words, adequate measures would play a significant role in checking the implications of dynamism and complexity associated with urban land use. Very central to this is the need to establish green belts within the city, which would serve as reserve zones to support the urban populace to prevent sprawl taking hold of the functional region (Besussi et al., 2010). Further research emanated from this work could be on the influence of these changes on the micro climate of the city, especially in the present time of global climate change and the coping strategies adopted looking at the from the socioeconomic perspective.

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