

Urban Land Use Change Analysis of a Traditional City from Remote Sensing Data: The Case of Ibadan Metropolitan Area, Nigeria

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Abstract: Urban land uses had been increasingly subjected to changes of different forms, sorts and types since urban explosion of the 1970s. People move to cities en-mass from the rural hinterland to the cities in anticipations to benefit from urban economy. However most Nigerian cities are not planned and thus are not prepared for the surge in urban explosion that resulted from the rural urban migration and the biological growth that made most Nigerian cities what they are today- a decadence of humanity. The changes in these residential land uses in urban area are subject of research discourse for a long time. This paper seeks to evaluate urban temporal changes in a typical traditional settlement in Nigeria-Ibadan. The techniques of remote sensing to evaluate land use land cover changes was employed and a projection into 2023 was done using *markov* change model. The density classification and the change rate were utilized in correlation analysis to identify the relationship between the density types at the base year with the rate of change in the study area. It was observed that there are considerable dynamic changes in Ibadan metropolis and the major contributor to changes is the vegetal cover, low density and sprawl development. There are growths by fission within even the high-density areas and the catchments area for rivers are also location for urban spatial growth or change. The paper concludes by suggesting ways to tame haphazard urban growth that characterizes Ibadan and major urban settlement in Nigeria.

Key words: Land use change % urban % change detection % change projection

INTRODUCTION

Human use of land has altered the structure and functioning of the ecosystem [1]. The most spatially and economically important human use of land globally includes cultivation in various ways, construction, reserves, protected lands and timber extraction [2]. Recently settlements and sprawl development are becoming large active land use changes especially in the developing regions of the world. The pattern of land use can provide us insight into the factors that have caused the land cover to change. The urban population in Africa is growing faster than any other continent. It is predicted that by 2030 about 5 billion people, approximately the population size of the entire continent today will be in urban areas and that these figures will be absorbed by the urban areas of the less developed regions [3]. The driving forces behind the rapid urbanization in Africa today are the combination of rural-urban migration and natural increase within the towns and cities themselves.

Nigeria has been regarded as the most populous nation in Africa with a teeming population of over 130 million crowded over a land area of about 923,000 square kilometers. It has over a hundred cities with population that passes for urban centres. Nigerian cities Notably Lagos Kano and Ibadan are among the first one hundred largest cities in the world (World Gazetteer, 2005), which translates into pressures on land and thus high urban dynamics.

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The pressures on land orchestrated by increased rate of urbanization brought with it intractable urban problems, such as poor environmental sanitation, pollution, crime, unemployment and overcrowding among others. Many writers confirmed that Nigerian urban centres are faced with rapid growth and development, which contribute to land use change.

The relationships between population increase, economic developments and land use change have generated research interest over two decades and half. While the trend in lateral growth, the pattern and direction of sprawl developments in many cities in Nigeria are limited by physical barrier such as lagoon, Rocky Mountains and other natural features, the influx of people into the cities complicated the urban condition through structural growth. The population increase naturally creates adjustment and readjustment of human and land use activities in space within urban systems thus causing lateral and structural changes. Lateral changes occur when the city expands in geographic boundaries leading to sprawl and peripheral developments while structural growth relates to increase in land use density within urban centres. The low-density areas gradually become subjected to intensive use and thus become high density or medium density use. This study attempts to examine the changes in land use pattern of Ibadan metropolitan region over a period of thirty-one (31) years through satellite remote sensing data. It also attempts a prediction of change to year 2023 using the weighted potential for change of each land use.

Human alterations of the terrestrial surface of the earth are unprecedented in their pace, magnitude and spatial reach, of these, none are more important than changes in land cover and land use [2]. It is important that the human elements of the land use land cover change be considered to provide a measure of the potentials of human as changed agents of land use land cover.

The United Nations Centre for Human Settlements UNCHS [4] observed that sustainable development is an integral component of human settlement development and gives full consideration to the needs and requirement of achieving economic growth and development, social development, social progress employment opportunities that are in harmony with the environment.

Though land use changes are indirect consequence of national economic growth, it is important to evaluate land use changes in the regional and the local context in order to assist in anticipating the impacts associated with change and contribute to an understanding of productive environmental sustainability [5]. It is not only necessary to understand the changed process in cities, the understanding of the agent of change of beneficiary of change can be useful indicators in planning and declaration of objective functions in cities.

Aim and objectives of the study: The study attempts to examine changed pattern of the urban landuse/landcover in Ibadan regions over a period of thirty-one (31) years thus providing explanation to the structural changes and the changed processes in a typical unplanned urban settlement.

The specific objectives include:

- C To examine the process of urban land use changes between 1972 and 2003
- C To identify the socio economic aspect of the changed process
- C To provide explanation to structural and lateral changes in the urban land use
- C To examine the influence of base year density on urban land use change
- C To project the change pattern to 2023

Section one of this paper discusses the introduction and the study area, while section two examine the theoretical underpinnings and past land use change studies. Section three discusses the methods adopted in the research, section four presents the results of change detection while the last section five presents the discussion and conclusions

Study area: This study focuses on the city of Ibadan, which comprises 11 local government councils, with 5 in the inner city and 6 in the outer areas. Since it's foundation in the 1800s, the city has had rapid growth; in fact it was regarded as

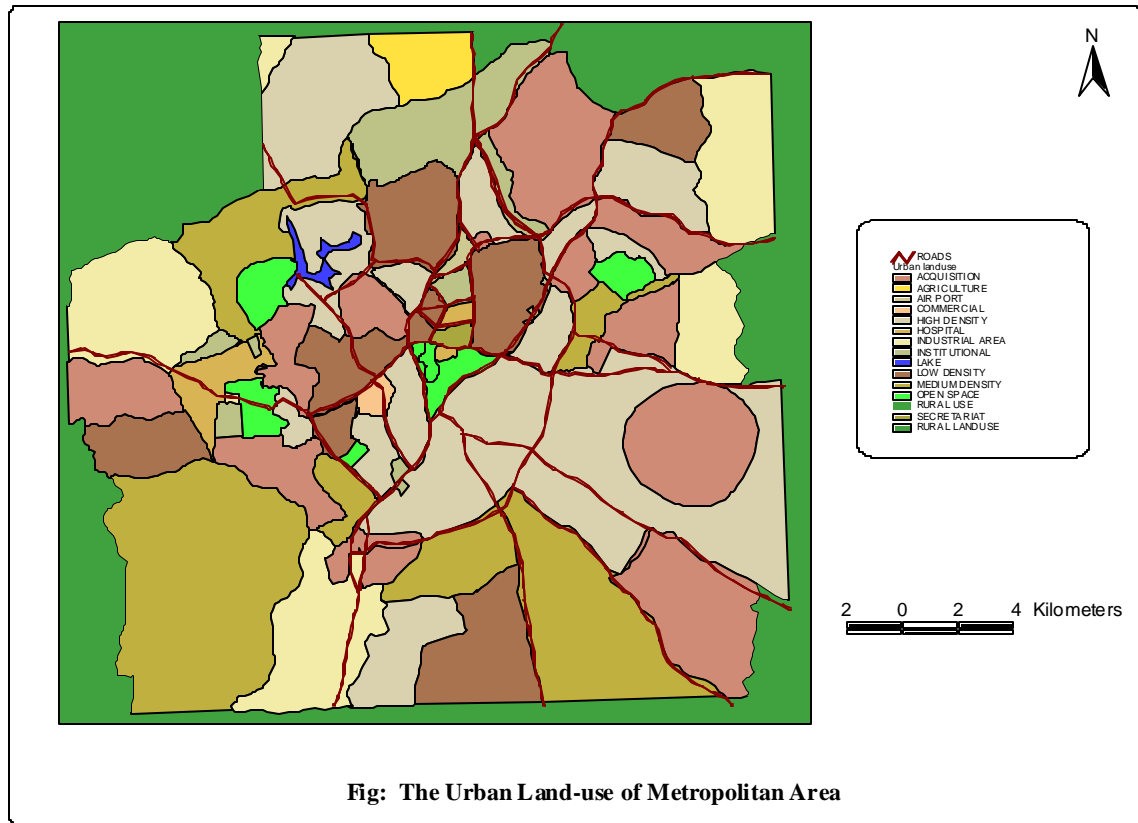


Fig. 1: Broad land use pattern in Ibadan metropolis (Source Ministry of Land and Housing Oyo State 1991)

one of the pre-colonial urban centres in Nigeria [6]. Developed land increased from only 100 ha in 1830 to 12 km² in 1931, 30 km² in 1963, 112 km² in 1973, 136 km² in 1981 and 214 km² in 1988. Similarly, in 1856, the population was estimated at 60,000; by 1890, it had increased to about 200,000; in 1963, it was 600,000 and today, it is almost 2 million [7]. Ibadan, the capital city of Oyo State, is reputed to be the most urbanized state in Nigeria after Lagos. Ibadan grew from a modest population of 200,00 in 1898 to 625,000 in 1963 and in 1991 official census of Ibadan at a disputed figure of 1.8 million.

Ibadan is a large sprawling city with no discernable pattern of growth or development and this has earned the city such epithets as “the world’s largest indigenous city,” “the black metropolis” or “the largest urban village in Africa”. Ibadan is on altitude of 237.7 metres above the mean seal level.

THEORETICAL UNDERPINNING

One of the foremost problems associated with industrialization and civilization is the urbanization and the consequent ills and fallouts. This is because industrialization and civilization are pull factor for the rural-urban migrants as well as cross-national migrants. In recent times most Nigerian cities especially Ibadan, Lagos and Kano have experienced tremendous planned and unplanned growth due to population explosion, which led to congestion, environmental degradation and urban socio-spatial upheavals. Planners and other urban gatekeepers manage urban space and residents for the purpose of efficient functioning and performance of urban systems. They however require the understanding of changed process in urban land use and the interactions with the changed agents in order to discharge their functions in urban space.

In essence, managing and planning for towns require the understanding of the forces and processes operating in them and the factors that naturally sort people of different socio-economic status out in space. Information on the existing land use/land cover pattern, its spatial distribution and changed process is a pre-requisite for planning, utilization and formulation of policies and programme for making any micro and macro-level developmental; unfortunately they are not readily available. Adeniyi [8] observed that information on land use can now be more easily and reliably obtained from remotely sensed and imagery.

The continuous process of change and development in the urban environment has assumed such dimensions that efficient and effective methods of collecting, analysing and storing reliable spatial data on the physical, social and economic features are indispensable for dealing with the manifold and complex problems of urban management and planning. Since the old *laissez faire* approach to regulating the growth of urban development is inadequate and no more relevant to the modern cities, there is a veritable need for an institutional control of urban development [9]. This in essence requires a sound knowledge of urban growth and a versatile tool for modelling and simulating such process in order to afford urban planners the necessary tool and skill for monitoring urban land use change.

Land use/land cover changes and change agents: The study of land use change referred to as change detection and the growth of urban centres have gained prominence in recent years. This is partly due to the fact that there is an increasing need for proper land use planning to control haphazard developments that characterized the city systems in most developing countries. Urban centres are also expanding at an unprecedented rate due to rapid urbanization and this leads to various urban problems such as slums, obsolescence, traffic congestion, blight and overcrowding.

There are many works on detection of land cover change due to urbanization processes, one of such is that by Kamaruzaman and Manaf [10], where IDRISI image processing system was used to assess deforestation in the Sungai Buloh forest Reserve, Peninsular Malaysia. The major cause of deforestation in the area was the conversion of land from forest to agriculture, mining, dam and water reservoir construction. They used two LANDSAT digital spectra data taken in 1988 and 1991 and IDRIS-PC version 4.0 image processing system for digital analysis, processing and classification of the satellite imagery which involves unsupervised classification, HISTOGRAM module and OVERLAY module. Most land use changes in urban and rural setting are direct results of policy changes and economic growth of urban populations.



Fig. 2: Location map of the study area

This study is concerned primarily with urban land use change detection and urban growth, therefore the models of urban growth developed by Burgess [11], modified by Homer Hoyt [12] and Harris and Ullman [13] are relevant in this study.

Concept of urban land use: The theories of urban land use have been subjects of a number of criticism, amplification and modification since the 1920s. It is a crude attempt to compartmentalize urban systems into structure that we can easily understand and explain. Though the proponents and many authors that had worked on these theories recognized the fact that every city has unique experience and history and thus it is difficult to box into a unified theory or concept the changed process and pattern of any urban area. It is however undeniable that theorizing and modeling urban land use greatly help in simplifying complex urban systems for easy understanding, interpretation, comprehension and therefore management. The three best known of urban land use structure theories are the concentric zone theory, the sector theory and the multi nuclei theory.

Concentric zones model: Burgess [11] developed the concentric zone theory, which states that cities tend to expand radially from the centre to form a series of concentric zones. The expansion comes about as a result of centripetal forces from an original core and as the growth occurs, each inner zone tends to extend its area by invading the next outer zone following a sequence know as invasion - succession. The rate of this process depends on the rate of the city's economic growth and on population expansion. In his study of American cities, Burgess postulates that urban land use development and pattern are represented in 5 concentric zones and a sixth lying beyond the immediate confine of the urban area [14].

- C The central business district (CBD), which is the focus of commercial social, civil life and of transportation.
- C The fringe of the CBD which is an area of wholesale, truck and rail road depot.
- C The zone of transition characterized by property in poor condition and run-down area being invaded by business and light manufacturing.
- C A worker' housing and factory zone with residence and plants in close proximity
- C A high class residential zone.
- C A commuter zone of residential suburbs and satellites commercial and shopping areas within accessible time distance.

Though, this theory was based on certain assumptions such as; cultural and social homogeneity, economy based on commerce and industry, private ownership of property and economic competition for space, easy rapid and cheap transportation in every direction the city centre is the main centre for employment. It provides a simplistic view and serve pedagogical purposes with regards to dynamics or urban growth. Hoyt [12], when he developed the sector theory amplified the limitation of these theories.

Sector theory: Homer Hoyt [12] developed radial sector theory; he concentrated on aerial pattern of shifts in residential location. He argued that the different income groups or classes in a city tend to live in district areas describable in terms of sectors of a circle around a city centre. Hoyt argued that the location and extension of high quality zones tend to proceed along the fastest existing transportation lines and either toward another existing nucleus of building of trading centres or toward the section of the city with open country. The competition for the centre increases rent thereby making it affordable only to the business outfits and the growth along any particular transport route consists of land use of similar characteristics.

However, in the Nigerian context and particularly against the contention that the business outfits always occupy the centre, there are certain factors that often influence the concentration of certain economic class or land uses in a given place [6, 15-17]. Which include social, economic, ethnic and fear of crime. Mabogunje further contested that Nigerian urban centres are rather multi- centric rather than monocentric.

Multiple nuclei: Harris and Ullman [13] contended that cities often develop around several distinct nuclei rather than one centre of origin. These other centres may be district centre established in an earlier urbanization phase and which persist as centres as city growth fills in the space between them. According to the theory, the emergence of separate nuclei reveals four main factors, which include;

- C Interdependence of some types of activity that have to be close to each other because of dependence on specialized needs.
- C The tendency or complimentary activities to agglomerate such as retail shops and office buildings.
- C The locational antagonism between dissimilar activities such as heavy industry and high-class residential development.
- C High rent and high land costs may attract or repel certain kinds of land use.

The number of nuclei and their functions will vary from city to city. Generally, the larger the city, the more nuclei it will contain. The major flaw of this theory is the clarification of the characteristic of the nuclei. This integrates the hierarchical core periphery model to the pattern of urban structures. There are traditional centres, modern centres, commercial centres, political/administrative centres, industrial centres and business centres. These also have ranges of goods and services from their distinct hubs. The concern of these papers is the analysis of the change process and projections of future changes in urban land use. In Nigeria. All cities apart from Abuja are organic in their origin and developed over a long period of time as build- on for existing pre-colonial urban centres [18].

Empirical evidence in most cities of the world has confirmed that none of the theories of urban structure can singly serve as a tool in understanding contemporary urban land use development and structure. Each city has unique history, structure and processes of changed pattern. The theories nonetheless provide us with the useful starting point in the search for the understanding of urban land use in developing countries [19].

Satellite remote sensing in urban growth modelling: The most commonly used approach to qualify land use changes has been the acquisition of aerial photographs, visual interpretation and the comparison with existing photographs and land use map data. Adeniyi and Bullock [20], Areola [21] and Fabiyi [15] among others have used aerial photographs and other remote sensing products to explain and map the spatial relationship between different land uses in urban areas.

Generally remote sensing image (platforms) do not record activity or the way land is being used (i.e., forest, agricultural, residential or industrial) directly but acquires response based on characteristics of land surface. Weng [22] states that satellite remote sensing is effective in providing multitemporal and multispectral data along with the required information for understanding and monitoring land development patterns and processes for building land use and land cover datasets.

A number of researchers had used multispectral remote sensing to evaluate land use land cover changes at the micro scales including Bradon & Bottomley [23] and Mass [24]. All these works examined changes in land use pattern over a given period. It is often not sufficient to analyse the changed process in Land use land cover but the also to understand the forces at play in the changed process.

Rao [25] moved close to this when he used Indian remote sensing to examine the changed pattern and used auxiliary data to project the land area of Tuni region into the year 2000. The approach was validated by two other methods including Causal modelling, cross-classification model and rating methods.

Rao [25] observes that human needs transform the land to different activities and that the quantifiable information of these dominant activities are necessary to develop future planning. Urban changes can be modelled through the observation of the past and projection to the future. Rao used a causal modelling approach where the causative factors were modelled to estimate the future changes in land use.

In his work Rao used correlation analysis to examine three factors that are judged responsible for urban land use change and used other methods causal modeling techniques, cross-classification and rating methods to validate the results of spatial analysis.

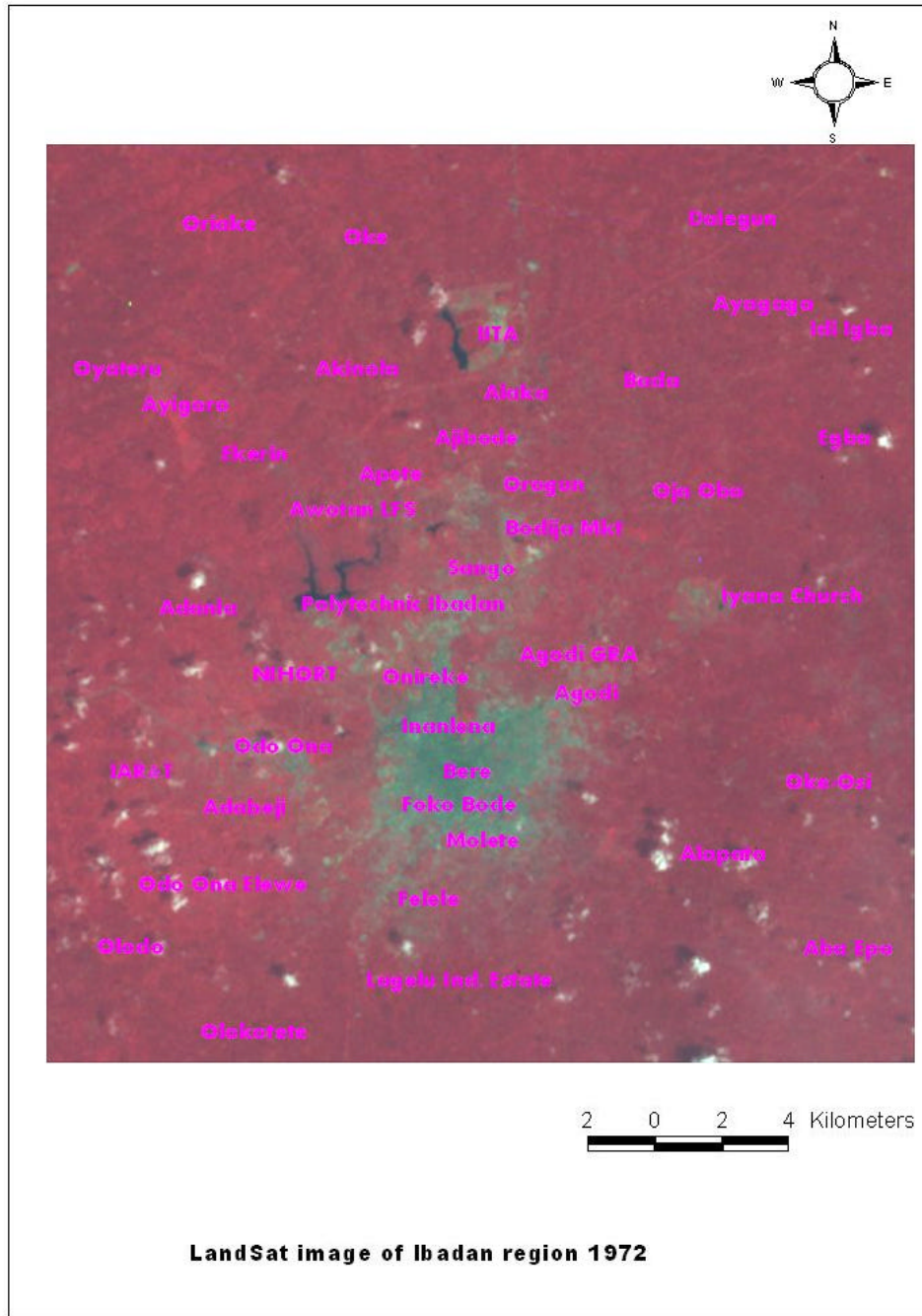


Fig. 3a
Fig. 3a-c: Satellite images of the study areas

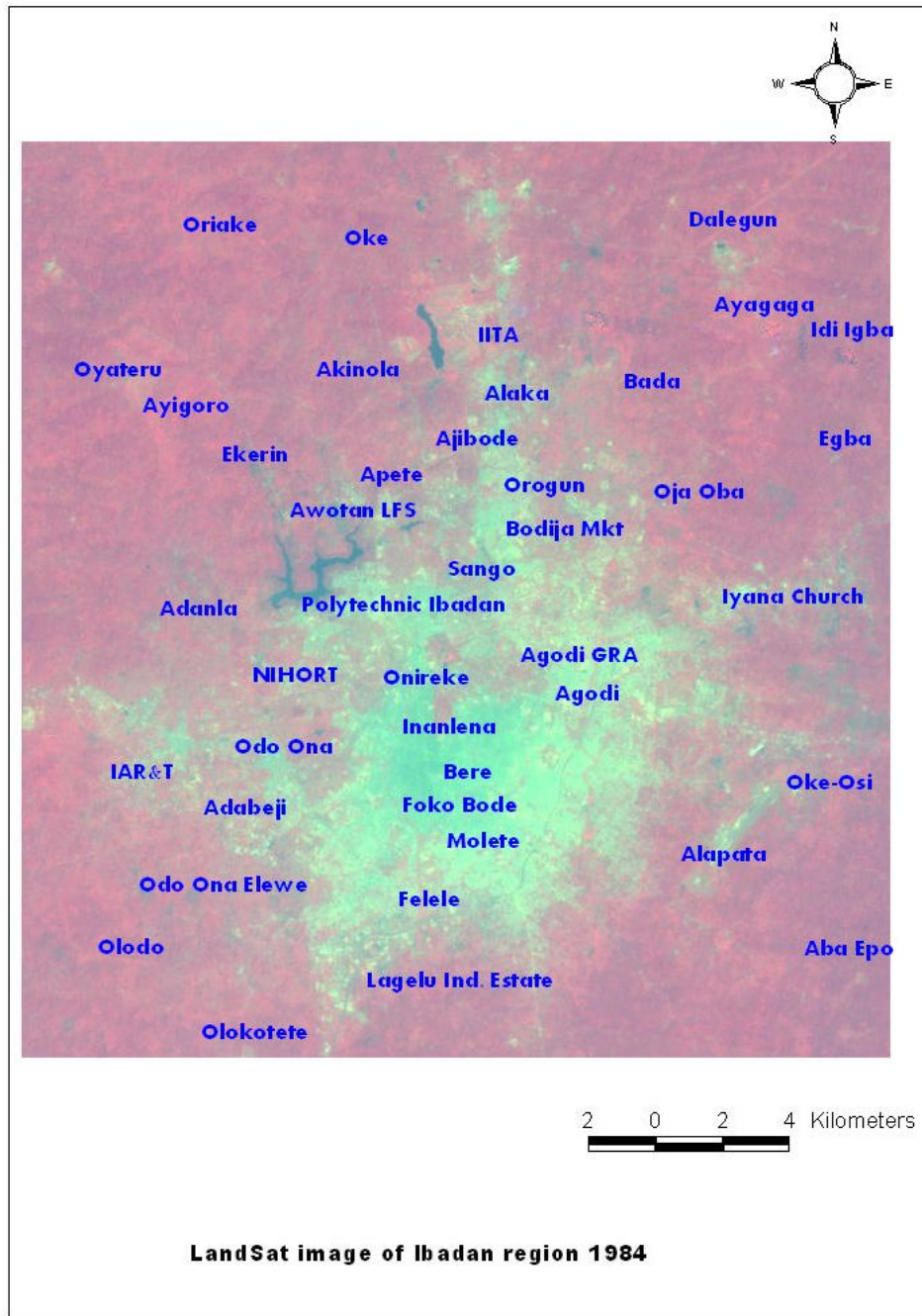


Fig. 3b
Fig. 3a-c: Satellite images of the study areas

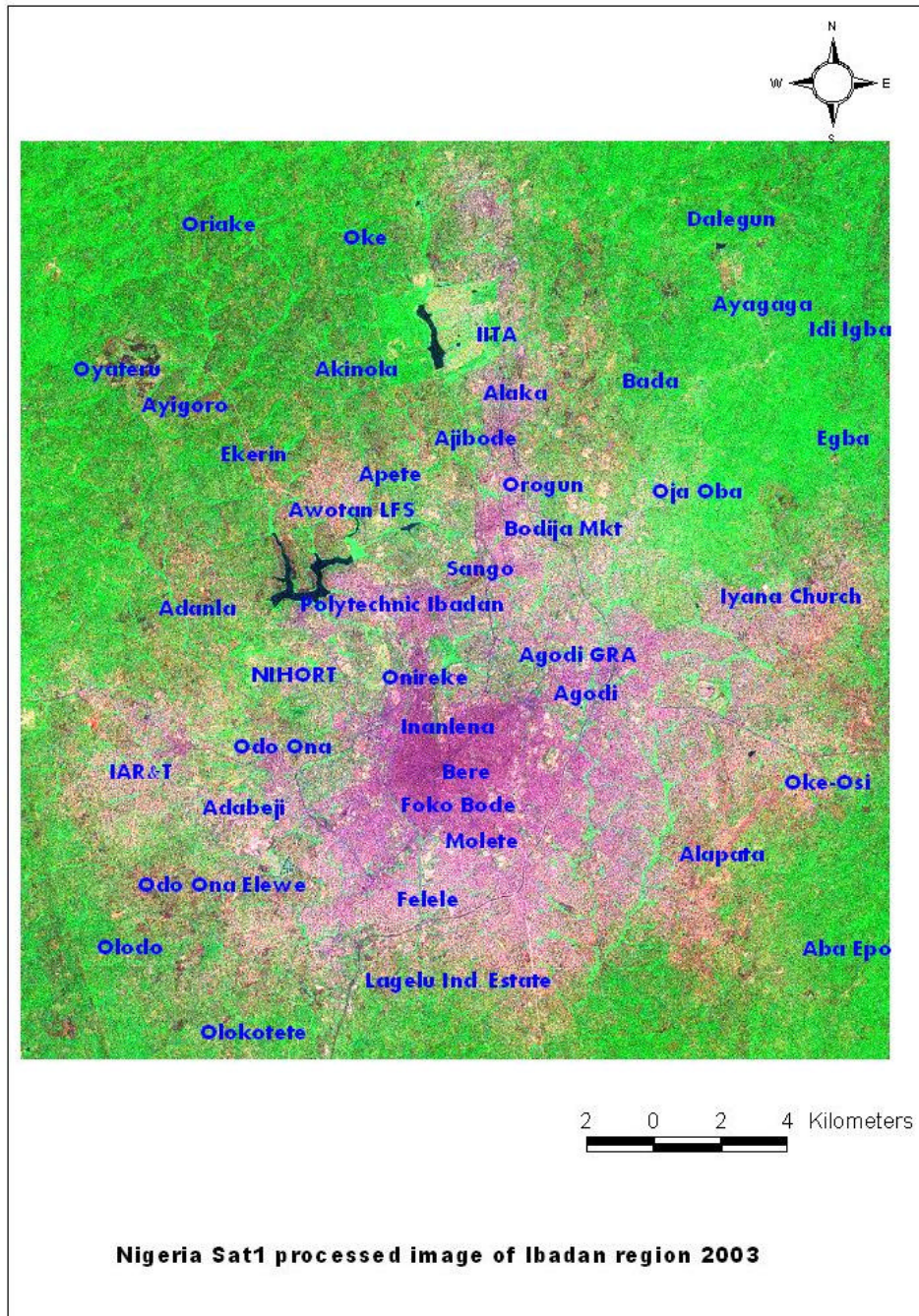


Fig. 3c
Fig. 3a-c: Satellite images of the study areas

Change process and change agent in urban Land use and land cover: Briassoulis [26] review of literature enables her to infer that landcover conversion involves a change from one cover type to another while land cover modification involves alterations of the structure or function without a wholesale change from one type to another. Similarly Turner *et al.* [26] also note that landuse change is likely to cause landcover change, but land cover may change even if the land use remains unaltered".

Nigeria has complex land systems where chiefs, families, individuals and government own land. Traditional land tenure throughout Nigeria was based on customary laws under which land was considered community property, but the customary law did little or nothing to avert crisis emanating from the use and distribution of the land. In response to a potential crisis in land distribution, the Federal Military Government promulgated the Land Use Decree of March 1978, thus establishing a uniform tenure system for all of Nigeria with a view to opening the land to development by individuals, corporations, institutions and governments. The decree gave state and local governments' authority to take over and assign any undeveloped land. Though this decree has been operational for the past two decades and half land is still mainly in the hands of individuals and families in most cities.

The change process in Nigeria is heavily dependent on the land holdings and the socio economic capacities of urban residents. The study seeks to provide explanation to change process in Ibadan metropolis.

METHODOLOGY

Data sources: Three types of data were used in the course of this study, which are Satellite images: Landsat images of the 1972, 1984 and Nigerian Sate 1 2003 were used for the land use classification for the time period. The study area was extracted from these satellite images and were separately Ortho-rectified into common geographic coordinate base. The geographic properties of the images were further refined to merge with the topographic maps of the study area (Fig. 3a -c).

Image analysis: The land Sat satellite data of 1972, 1984 and Nigerian SAT1 2003 were obtained as base data for analysis. The images were classified using supervised classification techniques. After the initial image processing and rectification, the images were enhanced in order to enable visual interpretation and better comprehend the tonal presentations, the nature, types and characteristics of the land use discernable from the images. Land use classification scheme was developed by careful modification of the Handerson classification scheme with particular reference to the peculiar characteristics of the study area. Ibadan metropolis is typical traditional settlements without central plan, thus it comprises of core traditional settlement mostly occupied by the indigenous population and represents the traditional centres of the city. According to Mabogunje [6] Ibadan has two centres, which are the traditional centre and commercial centres. Today Ibadan is multi centric cosmopolitan comprising of educational centre, commercial centre, new commercial hub, administrative centre and traditional core. Different ethnic and social enclaves also characterize it [17, 18].

The refined land use classification scheme was used as the input in the selection of the training sites that were used in the supervised classification. Using Erdas Imagine. With the aid of head on digitizing the classified image were vectorised and the map for each year period was captured.

The classification scheme developed has the following urban land use types

- | | |
|--------------------------|----------------------------------|
| C Urban core areas | C Medium density sprawl |
| C High density urban | C Low density sprawl |
| C Medium density urban | C Scattered sprawl |
| C Low density urban | C Vegetal cover |
| C Peri-urban development | C Rock outcrop |
| C High density sprawl | C Lake, reservoir and water body |

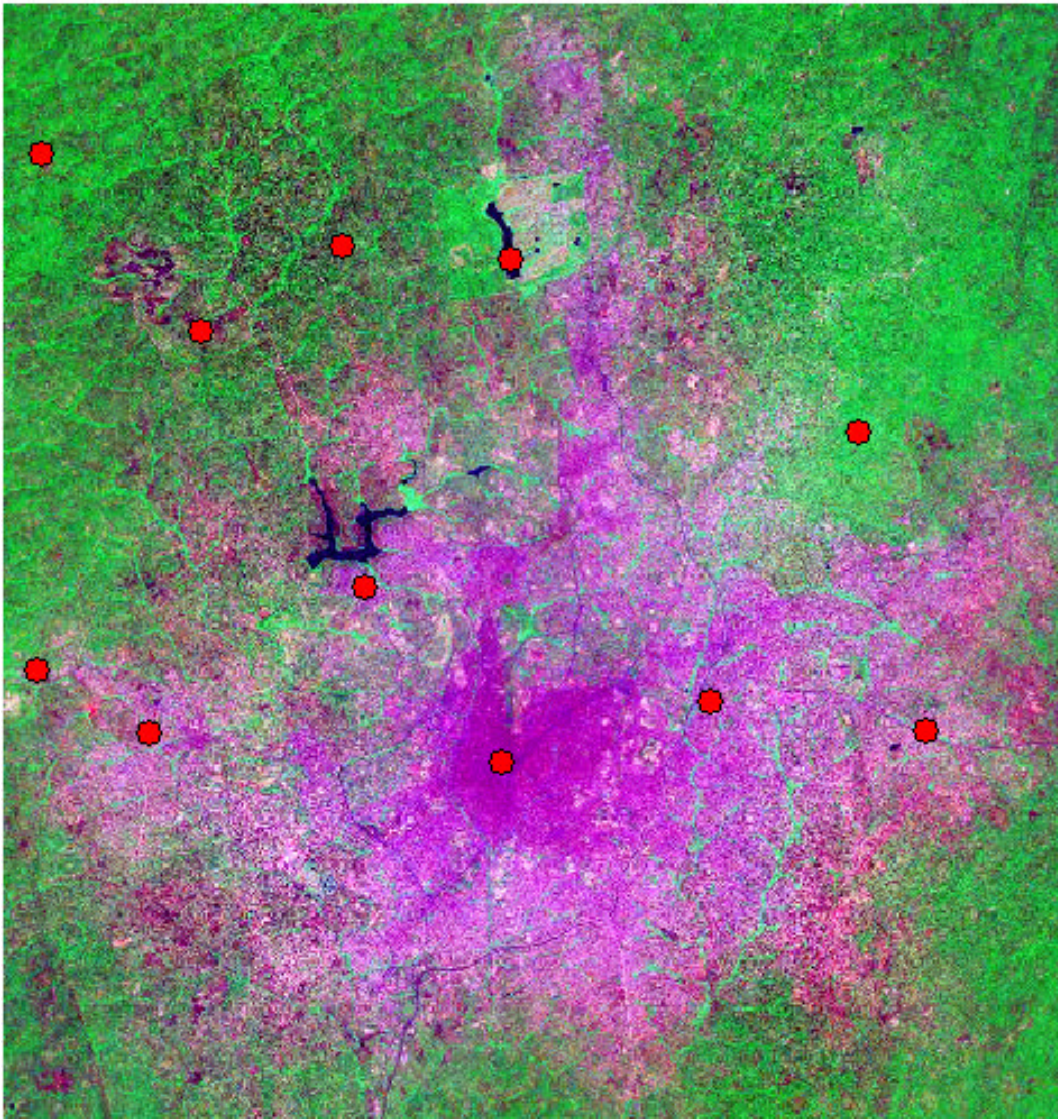


Fig. 4: Location of the training sites in Ibadan region

The twelve urban land use types were utilised to classify the three data sets into classes using the same templates. Each of these land use class type has a training site except the water body. Figure 4 shows the location of the training sites in Ibadan metropolis.

Using the changed statistics methods - image differencing, the images were compared in the two epochs (1972-1984 and 1984-2003) in IDRISI GIS software environment. The changes in each epoch were computed in the ArviewGIS environment using raster-vector conversion and computing total area of change in Kilometers Square. The approach is meant to compute the changed areas in real values and not as grid cells.

Future projection of land use change: We utilize the changes between 1984 and 2003 to project into 2023 in a marcov change detection method. The result were discussed and related to the findings of the correlation analysis.

URBAN LAND USE CONDITIONS IN IBADAN REGION

Ibadan land use land covers in 1972: In 1972 Nigeria was just emerging from the 4-year civil war (1966-1970) shortly after the collapse of colonial rule. Most cities including Ibadan were rather small but actively attracting rural migrants who want to benefit from the benefit of independence and the economic growth of cities that emerged as regional capitals with the active local and national politics. Table 2 shows the area covered by different land use classes in Ibadan region during the year 1972.

The Table shows that vegetation was the dominant land use land cover class in 1972, taking about 92 percent of the total area. This is followed by peri urban development, which covers an area of about 22.635 km² about 3.25% of the study area. Urban core, which represents the traditional parts and the pre-colonial parts of the city covered about 29.70 km² about 2.98%. Urban core is high-density areas and are not large space users. Though the area it covered is very small compare with other land use types yet it contain large number of multi-tenanted housing and accommodate very high population in the seventies. The peri-rban developments that came at this period are principally residential zones. The oil boom of the seventies place a lot of money in the hands of private individuals thus there a number of private development in the city (Fig. 3a-c).

Ibadan land use land covers in 1984: During the 1984 period, the vegetal cover has reduced substantially giving way to urban development, the total vegetal cover/open space left in the study area as at march 1984 is 436.564 as opposed to 642.300 km² in 1972. It covered about 63.12% of the total study area in 1984. In a period of twelve years a total of 205.73 km² of vegetal cover has disappeared for urban development. It shows an annual decrease of 17.14 km². Urban development has increased to an estimated amount of 34.9% of the entire region. Table 1 shows the differences in land use land cover in the region in the three observing periods

Table 1: Land use land cover in the three observation years (1972, 1984 and 2003)

Lulc Ibadan, 1972	Area in km ²	%	Lulc Ibadan, 1984	Area in km ² sq	%	Lulc Ibadan, 2003	Area in kmsq	%
Lake/water body	3.00	0.43	High density sprawl	0.94	0.14	High density sprawl	0.224	0.03
Low density urban	4.327	0.62	High density urban	11.424	1.65	High density urban	64.175	9.26
Peri-urban development	25.43	3.66	Lake/water Body	2.318	0.34	Lake/water Body	1.994	0.29
Urban Core	20.702	2.98	Low Density Sprawl	6.043	0.87	Low Density Urban	115.052	16.61
Vegetation/open Space	642.300	92.32	Low Density Urban	82.479	11.92	Medium Density Sprawl	1.166	0.17
Total	695.767	100.00	Medium Density Sprawl	23.581	3.41	Medium Density Urban	98.388	14.20
			Medium Density Urban	21.471	3.10	Peri-urban Development	41.152	5.94
			Peri-urban Development	20.347	2.94	Rock Outcrop	8.577	1.24
			Rock Outcrop	10.894	1.57	Scattered Sprawl	69.750	10.07
			Scattered Sprawl	45.369	6.56	Urban Core	22.634	3.27
			Urban Core	30.256	4.37	Vegetation/open Space	269.736	38.93
			Vegetation/open Space	436.564	63.12	Total	692.848	100.00
			Total	691.686	100.00			

Source: Author analysis of 1972 LandSat TM 1984 Landsat TM and 2003 Nigerian Sat1

Table 2: Total areas of Land use land cover change in Ibadan between 1972 and 1984 in Kilometres Square

Land use	UC	HDU	MDU	LDU	HDS	PUD	MDS	LDS	SSP	VGO	LWB	ROC
UC	19.316	0	0	0	0	5.68	0	0	0	3.84	0	0
HDU	1.37	0	0	0.28	0	1.26	0	0	0	9.35	0	0
MDU	0.05	0	0	1.95	0	2.99	0	0	0	17.85	0	0
LDU	0	0	0	2.01	0	12.82	0	0	0	65.99	0.87	0
HDS	0	0	0	0	0	0	0	0	0	0.91	0	0
PUD	0.01	0	0	0.06	0	0.29	0	0	0	19.93	0	0
MDS	0	0	0	0	0	1.98	0	0	0	21.59	0	0
LDS	0	0	0	0	0	0	0	0	0	6.043	0	0
SSP	0	0	0	0	0	0	0	0	0	44.82	0.64	0
VGO	0	0	0	0.01	0	0.40	0	0	0	433.56	0	0
LWB	0	0	0	0	0	0	0	0	0	0.74	1.464	0
ROC	0	0	0	0	0	0	0	0	0	10.872	0	0

Source: Author analysis of 1972 LandSat TM 1984 Landsat TM and 2003 Nigerian Sat1

Ibadan land use land covers in 2003: In the year 2003 there was virtually no low-density sprawl in the metropolis most of the low-density sprawls have been developed as medium density or high density. The growth of Ibadan metropolis reflects a situation of planlessness and ill structured growth. Figure 5a-c show the land use/land cover of the study area during the three observing years. Though vegetation and open space was still the largest space user in the city yet it has reduced to about 38.9% of the total land area from 63.12% in 1984. This show high evidence of sprawl development in the city taking up the available vegetal cover at the periphery. More than 826 km² of the vegetal covers were used up for urban development over a period of twelve years. A major growth contributor to urban developmental growth is the scattered sprawl that grew from 45.37 km² to 69.736 km² in 2003. High density urban also grew from 11 kilometres to 64 kilometres. Other has marginal increase. The low density urban however reduced from 115 to 16 km². The consideration for density classification was average number of building per unit area thus some areas classified as low density were build up in the 2003 periods. Apart from the Government lay out and institutional; areas most low-density residential areas have been built up. It is also noteworthy that the old air port which was classified in 1984 as low density areas and open spaces have been subdivided into commercial units thus wearing a medium density outlook in terms of building per unit area.

Change analysis: The period of change analysis was divided into two epochs based on the data available; the first epoch covers a period of sixteen years (1972-1984) while the second epoch covers a period of twelve years 1984 to 2003. Through image analysis and change detection analysis in IDRIS GIS, using image differencing the changes were measured and converted to vector GIS data for precise area measurements. The results of the changes in the tow epoch are presented in Table 2 and 3 and discussed in this section.

Table 2 shows that land use types that underwent significant changes during this epoch are low density urban that changed to high density by 0.28kmsqs, to medium density urban by 1.95 km² and peripheral urban development by 0.06 km², all other land uses took space from vegetation and open space for instance high density urban took 9.35 km², from the vegetal cover. Medium density, 17.85 km², low density urban; 65.99, low-density sprawl 6.043, medium density sprawl 21.59 km². The analysis shows that lateral growth was then norm in the epoch. Most development took place at the periphery as sprawl of different types. The vegetal cover is the highest recipient of the effect of urban growths. It is also noticed that the low density urban was also changing in densities to higher density per unit area.

Table 3 further confirms the earlier observations of the changes occurring in the land use classes between 1984 and 2003. Though lateral growth at the peripheral areas was pronounced in the first epoch (1972-1984). Different form of growth types growth by fission and growth by expansion could be noticed in all types of land use s in the second epoch (1984-2003). It is significant to note that the scattered sprawl in the 1984 changed to high-density urban over 6.7 km². It was observed that high density urban could be found even at the periphery in 2003. The sprawl developments that were

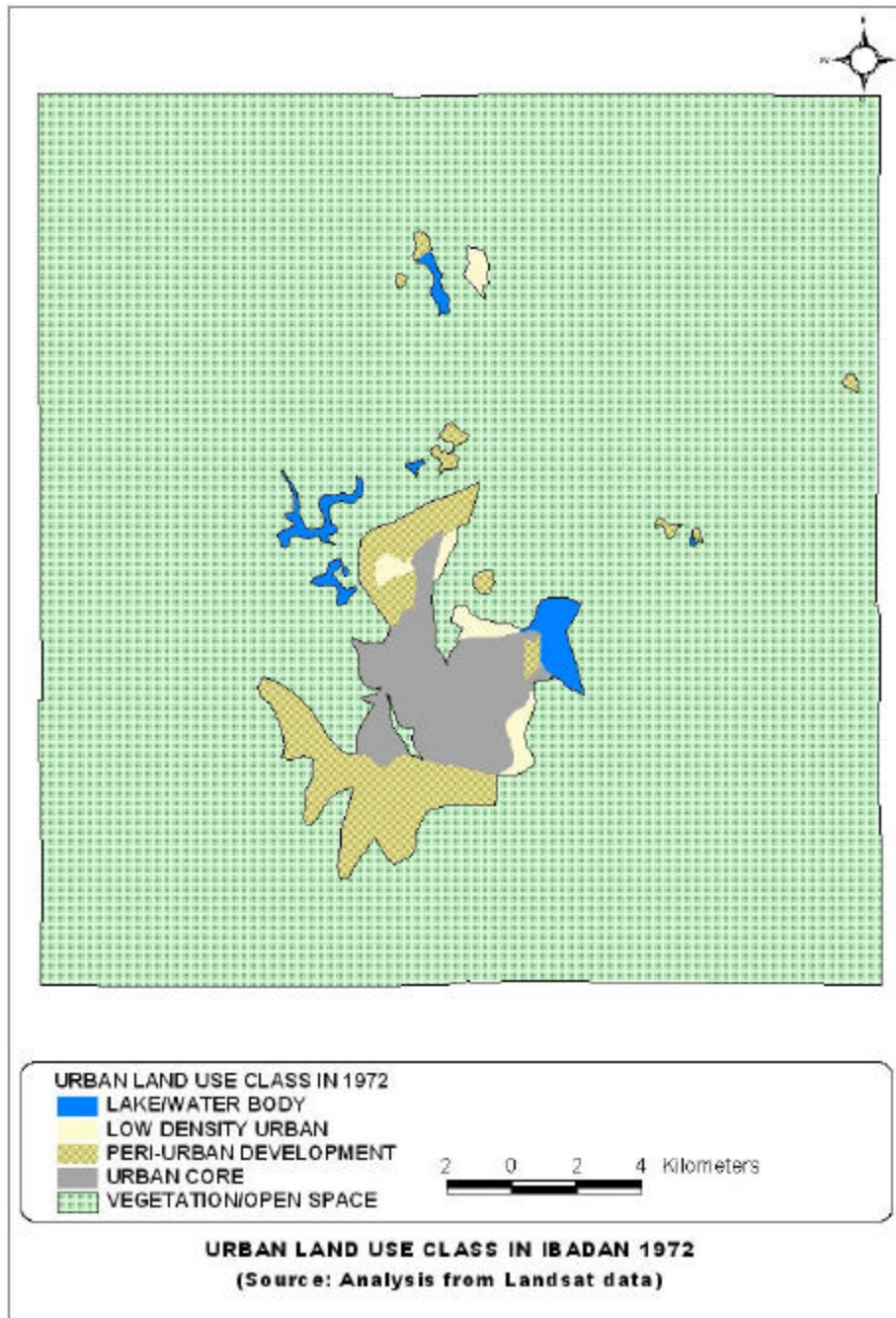


Fig. 5a

Fig. 5a-c: Urban land use classes in Ibadan region 1972, 1984 and 2003

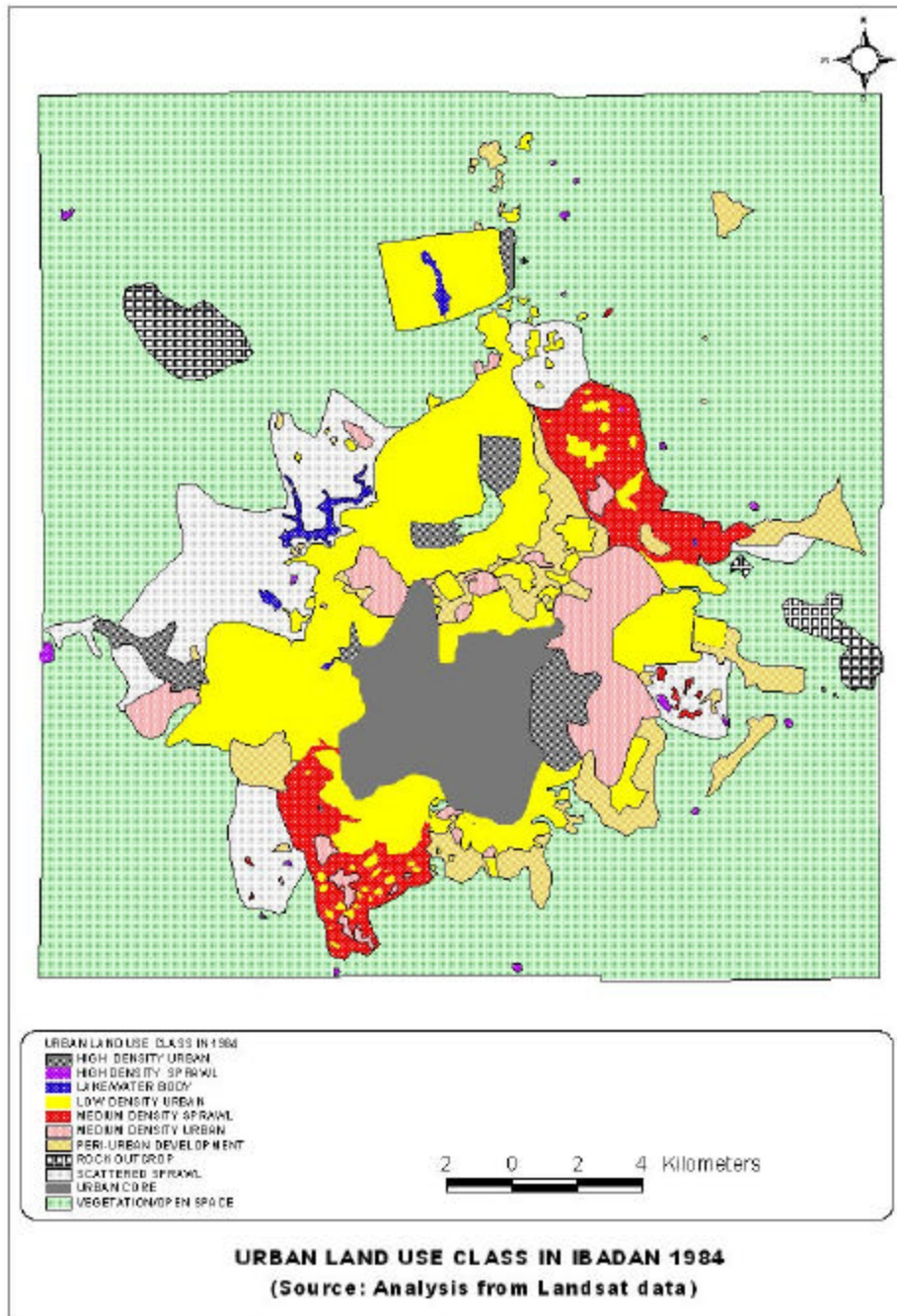


Fig. 5b

Fig. 5a-c: Urban land use classes in Ibadan region 1972, 1984 and 2003

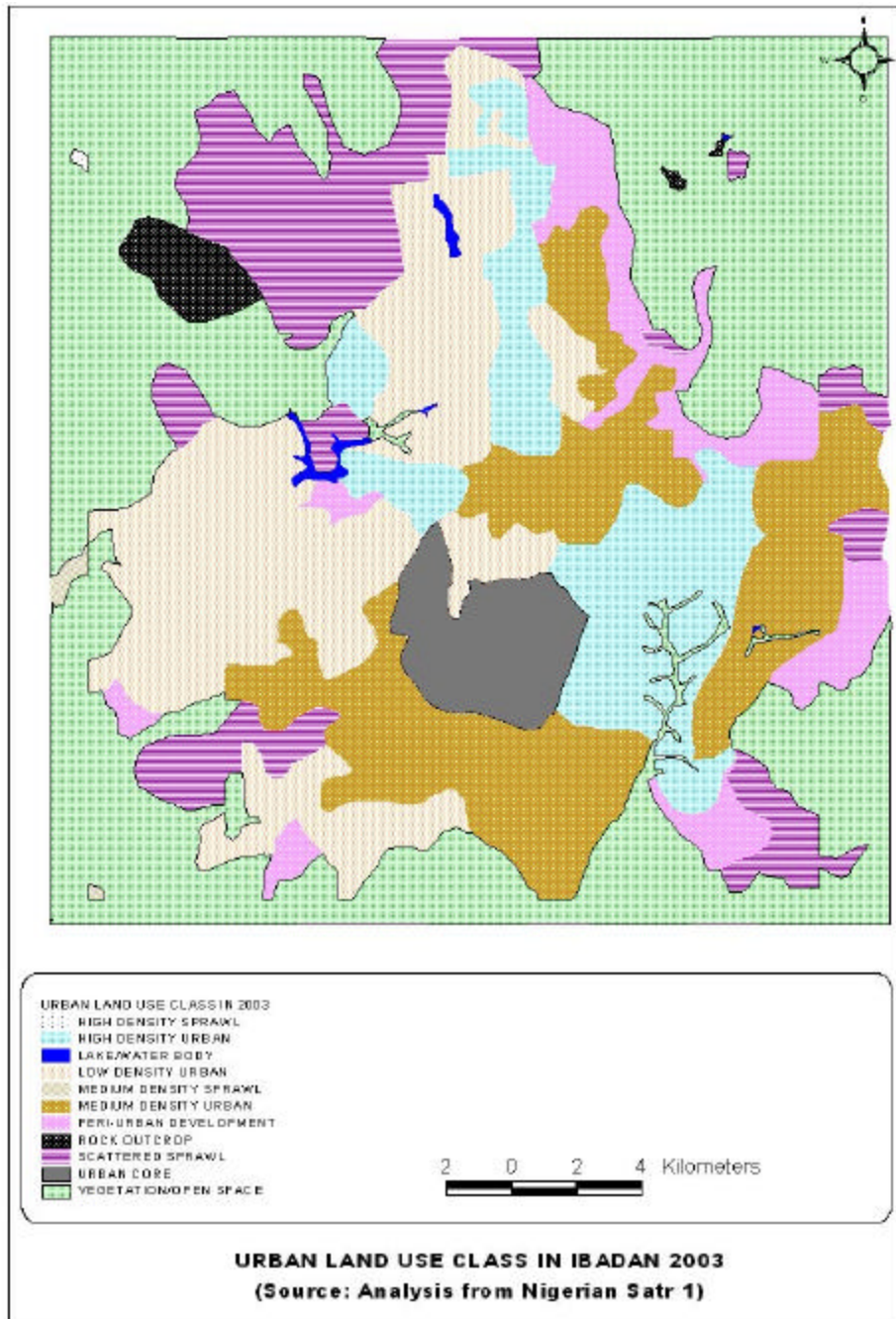


Fig. 5c

Fig. 5a-c: Urban land use classes in Ibadan region 1972, 1984 and 2003

Table 3: Total changed areas of land use land cover in Ibadan between 1984-2003 in square kilometers

Land use	UC	HDU	MDU	LDU	HDS	PUD	MDS	LDS	SSP	VGO	LWB	ROC
UC	30.25	2.87	0.02	0.08	0	0.00	0	0.0	0	0	0	0
HDU	0	8.47	13.73	18.50	0.07	3.39	2.26	0	6.78	14.53	0	0
MDU	0	0.09	8.94	22.21	0.13	12.07	9.17	5.18	4.633	31.50	0	0
LDU	0	0	0	39.52	0.06	2.86	8.42	0	25.78	28.61	0.47	0
HDS	0	0	0	0	0.08	0	0	0	0	0	0	0
PUD	0	0	0	1.34	0.96	1.97	2.20	0	0.81	34.123	0	3.79
MDS	0	0	0	0	0.21	0	0	0	0	0.58	0	0
LDS	0	0	0	0	0	0	0	0.15	0	0	0	0
SSP	0	0	0	0.13	0	0	0	0	7.36	63.26	0	0
VGO	0	0	0	0.59	0	0	0	0	0	258.32	0.22	0
LWB	0	0	0	0	0	0	0	0	0	0.02	1.63	0
ROC	0	0	0	0	0	0	0	0	0	1.74		7.10

Source: Author analysis of 1972 LandSat TM 1984 Landsat TM and 2003 Nigerian Sat1

Table 4: weighting of land use density potential for change

Land use class	Weight	Land use	Weight
Commercial	3	Low density	4
Agricultural	5	Medium density	3
Airport	2	Open space	5
High density	2	Rural use/vegetation	5
Hospital	1	Secretariat/Institutional	1
Industrial area	2	Lake, reservoir and water body	0

Table 5: Density types and the rate of change between 1972 and 1984

Spearman's rho	Rate of change correlation coefficient significant at (2-tailed)	Rate of change	Density weighting
		1.000	.491**
	N	78.000	78.000
	Density weighting	.491**	1.000
	N	78.000	78.000

** Correlation is significant at the 0.01 level (2 tailed)

low density in the first epoch are increasingly built upon to high-density urban and medium density urban. Medium density areas are changing to high-density areas (13.73 km²), while vegetal different urban land use types continuously used up covers.

Generally however the land use types that are subject of major changes are vegetal covers and sprawl development. During this epoch there were no more changes in the core areas and the transition zones of the city but large changes occur at the peripheral development. The features of the urban cores and high density urban prominently featured at the periphery. Most low density planned settlement around Bodija, Agodi, Iyaganku still retain some form of low density, but all the earlier unplanned low-density areas around the Ashi, Iwo road, Bashorn, Sanyo are all changing to medium density urban and even high density urban. It reflects urban development in the atmosphere of legal void or inappropriate development control measures. The roads in the sprawl are windy narrow and poorly managed. The building at the periphery are not different from the types found in the core areas apart from the age of buildings most sprawl development in Ibadan are similitude of the building types in the tradition core and the transition zones. The changed detection through image difference between 1984 and 2003 is shown in Fig. 6.

Change map between 1984- 2003

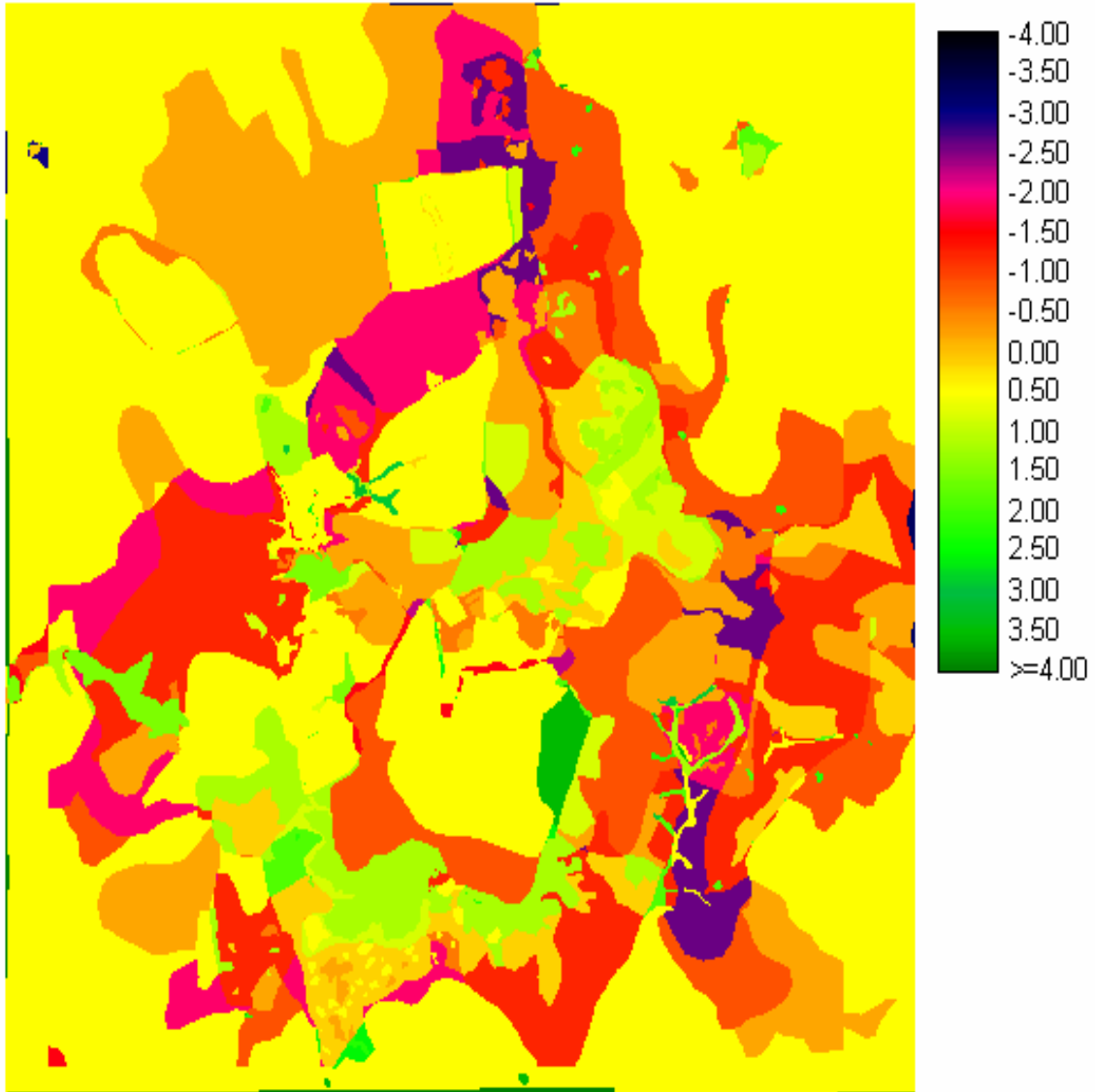


Fig. 6: Image difference between 1984 and 2003

Table 6: Markov Chain Change Projection of Urban Land Use In Ibadan 2003 to 2023

Land use class	High density sprawl	High density urban	Lake/water body	Low density urban	Medium density sprawl	Medium density urban	Peri-urban development	Rock outcrop	Scattered sprawl	Urban core	Vegetation/Open space
High density sprawl	0.1024	0.0000	0.0000	0.0913	0.2344	0.923	0.1997	0.0000	0.0000	0.1828	0.0971
High density urban	0.0000	0.0740	0.0000	0.1539	0.0000	0.4624	0.0454	0.0014	0.0841	0.0286	0.1512
Lake/ water body	0.0000	0.0042	0.6512	0.2146	0.0000	0.0174	0.0115	0.0000	0.0269	0.0000	0.0741
Low density urban	0.0066	0.3464	0.0018	0.4111	0.0179	0.1935	0.0226	0.0000	0.0000	0.0000	0.0000
Medium density sprawl	0.0000	0.3742	0.0007	0.3461	0.0000	0.2554	0.0000	0.0001	0.0207	0.0028	0.0000
Medium density urban	0.1019	0.1253	0.0000	0.1364	0.2740	0.0169	0.2334	0.0000	0.0000	0.0000	0.1121
Peri-urban development	0.0000	0.6520	0.0016	0.2521	0.0000	0.0785	0.0000	0.0004	0.099	0.0054	0.0000
Rock outcrop	0.0000	0.0144	0.0001	0.0000	0.0000	0.2496	0.1255	0.5859	0.0234	0.0010	0.0000
Scattered sprawl	0.0057	0.1391	0.0065	0.4803	0.0168	0.2151	0.0339	0.0001	0.0257	0.0000	0.0770
Urban core	0.0000	0.1343	0.0000	0.0551	0.0000	0.2025	0.0000	0.0001	0.0042	0.6038	0.0000
Vegetation/open space	0.0057	0.0267	0.0002	0.1106	0.0000	0.1120	0.0571	0.0047	0.1456	0.0003	0.5428

Figure 6 shows that the major are of change could be found in the transition zones and the peripheral developments. Some institutional areas such as University of Ibadan, IITA record the lowest land use change during this epoch. The core areas and Planned Urban development are also low (the yellow areas).

The changes over the time period were correlated with the density types in each ward as obtained from the Rating ward. The density types were assigned weighing values base on potential for change or potential for growths. The low density areas in 1984, the peripheral development area, Peri-urban development and the vegetal cover are assigned the highest value of change potential for urban growth, thus a value of 5 was assigned to these categories of land use in 1984, Medium density urban, Medium density sprawl were assigned a value of 4 and high density has 2 while Urban core has land institutions and forest area has 1 secretariat and administrative areas were assigned 2. The Table 5 shows the potential weighting for change.

The weightings were based on the assumed potential for urban growth in these areas. Ibadan growth has no practical institutional control, therefore the propensity that growth will occur is the available developable land within a particular use types. The high density area were assigned a weight of 2 since there are no space for expansion except growth by fission as identified by Mabogunje [6], Agbola [9] and Fabiyi [17]. The secretariat complex and other institutional zones we reassigned the least weight (1) because the potential for sprawl development is rare due to institutional control of land use in these areas. The land use map produced by the Oyo state land and housing department in 1992 was used to spatially assign weight to regions as shown in Fig. 1.

Correlates of urban land use change: The correlation analysis indicates that initial density types weighting has correlation with the resulting land se types. A correlation value of 0.49 significant at 0.01 2-tailed test was obtained as shown in Table 4. It shows there is a significant relationship between the weighting of the initial land use types and the potential future land use change pattern. The low density and vegetation land use types has high potential of accommodation urban growth and changes. While growth by fission is low the medium density also has the potential for growth and thus becoming high density. The movement of urban population across space relates to economic changes or household changes. There are generational shift in the housing types and ownerships in Ibadan in both planned and unplanned sections of the city. For instance Old bodija, Agodi GRA and Iyagaku GRA all in low-density areas accommodated the rich, class of late fifties and the sixties, while Mokola layout accommodated the middle class of the sixties and early seventies. Most of these low density regions house the aged, retirees and some that are moving down the ladder of urban economy while businesses are taking over some old residential apartment. Some of these residential areas are rebuilt into some form of medium density settlement. Thus, the potential for future urban dynamics of the low-density areas is markedly high. The peripheral development also grow with the influx of new generation meddle class migrating

from the inner city to build the low density suburb into the middle class residential precinct of even poor residential precinct.

The land ownership in Ibadan is chaotic, a combination of individual ownership, family ownerships, communal ownerships and government ownerships, in practical terms there is a thin line between these types of land ownerships. Though the existing land use decree of 1978 vested all urban land into the custodian of the state governors, in reality private ownerships and transference are still the norms. This has significant negative effect on housing developments and urban growth.

Projected change analysis: The study further attempted a projection of the changed process into the next twenty years from the terminal year of the analysis (2003), using Markov chain module in IDRISI GIS software. The Markov chain detection shows the probability of change of land use class for one type to another. The MARKOV module in IDRISI GIS analyses a pair of land cover images and outputs a transition probability matrix, a transition areas matrix and a set of conditional probability images. The transition probability matrix is a text file that records the probability that each land cover category will change to every other category (Table 6). The transition areas matrix is a text file that records the number of pixels that are expected to change from each land cover type to each other land cover type over the twenty (20) year period considered. The rows represent the older land cover categories and the columns represent the newer categories. The table 6 shows that the high projected probabilities of change are high density sprawl changing to medium density urban (0.92), Peri-urban development changing to high density urban (0.65), the scattered sprawl also has high probability of changing to low density urban (0.48). The projected spatial changes are shown in Fig. 6. It clearly shows that the area that had least potential of change is the water body while the active land use types is the high-density sprawl.

DISCUSSION

Undoubtedly, the results of the spatial operations and analysis reveal the spatial dynamics of the urban land uses in Ibadan metropolis. The socio economic changes in Nigerian cities are translated into block and mortar in form of physical developments. The major dynamics of urban land use changes was observed in the first epoch between 1972 and 1984. That was the period when the economic development of Nigeria was in its highest peak, before the down turn in the mid eighties. The sprawl developments that featured prominently in the second epoch are in form of shanties and ramshackle buildings. The development at the peripheries are not significantly different from the types of housing in the core areas and the transition zones. It is a marked reflection of low economic growth and the high involvement of the informal sector in housing supply during this epoch. The contribution of the state and corporate private sector in housing provision during the second epoch (1984-2003) is very negligible only limited to the institutional areas and secretariat. Majority of the housing stock in the city are supplied by the middle-income homeowners. All available open spaces in the city and the peripheral areas were built upon, consequently areas classified as low-density areas gradually become high-density areas in the second epoch. The growth dynamics also reflect the absence of state control of the use of land and building activities socially in the pattern of urban development. Consequently, slum-like development could be found in all parts of the city [15]. From the foregoing, the change pattern and temporal process in Ibadan does not conform to the popular land use theories; it comprises of urban core, surrounded by the high, medium and low-density areas. The peripheral development unexpectedly houses the rich, the middle and the rich class sector of the society. The high-density sprawl, low-density sprawl and the medium-density sprawl house the poor, the middle class and the rich class, respectively.

It is also obvious that the city is growing at such an alarming rate using up all the green and other forms of soft landscape in the city. The city is also growing by succession and invasion where high density invades low density and medium density zones. There is need therefore to enact development control policies for sustainable development of the city and the region.

CONCLUSIONS

The monitoring of rapid urban growth as evidenced by changes in land use in this study is a major concern that has been frustrated by lack of up to date information on changes in urban land use. Such information is necessary to provide a basis for a more effective understanding and management of the urban environment. The approach adopted in this study clearly demonstrated the potential of GIS and remote sensing techniques in measuring change pattern of urban land use even in traditional unplanned settlements.

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