

# **Land Use Change Detection and Analysis Using Remotely Sensed Data in Lekki Peninsula Area of Lagos, Nigeria**

**James Bolarinwa OLALEYE, Oludayo Emmanuel ABIODUN and Queen IGBOKWE, Nigeria**

**Key Words:** Land Use, Change Detection, Remote Sensing, GIS

## **SUMMARY**

Land use is generating worldwide interest as changes in land use are at a rapid rate and it is estimated by the United Nation's Population Fund (1999) that by the year 2025, 80% of the world's population will live in cities. Most major metropolitan areas face the growing problems of Land development; residential and commercial development is replacing undeveloped land at an unprecedented rate.

Information on land in relation to how it is being used as well as changes in such land use has become a prime pre-requisite for the growth and development of any nation. Change detection involves the use of time series satellite imageries and orthophoto maps of the study area, from which Land use maps can be generated by visual interpretation or image processing.

The use of remotely sensed data (satellite and aerial) to detect changes in Land use as well as precise and accurate analysis using GIS is widely preferred over other conventional survey techniques because the method is very efficient for assessing the change or degrading trends of a region.

In this work, the changing pattern in Land use in Lekki Peninsula area of Lagos, Nigeria over the period of time spanning 39 years is examined using a topographical map of 1964 and a Quick Bird image of 2003. A Land use map of the study area was produced using ArcGIS 9.2, which was used for the digitization and analysis. Evolution in new classes of Land use was observed. Industrial, Commercial and recreational Land use class were among the new classes of Land use present in 2003 as compared to the predominantly educational Land use class obtainable in 1964. The study also revealed a phenomenal rise in the area extent of built up areas from 40.93 hectares in 1964 to 7271.19 hectares in 2003.

It is concluded that remote sensing and GIS tools provide an outstanding platform from which accurate information on Land use changes and patterns can be obtained and that Lekki Peninsula area of Lagos has experienced tremendous changes in land use in between 1964 and 2003, so, efforts should be made to regularly update available data in order to control further development.

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## **1. INTRODUCTION**

A modern nation, as a modern business, must have adequate information on many complex interrelated aspects of its activities in order to make decisions. Land use is only one such aspect, but knowledge about land use and land cover has become increasingly important as the Nation plans to overcome the problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, and loss of fish and wildlife habitat. Land use data are needed in the analysis of environmental processes and problems that must be understood if living conditions and standards are to be improved or maintained at current levels. One of the prime prerequisites for better use of land is information on existing land use patterns and changes in land use through time.

Land development results in a loss of natural vegetation and open spaces and a general decline in the spatial extent and connectivity of wetlands, wildlife habitat, and agricultural lands. While land use changes are a consequence of national growth, regional assessments of historical and contemporary land use change are needed to anticipate the impacts associated with change and contribute to an understanding of productive environmental sustainability.

These land use changes can be substantial but are difficult to grasp when they occur incrementally. Recently, data from satellites has dramatically illustrated the rates at which these human-induced changes are occurring. Temporal mapping from satellite data has successfully demonstrated the utility of integrating existing historic maps with remotely sensed data and related geographic information to dynamically map land characteristics for large metropolitan areas. These regional databases provide a strong visual portrayal of recognized growth patterns, and dramatically convey how the progress of modern development results in profound changes to the landscape.

Land is the stage on which all human activity is being conducted and the source of the materials needed for this conduct. Human use of land resources gives rise to "land use" which varies with the purposes it serves, whether they be food production, provision of shelter, recreation, extraction and processing of materials, and so on, as well as the bio-physical characteristics of land itself. Hence, land use is being shaped under the influence of two broad sets of forces – human needs and environmental features and processes. Neither one of these forces stays still; they are in a constant state of flux as change is the quintessence of life. Changes in the uses of land occurring at various spatial levels and within various time periods are the material expressions, among others, of environmental and human dynamics and of their interactions which are mediated by land. These changes have at times beneficial, at times detrimental impacts and effects, the latter being the chief causes of concern as they impinge

variously on human well-being and welfare. Land use change has a long history as there have been no instances in which people used land and its resources without causing any harm.

The magnitude of land use change varies with the time period being examined as well as with the geographical area. Moreover, assessments of these changes depend on the source, the definitions of land use types, the spatial groupings, and the data sets used.

In the last 300 years the impacts of land use change have increasingly assumed from significant to threatening proportions. What is most important, however, is that, with few exceptions, it is human and not nature's agency which brings about these changes and which is responsible for their magnitude and severity. Simply consider these major environmental problems: desertification, eutrophication, acidification, climate change, eustatic sea-level rise, greenhouse effect, biodiversity loss. In all of them and in myriad other less publicized and less visible, land use change caused by human activities is implicated to a greater or lesser extent. The impacts of these environmental problems are serious both in the short and in the long term. In the short term, food security, human vulnerability, health and safety are at stake; in the longer term, the viability of earth is being threatened.

Remote sensing and the spatial analysis technology have been recognized and used as powerful and effective tools to monitor land usage and surface changes. Satellite remote sensing collects multi-spectrum, multi resolution, multi-period data and provides valuable information in understanding and monitoring the process of land use change, and in constructing land use databases.

The purpose of the study is to present remote sensing and spatial analysis technology (GIS) as a powerful tool in studying and analysing Land Use Changes for effective land development and planning.

## **1.1 Study Area**

Lekki Peninsula is located along the coastal region of Lagos State in South western Nigeria. The Oxford advanced learners dictionary defines a Peninsula as "an area of Land, almost surrounded by water and connected to the Mainland by an Isthmus" It is a vast area with an extent in excess of 2890 hectares with an existing thickly populated urban area. It also hosts recreational sites such as Lekki beach, Alfa beach e.t.c, which accounts for the huge influx of tourists. A survey carried out between the early to mid 90's put the population of this region at an estimated 195892 people, although this figure would have greatly increased due to the large exodus of people into the area in recent years.

## **1.2 Aim**

The aim of this work is to study the changes in land use in the study area between 1964 and 2003 and present same in manner that can aid quick and useful decisions for the purpose of land development, administration and planning for a sustainable environment.

It has following specific objectives:

- To analyze the land use changes in Lekki Peninsula.
- To prepare a land use map of the study area using topographic maps, satellite imageries and ground truth survey
- To assess the implications of the changes observed in the area and make appropriate recommendation.

### **1.3 Scope of Study**

This study examines changes in land use in the Lekki peninsula area of Lagos only. It does not cover some adjacent areas of the study area

## **2. ANALYZING LANDUSE CHANGES**

The analysis of land use change revolves around two central and interrelated questions: "what are the causes/drivers and what are the impacts". This first of these questions is addressed here. The precise meaning of the "drivers" or "determinants" or "driving forces" of land use change is not always clear, commonly accepted and understood by all those who engage in studies of land use change. It is almost unanimously accepted that there are two main categories: bio-physical and socio-economic drivers. The bio-physical drivers include characteristics and processes of the natural environment such as: weather and climate variations, landform, topography, and geomorphic processes, volcanic eruptions, plant succession, soil types and processes, drainage patterns, availability of natural resources and so on. The socio-economic drivers comprise demographic, social, economic, political and institutional factors and processes such as population and population change, industrial structure and change, technology and technological change, the family, the market, various public sector bodies and the related policies and rules, values, community organization and norms, etc. It is obvious that these factors changes in space and time.

The last two centuries have witnessed the scientific and technological developments which have brought about tremendous change in Land-use. Rapid land use development and increasing land-use changes due to increasing population and economic growth in selected landscapes is being witnessed of late. Nowadays there is rapid growth in land use and industrialization and there is increasing pressure on land, water and environment in big cities. Changes in land use may be found everywhere in major cities. Every city is expanding in all directions resulting in large-scale changes in land use. The study of the land use faction of this nature can be conducted successfully with the help of GIS.

Geographical Information Systems (GIS) can serve as a valuable tool for land use change detection and has a role to play in improving the Environment. Change detection involves the use of multi-date (time series) aerial photos, toposheets or satellite imageries of the study area, from which land use maps can be generated by visual interpretation or digital image processing. Remote sensing and photogrammetry products are integrated in a geographic

information system (GIS) to better study land use change patterns over time. Remote sensing has provided an efficient method and perfect alternative of data acquisition for land use administration.

## **2.1 Geographic Information System (GIS)**

Maps have been used for thousands of years, but it is only within the last few decades that the technology has existed to combine maps with computer graphics and databases to create geographic information systems or GIS. Many GIS databases consist of sets of information called Layers. Each layer represents a particular type of geographic data. For example, one layer may include information on the streets in an area. Another layer may contain information on the soil in that area, while another records elevation. The GIS can combine these layers into one image, showing how the streets, soil, and elevation relate to one another. A GIS database can include as many as 100 layers. This capability of GIS makes it a very useful tool in the analysis of land use changes. Layers for land use change analysis can be datasets obtained at different epochs, different classes of land use at the same epoch, drivers of land use change etc. The applications of a GIS are vast and continue to grow. By using a GIS, scientists can research changes in the environment; engineers can design road systems; electrical companies can manage their complex networks of power lines; governments can track the uses of land, make policies to guide the use of land for a sustainable environment; fire and police departments can plan emergency routes.

Computerized mapping and spatial analysis have been developed simultaneously in several related fields. The present status would not have been achieved without close interaction between various fields such as utility networks, cadastral mapping, topographic mapping, thematic cartography, surveying and photogrammetry, remote sensing, image processing, computer science, rural and urban planning, earth science, and geography. The GIS technology is rapidly becoming a standard tool for management of natural resources. The effective use of large spatial data volumes is dependent upon the existence of an efficient geographic handling and processing system to transform this data into usable information.

The GIS technology is employed to assist decision-makers by indicating various alternatives in development and conservation planning and by modelling the potential outcomes of a series of scenarios. It should be noted that any task begins and ends with the real world. Data are collected about the real world. After the data are analysed, information is compiled for decision-makers. Based on this information, actions are taken and plans implemented in the real world.

## **2.2 Benefits of Remote Sensing**

Significant improvements have been made in the method of mapping from images. Orbiting remote sensing satellites now provide high resolution images of the earth, which when coupled with GPS derived coordinates can be used to produce maps more easily, more quickly, and more cheaply (Olaleye 1992). Of greater significance is the development of

digital image processing techniques and intelligent software packages which have made the extraction of spatial information from such data by the computer a reality, thus making the method a rather useful tool for monitoring the earth's resources. Because of the vantage orbital position, the multi-channel design, operational flexibility, and improved resolution of many remote sensor systems, this technique is proving to be a cost-effective method for collecting a variety of information over large areas of the earth. Furthermore, sophisticated camera systems are now carried in low flying aircrafts for high resolution images which can be used for large scale maps. From simple desktop devices for planimetric map production to full photogrammetric workstation for 3D data capture, the impact of technology is immense. In all methods, the skill and learning time required by the surveyor to produce a map is just a fraction of what he needed for the traditional methods (Olaleye 1992). Also, the turn-around time and cost of making maps are comparatively low. Perhaps the more recent and noteworthy development is the possibility of integrating image data with position data in an application. For instance, position data acquired with the GPS can be used directly in an image acquired with a camera and the resulting georeferenced image can be processed even in real time to provide information for some decision in a manner similar to the human visual/positioning ability. The operations of the instruments are so simple that even self learning is sufficient to get the user up and running in a short time.

### **3. METHODOLOGY**

This research was carried out with the intention of producing a highly reliable result, and hence, adequate attention was paid into the various stages of the work.

#### **3.1 Data Acquisition**

Data acquisition is a very important aspect of GIS, the type of data obtained and the accuracy of the data is very important because it determines the output of the information obtained. The data acquired for the purpose of this work includes:

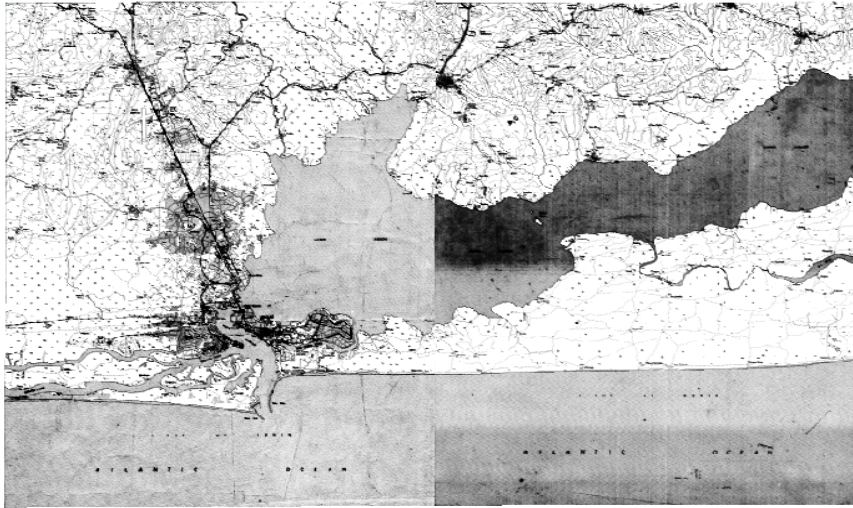
- Existing 1 in 50,000 topographic maps of the study area was obtained from the office of the Surveyor- General of Lagos State of Nigeria.
- A Quick Bird satellite imagery of the Lekki Peninsula region with 30m resolution was obtained from GCLME/UNILAG centre for environmental management.
- Coordinates of different locations in the study area was obtained by the use of a GPS using the WGS84 31N Minna datum

Having had the base maps (topographical sheets and satellite imagery), interviews were conducted in the Lekki area as source of additional information and the features found on the map and image verified on the ground (ground truthing)

#### **3.2 Data Manipulation**

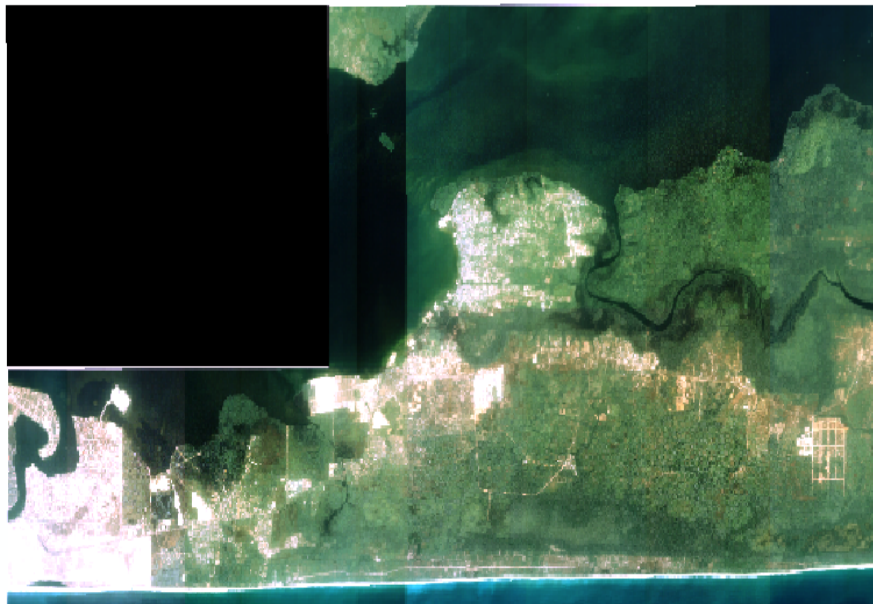
The Topographical sheets were scanned, and this process converted it from its analog format to digital format, the topographical maps were in Longitude and Latitude (Geographic

coordinate system) it was then converted to Eastings and Northings (Projected coordinate system) in metres, using a conversion software called the coordinate converter. The new coordinate was to georeference in ARCGIS. Sixteen points were used for georeferencing to improve accuracy.

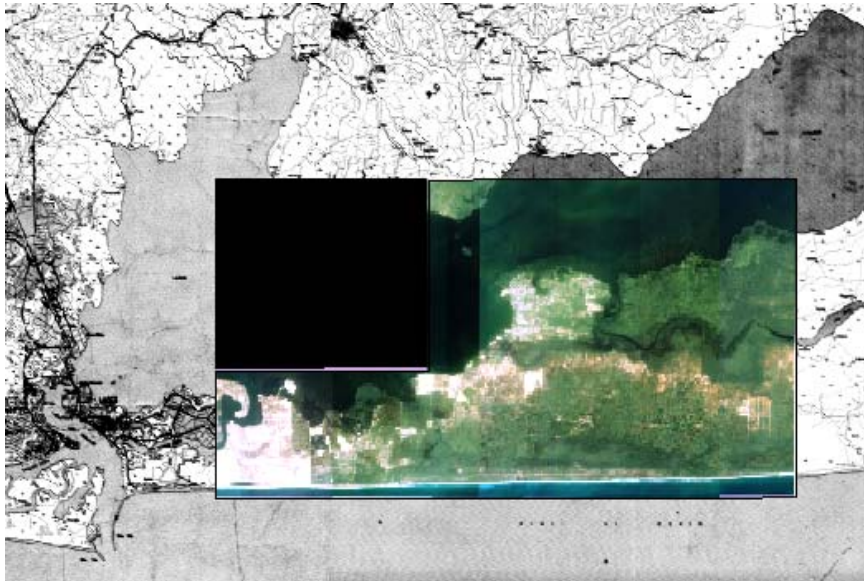


**Figure 3.1** shows the edge matched 1964 topographical map.

The satellite imageries were merged using the mosaic tool in ARCGIS. (mosaic is a way of joining rectangular tiles together).



**Figure 3.2** shows the mosaic Quick bird 2003 satellite imagery of Lekki.

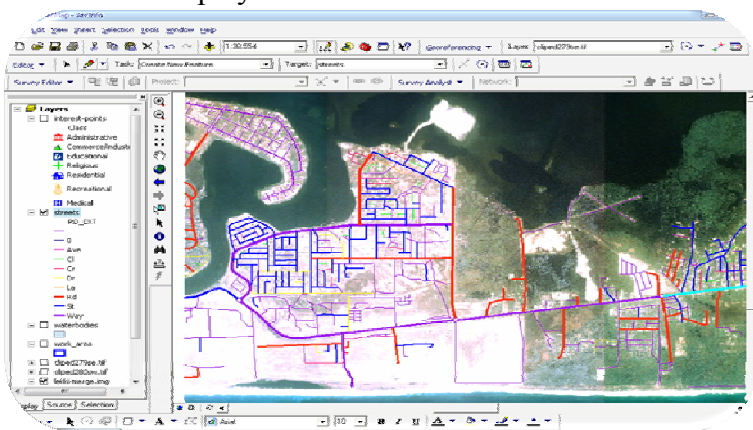


**Figure 3.3** shows overlaid Lekki satellite imagery of 2003 on the topographical sheets of 1964.

Digitizing was done so as to be able to do analysis because analysis cannot be done on a raster image. Different layers were created, such as roads, water bodies, vegetation, built up areas etc.

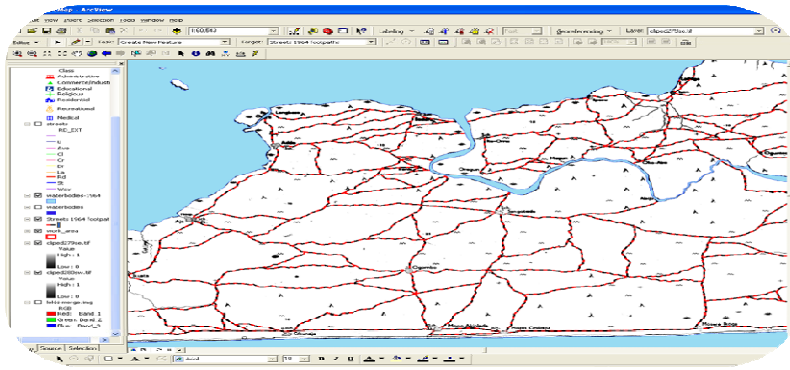
#### 4. RESULTS AND ANALYSIS

Having completed the stage of database implementation, user friendly analysis is made possible in the GIS environment. The program presents an interface, which enables the user to make a choice based on the user's aims and objectives. The real strength of GIS comes in when a relational database is linked with the graphics in real time. A good GIS allows the user to select attributes in the database and to view the results on an interface displayed which can be printed as hard copy. These operations are carried out in this work and some of the results are as displayed and discussed below.



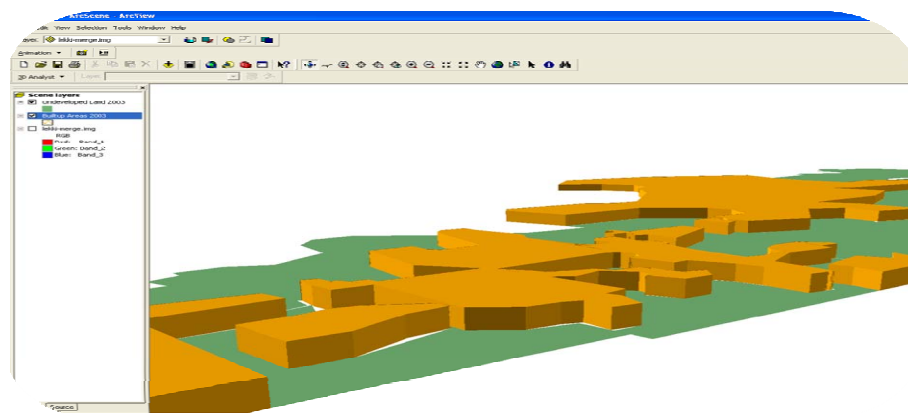
**Fig 4.1a:** Road Network Classification as at 2003





**Fig 4.1b:** Road Network Classification as at 1964

From **Fig. 4.1b** above, sparse distribution in LandUse in the study area as at the 1964 which comprised mainly of educational LandUse class i.e schools, with one or two other classes of LandUse can be observed. The road network classification that was present can also be observed. During this period, the only identifiable road network consisted of Footpaths which crisscrossed each other and were void of any form of planning. The case is by far different for the year 2003. **Fig. 4.1a** shows the road network classification that was obtainable. Different classes of roads had evolved during this period such as pedestrian pathways, Highways, Carriageways (dual and single), Expressways etc. Several classes of LandUse had evolved such as administrative, religious and commercial LandUse and these LandUses were evenly distributed all over the study area.



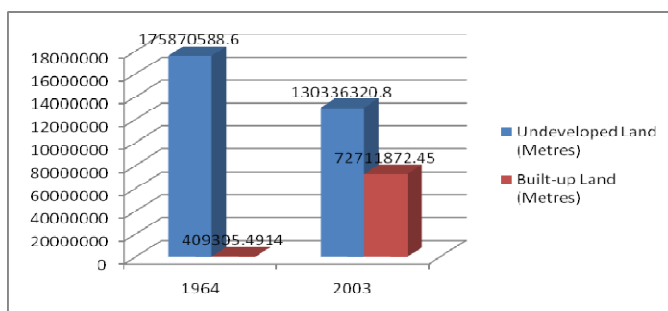
**Fig 4.2a:** Query showing a 3D display of Built-up areas against Undeveloped Areas in 2003



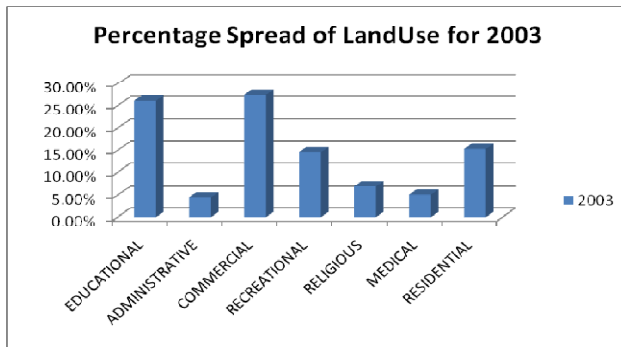
**Fig 4.2b:** Query showing a 3D display of built-up areas against undeveloped areas in 1964

This is the complex process of building a three-dimensional representation of a surface, given a set of elevation points (z- values). The area in orange represents the built-up area while the portion in green represents the undeveloped area. Built-up area accounted for approximately 7271.19 Hectares of the extent of the study area. The undeveloped land accounted for approximately 13033.63 Hectares of the extent of the study area. It can be observed that the entire study area is virtually developed and built up. If Fig 4.2a is compared with Fig. 4.1a, it will be observed that the undeveloped areas are actually wetlands that may pose serious dangers to life if developed. Judging by the proximity of the developed areas to water bodies, it is not impossible that some wetlands have already been developed.

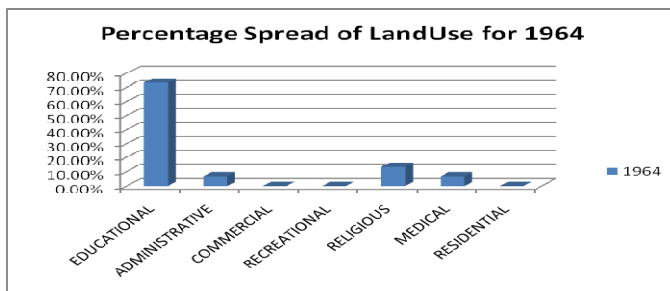
Fig. 4.2b presents the scenario as at 1964 where development is scanty and built up areas scattered. **Figure 4.3b** also shows a 3-dimensional representation of built-up areas against undeveloped areas for the year 1964. Built-up land accounted for approximately 40.93 Hectares of the extent of the study area. The undeveloped land accounted for approximately 17587.06 Hectares of the extent of the study area. The result of the comparison of 1964 to 2003 scenarios are presented in the bar chart of Fig. 4.2c



**Fig 4.2c:** Bar chart comparing built-up land and undeveloped land for 1964 and 2003

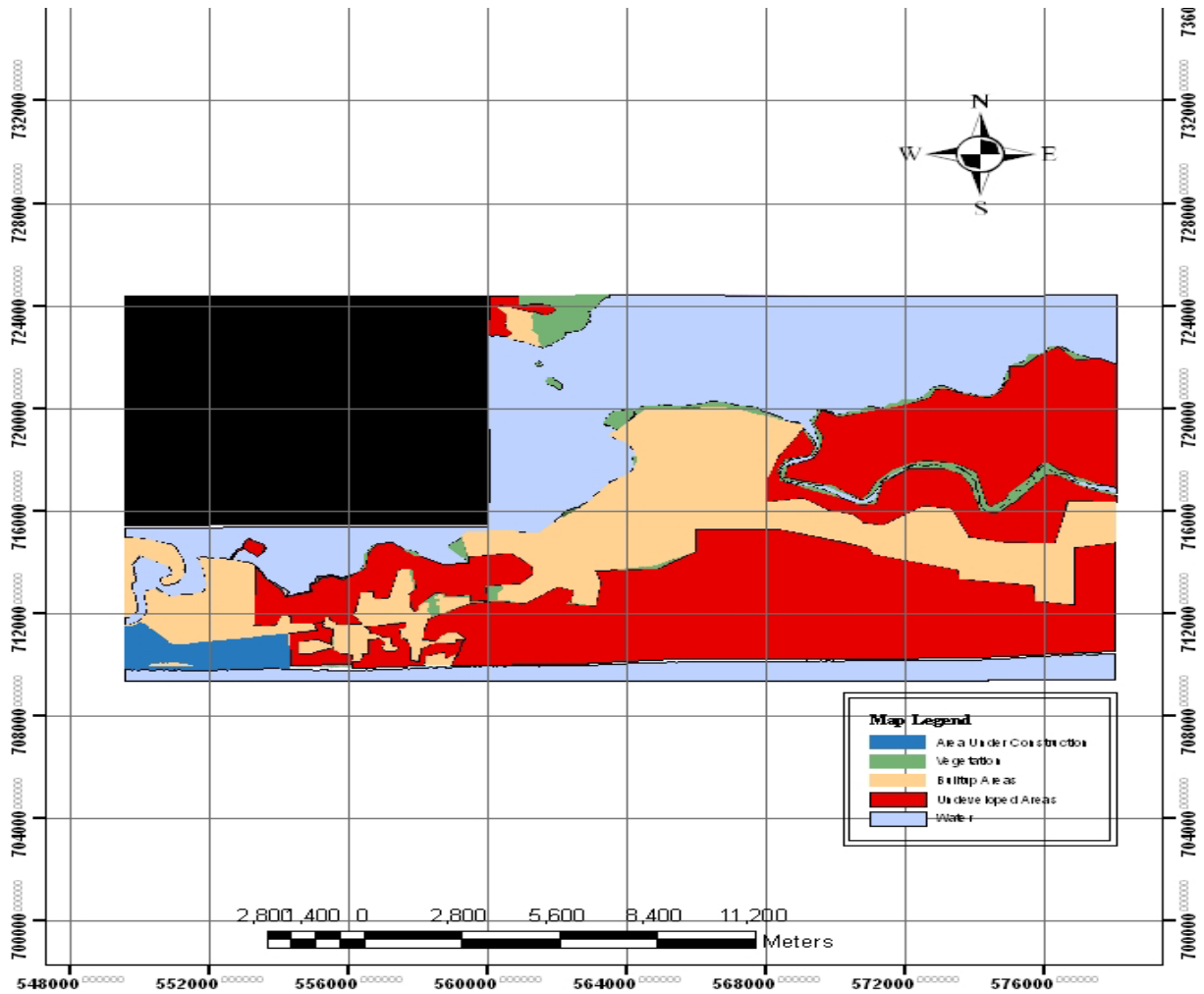


**Fig 4.3a:** Bar Chart showing the Percentage spread of Land Use for year 2003.



**Fig 4.3b:** Bar Chart showing the Percentage spread of Land Use for year 1964.

The different classes of land use obtainable in 1964 and 2003 are presented in the bar charts of Fig. 4.3a and 4.3b. Development was basically educational with scanty developments in administrative, religious and medical classes of land use. All the classes of land use observed in the area are well developed 2003 chart showing a wide difference when compared with 1964. These different classes obtained from the 2003 data are presented in different colours in Fig. 4.4a below.



**Fig 4.5a:** Land Use map of Lekki Peninsula showing the different Land Uses

#### 4.1 Discussion

Lekki Peninsula witnessed a tremendous growth rate between 1964 and 2003, both in terms of Human and infrastructural development. Because undeveloped land in Lekki in 2003 are basically wetlands with a few exception, there is the likelihood of serious challenges for the area because it has to deal with the problems associated with Land development such as urban sprawl, decline in the extent of important ecosystems such as the wetlands and wildlife habitats and a general loss of vegetation and open space. If the rate observed between 1964 and 2003 is maintained with the great influx people in the area, there is no doubt that Lekki peninsula in Lagos will soon turn to another slum, an abode for hoodlums with inadequate facilities. Effective road networks are of paramount importance to the process of urban development on any level. When roads networks are effective, there will be increased mobility, both in goods and services and as a result, business, commerce and other human activities will be situated in such areas. The road network available in 2003 reveal a well planned system that can aid easy movement of people in and out of the area. Recent

observation in the Lekki area reveal heavy traffic congestion at major junctions of the area. This therefore foretells a doomsday for traffic system in the area in the nearest future if the current rate of development is unchecked.

The year 2003 revealed a phenomenal rise in the evolution of various classes of Land Use. Commercial, recreational and residential accounted for 27.40%, 14.60% and 15.30% respectively and were amongst the highest classes of Land Use. Some of the major contributory factors to this scenario are the presence of very good road network systems which allows for easier mobility of people, goods and services and also the presence of several beaches within the vicinity which caused a huge influx of tourists into the study area. The ambience and scenery of Lekki Peninsula coupled with the above stated factors accounts for the large number of residential estates that are present in the area. This beautiful scenery may soon change if other classes of land use should evolve.

## 5. CONCLUSION

Results in this work have shown that Lekki Peninsula has gone through a tremendous change in the last years within 1964 and 2003. Lekki Peninsula that used to be mainly footpath and undeveloped now has different road networks and various land use classes and this has made people migrate into this area. This study has also demonstrated the effectiveness of the use of remotely sensed data using GIS tools in the study of land use change and analysis. These tools have been able to reveal evolving trends in land use within the study area, the pattern of such trends as well other relevant information.

It is therefore recommended that continuous data collection, analysis interpretation and updating of data concerning developments in the area is required to monitor the developments for quick response in decision making by appropriate authorities. Appropriate planning policy is also required to curtail the possibility of the area transforming into another city slum.

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## **BIOGRAPHICAL NOTES**

### **Dr. J. B. Olaleye, Ph. D., University of New Brunswick, Canada**

Associate Professor, Ag. HOD, Department of Surveying and Geoinformatics, University of Lagos, Nigeria (2000-2002 and 2007 to date)

Member, Nigerian Institution of Surveyors, Geoinformation Society of Nigeria, National Association of Geodesists, Over fifty (50) International Journal and Conference Publications.

### **Mr. O. E. Abiodun, B.Sc., M.Sc., University of Lagos.**

Lecturer III, Osun State College of Technology, Esa Oke (2004), Assistant Lecturer, Department of Surveying and Geoinformatics, University of Lagos, Nigeria

Associate Member, Nigerian Institution of Surveyors; Member, Geoinformation Society of Nigeria, National Association of Geodesists.

### **Ms. Q. C Igbokwe, B.Sc., University of Lagos.**

Student Member, Nigerian Institution of Surveyors.

## CONTACTS

Dr. J. B. Olaleye  
Department of Surveying and Geoinformatics  
University of Lagos  
Akoka, Yaba  
Lagos  
NIGERIA  
Tel. + 234 708 768 2900.  
E-mail: [jb\\_ola@yahoo.com](mailto:jb_ola@yahoo.com)  
[www.unilag.edu.ng](http://www.unilag.edu.ng)

Mr. O. E. Abiodun  
Dr. J. B. Olaleye  
Department of Surveying and Geoinformatics  
University of Lagos  
Akoka, Yaba  
Lagos  
NIGERIA  
Tel. + 234 806 651 3914  
E-mail: [abiodunoludayo@yahoo.com](mailto:abiodunoludayo@yahoo.com),  
[www.unilag.edu.ng](http://www.unilag.edu.ng)