LAND USE/LAND COVER MAPPING AND CHANGE DETECTION IN ILORIN AND ITS ENVIRONS, NIGERIA

BY

JIBRIL, MAMMAN SABA

(Ph.D/SSSE/1999/38)

DEPARTMENT OF GEOGRAPHY,

FEDERAL UNIVERSITY OF TECHNOLOGY,

MINNA.

A thesis submitted to the Postgraduate School,

Federal University of Technology, Minna in partial fulfillment of the requirements

for the award of the Degree of Doctor of Philosophy (Ph.D) in Geography with

Remote Sensing Applications

JUNE 2008

DEDICATION

This thesis is dedicated to all members (living and dead) of my immediate and extended families and those who risk their lives in resisting the forceful and unjust acquisition of Dumagi Community land by the Kwara state government for the white Zimbabwean farmers.

ACKNOWLEDGEMENT

Thanks be to Allahu ta' ala for His continual protection, mercy, blessing and guidance.

I owe a special debt of gratitude to the following people and establishments for their respective contributions:

Professor J.M Baba, my major supervisor, for his inelastic but professorial patience with me in several ways and throughout the course of this work. Infact, he did the supervision in a very professorial way, which I so much enjoyed. Dr. A.A Okhimamhe, my co-supervisor for his understanding and cooperation. He accepted me when I needed him most. Dr. P.S. Akinyeye, HOD, Geography and the other lecturers in the Department for their very illuminating lectures, instructions and pieces of advice.

My gratitudes go to Dr. A.M Jinadu, of Department of Urban and Regional Planning (FUTMX), who was my senior in the course of our Ph.D Programmes, for his useful solicited explanations in relevant areas. I thank Mr. U.E. Gbadafu, former Secretary, Post graduate School, (FUT MX) and his staff Mallams K.S Mashegu and A. Suleiman for giving me prompt attention any time I needed information from the School.

My colleague, Mal. S. A. Sati (NDA, Kaduna), who straightened out some of the grammatical expressions and others including Professors L.O Enukora, Bala Dogo, Cols U. Usman (rtd), A. S. Sharu (rtd), Drs. J.K. Aremu, O. N. Onwumere, D.D.Osa-Afiana, Mals Abubakar C.Nkochi, Aliyu Bokuta and late Moh. Babangida Abubakar of Katsina State University. They were my sundry advisers, who were never tired of asking after my work, during the course of the programme. Mal. Umar Hai'rau for down-loading materials for me from the internet at various periods and Mr. Ben Helda, Mals U. Alhaji Ibrahim and Ahmed for their cartographic work.

Professor J. F. Olorunfemi of University of Ilorin and currently, the Executive Director, National Centre for Remote Sensing, Jos, Dr. A. J. Aderamo of University of llorin and Dr. A. S. O. Soneye of University of Lagos, Dr. E.A. Olowolafe of University of Jos and Mal. Murtala Muhd. of National Population Commission, Ilorin are among my very rich stores of information from where I gratefully drew quite a great deal of relevant data for this work. Similarly, I wish to thank Mrs B.C. Leke, S. Adekola, G. Samuel, L.O Balogun and Alhaji M.I. Mainu, U. Christopher all of Department of Remote Sensing/GIS, Federal Ministry of Agric and Rural Development, Kaduna, for their cooperation, especially in the interpretation of satellite imageries and subsequent map production. We have now become very close friends!

To my fellow Ph.D students and colleagues, Drs. Balogun, Sanusi and S.A. Oyegbele who I met for the first time in the hall of an 8-hour Ph.D qualifying examination, during the course of our programme. I say thank you very much for your company.

Special thanks go to my wife, Hajiya Halima, for her continual soft words of encouragement over this work. My children have also been very concerned. For instance, they expected me to have finished the programme, when I had not even defended the proposal!

I also humbly appreciate the moral and financial support of every other member of my family, friends and colleagues towards the successful completion of this work. My grateful thanks also go to the Federal Ministry of Agriculture and Rural Development, Department of Remote Sensing and GIS (Livestock House), Kaduna; the National Space Research Development Agency (NSRA), Abuja, for providing the equipment, tools and imageries; Kwara State Ministry of Lands and Survey, Survey Division, Ilorin; Kwara State Agricultural Development Project, Ilorin; for providing the maps; Federal Ministry of Survey, Kaduna, for providing sheets of topographical maps of Nigeria; and finally, the Rosemma Computer Centre, Mando, Kaduna and Mr. J.B Ajibuah (NDA) for computer work.

I thank the traditional heads of the wards we picked/selected for oral interview and structural questionnaire administration. The state ministries and parastatals that were also used for the purpose of oral interview are equally here gratefully acknowledged. The field assistants, inspite of just little stipend, were always with me anytime I needed their service. They really made me proud! I pray God to bless them.

To cap it all, I gratefully acknowledge the study leave granted me by the Nigerian Defence Academy, Kaduna. Surely, without the involvement of these people and establishments, this research work would not have been successful. Therefore, I say thank you all and God bless.

JIBRIL M.S

July, 2008

CHAPTER FOUR

CHAPTER FIVE

CHAPTER SIX

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Land is a very sensitive natural resource in Nigeria. It is a base for almost every human development, be it economic, political or social. It is therefore, no wonder that there are usually intra and inter communal land disputes, sometimes assuming national and international dimensions.

In man's efforts to satisfy his wants, interactions do occur between him and his environment. Thus, the use to which land is put in any environment obviously reflects the needs of man. The more man puts the land into use (as a resource), the nearer is the man – environment relationship, which will increase the number of land use/land cover types that might be introduced. This will then necessitate the need to study and monitor land use/land cover changes periodically in order to acquire the desired data for planning.

Land use refers to the way and manner in which man manipulates the land for his own use. Man uses the land in various ways for his own benefits. For example, land is being used for agriculture, mining, commercial activities and even for transportation as routes are constructed on the land for the land moving vehicles. Man also uses the land for space and it serves as repository for other natural resources like water, forest, soil and wild life (Jibril, 1994).

According to Chapin (1976), the term land use originally belongs to the group of concepts in agricultural economy and used to imply economic use, to which a piece of land is put, for instance, land use for pasture and crop land. The term, when used in urban studies implies the spatial distribution of industries, commercial, recreational, education and public activities. Urban land use is the focus of this research work, Lo simply (1976) defines land use as the use of land made by man.

Land is a resource, which is basically meant for human use. He is therefore, always busy making use of land in one way or the other. In this regard, Lillesand and Kiefer (1987) opined that the term land use relates to the human activity associated with a specific piece of land. For instance, a track of land that is being used for a housing purpose, its land use could be described as urban use. And a parcel, which is used for farming activities could be said to be an agricultural land use. All uses indeed are interconnected.

However, according to Campbell (1983), land use has been studied from many diverse view points so that no single definition is really appropriate in all different contexts. It is possible for example, to look at land use from the land capability point of view by evaluating the land in relation to the various natural characteristics like climate, geology, soil, topography, hydrology and biology. These and other definitions provided by Aldrich (1981), Jorg (1986) and Lawson and Stewart (1965) centre on relationship between man and environment (the land).

While land-use encompasses several different aspects of man's relationship to the environment (e.g activity, ownership, land quality); land cover on the other hand, is represented by the natural and artificial compositions covering the earth's surface at a certain location. For example, the land cover for a given location might be classified as deciduous forest when the land use is that of a wild life refuge or mining operations (Avery and Berlin, 1985, Burley, 1961).

Vegetal cover is a fast changing phenomenon and is one of the most sensitive indicators of environmental and global change. According to Philip (1997), the behaviour of vegetation change reveals the interconnected nature of climate on earth. Aside from the expected seasonal variations, it reveals how human activities; such as deforestation and urbanization are having a profound effect on ecosystem characteristics.

Almost all human activities such as clearing of large tracks for cultivation, the cutting of wood for fuel, logging, grazing, and bush burning usually result in the modification of land resources.

One of the prime prerequisites for better use of land is information on existing land use pattern and changes in land use/ land cover over time. For example, knowledge on land use makes one to be aware of the number of hectares of land that are urbanized in a given region and changes that may be involved in the number of hectares from time to time.

For various parts of the world, land use maps have been compiled and published so as to get information for the maximum use of land. Irrespective of their scale or form, maps need to be revised periodically at a pace commensurate with the dynamics in the environment. In Nigeria, such maps are either out of print or severely out-dated (Lo, 1986 and Soneye, 1992), and is therefore not useful for planning purposes. Moreover, land use maps/information are normally essential for town planners and administrators as reference documents for their duty.

Land is scarce in urban centres because of the high concentration of population and the subsequent demands on the land for various uses. The ever-increasing population of Nigeria's urban centres due to the continuous influx of people, especially rural dwellers, into them, keep the pressure on urban land high. This pressure on land always translates into continuous land use changes as a result of the economic and social changes, which are always taking place within the urban environment. Thus, urban dynamics, both social-economic and spatial, are a major feature of the Nigerian urban system. The management component of the process does not seem to always proceed with the same vigour as rate of changes taking place in urban centres.

In Nigeria and in developing countries generally, most of the cities are not planned. Where they have urban plan at all, they are not being followed (implemented). Structures are thus erected even at marginal areas, making the cities to look undefined. Town planners, managers and analysts and other municipal officials therefore need pertinent, timely and reliable information to shape and to reshape the Nigerian urban centres in terms of plan and management. In this context, Horton and Marble (1969) assert that remote sensing offers a significant opportunity to help improve the effectiveness of urban management, to help guide urban growth and development and to help maintain and improve the quality of metropolitan environments.

Because of the high population density in the Nigerian urban centres, the available infrastructural facilities are grossly inadequate. The cities are therefore yawning for the provision of basic amenities such as water, roads, electricity, health services, educational institutions and recreational centres. Reliable, adequate and timely information are thus required on land use patterns in planning for the provision of these amenities.

Furthermore, management and planning of urban space require information on land use, land cover, and changing patterns. Continuous mapping and monitoring of land use and land cover changes using the appropriate methods and tools provides the planning and decision makers with required information, especially about the state of development and the nature of changes that have occurred. Though numerous techniques for mapping and monitoring land use/land cover changes exist, remote sensing provides the most vital tools by which information can be obtained and analysed for planning purposes at the district and as well as the city levels. Remote sensing becomes useful because it provides synoptic view and multitemporal land use/cover data often required.

1.2 Statement of Research Problem

Before the advent of colonialism, Nigeria had already evolved its own system of cities. Examples are Sokoto, Kano, Zaria, Gumel and Ilorin in the North. In the South, similar urban centres existed such as Saki, Iseyin, Ogbomoso, Ede and Iwo. Others are Port Harcourt, Calabar and Lagos (Ogunsanya, 2002 and Onokerhoraye, 1982).

In 1950, only about 24% of the city of Ilorin was developed. But the proportion (of developed land) remarkably increased to about 30% and 50% in 1963 and 1973 respectively (Olorunfemi, 1983). In a similar study carried out by Oyegun and Olaniran (not dated), the built-up area of the city in 1963 was calculated to be $4.9km^2$ and this increased to $18.74km^2$ later in 1974.

The movement of the University of Ilorin to its main campus in 1981 has resulted in a kind of "leap-frog" sprawl development along the university road mainly because of land speculation. Thus, most of the land along this road is owned by people who have no immediate plans to develop it, hence, the haphazard manner of development along that direction (Olorunfemi, 1985).

The creation of Kwara State in 1967 and the choice of Ilorin as the state capital resulted in its rapid population increases and areal expansions. According to Doxiadis and Associates (1976), for instance, the first estimate of the population of Ilorin after the establishment of the British Colonial Administration was made in 1911 and this put the town population at 36,343. The 1953 census indicates the town's population at 40,994. The figure rose to 208,546 in the 1963 census. The population in 1991 was put at 532,088. The projected population of Ilorin for 1994 is 675,000. (NPC, Ilorin, 2000). The provisional result of the 2006 census gives the population of Ilorin as 777,667. This is made up of 390,781 males and 386,886 females (FRN, 2007). The physical growth of Ilorin cannot be isolated from the increase in the population of the city. The population of Ilorin increased astronomically, which also affected the land area of the city (Adedibu et al, 1998).

Ilorin city has experienced a rapid growth in the number of medium size and large scale commercial establishments available over the years. The predominant commercial areas where there are concentrations of business establishments are major city roads like Murtala Mohammed, Ibrahim Taiwo, Wahab Folawiyo, Umar Saro, Ajasse Ipo and Jebba. Others are the traditional central area of Ilorin at Oja-Oba and other various commercial centres all over the city. Substantial increase in the number of manufacturing and construction industries is also an index of structural changes in the city of Ilorin. The industries were established at different periods and in different locations. For instance, the Tate and Lyle Industries, the International Tobacco Company and the Matches Industries are the first set of industries located in Ilorin. Later industries emerged to include Global Soap and Detergent Industries Ltd, Rajrab Pharmaceutical Company, to mention but a few (Oloru, 1998).

The establishment of educational institutions in Ilorin such as the University, Kwara State Polytechnic, College of Education, School of Nursing and Midwifery, College of Arabic and Legal Studies, Theological College and many secondary schools is also another contributing factor towards the growth of Ilorin. More than ever before, large tracts of land are cleared annually for cultivation of both food and cash crops.

Therefore, because of high competition for land, people erect their structures on almost any available parcel of land. In some cases, in the course of house constructions, people have often encroached on the river valleys, and have not given allowance to the incidence of river flooding (Jimoh, 1997).

The aforementioned developments, which have resulted form man-environment interaction, undoubtedly have become a worrying development for the Kwara State Government (KWSG), because of their (i.e developments) positive and negative implications on economic, social and physical (spatial) efficient planning of the city. Unfortunately, due to insufficient and lack of proper management of the available funds (by the KWSG) there has been no proper methodology to adequately monitor these developments in order to obtain sufficient and reliable data. On this basis, the KWSG could barely improve the often appalling conditions in which ever increasing numbers of people in Ilorin have to live. Against this background, remote sensing technology, because of its synoptic coverage, repetitivity and improved resolution of its products amongst others, is used in this study to generate adequate, efficient, relatively cheap, reliable and real time current data to monitor land use and land cover changes in the city and environs of Ilorin.

A number of studies (Olorunfemi, 1985, 1983 and 1987: Aderamo, 1997; Adedibu et al 1998, and 1980; Muhamood, 1984) have used aerial photographs and to a lesser extent satellite images to monitor land use/land cover changes over time of Ilorin. But, the areal coverage of these works on the categories and/or classes of changes were restricted only to the built-up area of the city. Thus, every other class considered by such studies were only those found within the city. Through such researches, it is not possible therefore, to have appreciable understanding/data of land use patterns of the outskirts of the city. In other words, these studies did not focus on detecting changes in vegetal cover of the periphery of Ilorin. In addition, as of recent, no literature has considered the rate at which vegetal cover depletes at the country side of the city of Ilorin. This is a worrisome development considering the adverse affects of devegetation, which include reduction in biological production, soil erosion and wild life dispersal amongst others. To put in another way, repetitive vegetation monitoring through the use of remote sensing technology in the study area would be a great contribution to scientific knowledge. In the same vein, previous studies are also not available on the study area, which give recent information on various statistics of areal coverage of built-up (area) inspite of current urban sprawl with its consequences on the social-economic activities of the country side of Ilorin city. The desired immediate, but relevant need for such studies constitutes a problem to this study.

1.3 Aim and Objectives

The aim of this study is to use remote sensing data to monitor land use and land cover changes in Ilorin with a view to understanding the emerging patterns and their spatial implications.

The objectives are to:

(1) Map land use and land cover changes of Ilorin for the period 1976-2004

(2) Determine the rate of spatial expansion of Ilorin during the periods.

(3) Examine the relationship between population growth and land use change.

(4) Identify the factors of land use/land cover changes with a view to understanding the process of change.

(5) Identify the problems arising from the observable changes in land use patterns.

1.4 Justification

Urban land use is a dynamic phenomenon that undergoes changes all the time to reflect the different degrees of the impact of man on the urban environment. This in effect makes modern cities to be most characterized by high levels of internal differentiation. Keeping pace with such changes has become an arduous task for regional planners particularly in Africa. (Lo, 1976; Barret and Curtis, 1976; Clark, 1982; Rilwani and Ufuah, 1999). An attempt to classify land use/cover in a city is therefore a fundamental step to the understanding of the spatial structure of the city. City environment thus, needs to be constantly monitored and understood. It is on such basis, according to Horton (1969), that the description and maintenance of the current status o urban activities could be achieved. Ilorin city plays, on a continual basis an important commercial, industrial, political, administrative (being the state headquarters), educational and religious roles for her teeming population. So, as a rapidly growing city, it is still adding more functions to these primary roles and it is therefore very liable to change in nature – in size, shape, plan building styles etc. This makes her activities too complex to be adequately addressed through the use of aerial photographs.

In Nigeria, quite a number of researchers have employed remote sensing techniques to monitor urban land use change over time (Ajayi, 1981; Olurunfemi, 1987; Idris, 1988; Sogunle and Fagbemi, 1990; Omuta and Ikhuoria, 1994; Aderamo, 1997; Adedibu etal, 1998) but they mostly focused on composite growth patterns and the areal coverage of the land use/cover changes, which might not be adequate (as data) for efficient land use planning. This study therefore, attempts to go a step further by identifying the problems arising form the observable changes in land use pattern, an appreciation of which could help the planner design sustainable urban and rural land use policy.

In addition, these earlier studies made use of aerial photographs as a method of monitoring urban growth, which are usually laden with assorted problems ranging from high cost through lack of repetitivity of data acquisition and time to difficulty in assessing the resultant aerial photographs, especially in developing countries. These short comings were also recognised by Haralick, (1979); Jensen, (1983) Vengen, (1982); Olurunfem, (1983, 1987); Sada et al (1983); Lo (1986); Singh (1986); NRSC (1989); Forster (1993); Kressler and Steinnocher (1999); and Jinadu, (2004) among others. The methods therefore do not yield the needed time series data, which are very pertinent to urban study and planning. In the light of this, and in order to avoid falling, into the trap of obtaining an unreliable, untimely and inadequate data (through the use of the said aerial photographs), this study attempts the use of the multistage and multi-sensor approach to investigate urban land use change in the study area for improved resolution and aerial coverage, which provides another justification for this work.

This study is further justified by the fact that there is hardly any urban centre especially in developing countries such as Nigeria, which has sufficient, timely and reliable data to control and plan its fast sprawling built-up area. On this issue, Garner (1977:354) wrote:

> *"Urban research is still in a relatively primitive stage of development and in spite of the voluminous literature much more work is needed to provide a comprehensive understanding of the complex integrated growth and structure of urban areas".*

Thus, this study is an attempt to provide additional empirical data, which will not only update what already exist but would also facilitate more efficient planning of Ilorin city by the relevant authorities.

1.5 Scope and Limitations of the Study

Based on the GIS calculation of the satellite images of Ilorin and environs (section 4.1.1), the total areal coverage of the study area is 761.183Km^2. This includes some peripheral areas of Ilorin since the city has grown spatially extending far into areas beyond its initial boundaries. The study includes the peripheral areas so as to have an appreciation of the land cover changes. The Ilorin metropolis consists of three Federal Government approved Local Government Areas:- Ilorin West, Ilorin East; Ilorin South with headquarters at Oja-Oba (CBD of the city); Oke-Oyi; and Fufu respectively.

The study area however shares common boundaries with Moro L.G.A to the North-West, Asa L.G.A on the South-West and Ifelodun to the South-East. Ilorin West is the most populated of the three local government areas (Table 1.1), and thus, it has a more complex land use system.

Table 1.1: Year 2000 Population by L.G.As

L.G.A	Population
Ilorin East	239,021
Ilorin South	200,329
Ilorin West	307,352

Source: NPC Kwara State Ilorin (2000)

The indigenous area of Ilorin is made up of wards headed by traditional ward heads. These wards are Ajikobi, Alanamu, Gambari, Fulani, Magaji Are and Magaji-Gari (Fig.1.1). Some of the localities under these wards include Okelele, Abayawo, Gambari, Oloje, Pakata, Okesuna, Baboko, Adewole, Adeta, Adabata, Kuntu, Okekere, Edun, e.t.c.

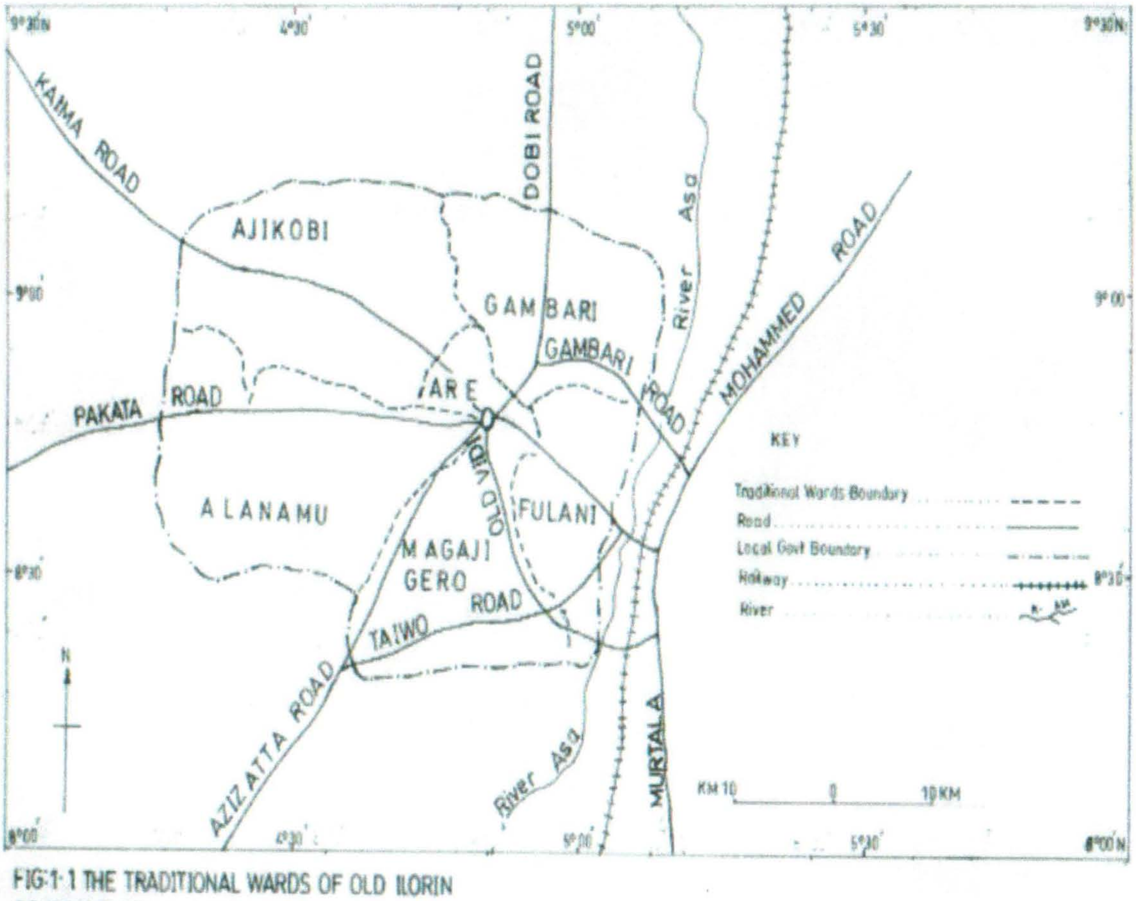


FIG:1·1 THE TRADITIONAL WARDS OF OLD ILORIN
SOURCE:-OLORU AJ (1998)

There are some other residential areas located outside the indigenous area of Ilorin. They are otherwise known as New Ilorin. Examples are Sabo, Surulere, Aboogba, Odokun, Gaa-Akanbi, Akerebiata, Sariki Kanuun e.t.c. They are found just by the indigenous area.

The suburb areas, which were founded as separate villages, have been submerged by the city of Ilorin as a result of rapid development. They included Fate, Ero-Omo, Kulende, Tanke, Odota, olorunsugo and Oyun.

The study therefore, covers both the old and new parts of the city of Ilorin. It is River Asa that naturally divides the city into the two parts. Both (old and new Illorin) have been attracting population influx, giving rise to major physical developments.

CHAPTER TWO

2.0 CONCEPTUAL BACKGROUND AND LITERATURE REVIEW

2.1 Introduction

This chapter is concerned with some relevant background concepts of the study and reviews the relevant literature. The former section considers theories and models of urbanization, historical analysis of urban growth and the land value surface. Others are size and shape of urban fields and breaking point theory and above all land use models of urban growth which all combine to form the foundation of this study. The literature review section considers in detail the concept and development of remote sensing technology as well as its application to land use and land cover change evaluation and monitoring amongst others. The review however places emphasis on remote sensing application to urban studies, which is the main theme of the study. Change Detection Algorithms (CDAs) are reviewed in this section under three categories, which are classification, enhancement, and simulation-based CDAs.

2.2 Conceptual Background and Theoretical Framework

2.2.1 Definition of Urbanization

Dickinson (1974) in Mabogunje, 1971 defines urban centre as a compact settlement engaged in non-agricultural occupation. According to Mabogunje (1971), this definition does not go down well with cities of the developing world. Most urban centres in the developing world began with a substantial proportion of their inhabitants being farmers. As specialization increased and transport improved there was the tendency for urban centres to concentrate more and more on secondary and tertiary activities. Louis (1938) defines an urban centre as a relatively large, dense and permanent settlement of socially heterogeneous individuals. According to Lindgren (1974), urban areas represent a complex association of population concentrations, intensive economic activities, and diverse life style. They are a microcosm of human activities, and frequently experience rapid changes that need to be monitored and understood. According to Whynne-Hammond (1979), most towns can be identified by their closely packed buildings and streets, high population densities and non-agricultural functions. They are also distinctive in terms of their human aspects, numerous and diverse groups of people living in close proximity, sharing the same social facilities yet lacking strong social contacts. Individual anonymity is often a feature of such areas together with human mobility (occupational and geographical), social instability, complex class, structures, wide variation in human wealth and heterogeneous ways of life.

From these concepts/definitions of urbanization (as well as those given by Berry, 1964 and brown 1967), it can clearly be understood that urbanization is simply the process in which the number of people living in cities increases compared with the number of people living in rural areas, which has become not only one of the main features of life in recent years, but also one of the major causes of modern economic and social problems.

Urbanization is the function of three basic conditions. These conditions are spelt out by Mabogunje (1971); Whynne – Hammond (1979) and Clark (1982) as:-

(i) Surplus of food production with which to feed the class of specialists whose activities are now withdrawn from agriculture.

(ii) there is need for the existence of administrators to exercise power over both the food producers and the specialists and above all else, it is their special function to provide and maintain stable and peaceful conditions under which both group can operate to best advantage.

(iii) the specialists who produce assorted goods can only function well if there are classes of traders and merchants who are to provide them with raw materials and distribute their products. Trading sets in motion a substantial flow of goods and services, which are clearly needed in cities.

Urbanization is a continuing process, related to the increasing functional specialization in human society. Thus, the need to seek for appropriate data for it's planning is inevitable. On the basis of this, Daniel and Hopkinson (1986:235) opined that:

> *'The blame for the increase in urban sprawl is placed at the door of planners as any change in land use requires planning permission.*

2.2.2 The Land Value Surface

Some land areas are more attractive than some others. The most highly attractive land areas are thus hotly competed for by the potential users in order to minimize transport cost. As a city grows, so remoter and therefore inferior locations are brought into use. According to Garner (1977); Daniel and Hopkinson (1986), an understanding of the pattern of land values would help in understanding the internal structure of cities. The specific patterns of land values, just like their equivalent patterns of land uses, obviously vary from city to city depending upon local circumstances. Garner (1977) identified three elements common to all cities viz:

(i) Land values reach a grand peak in the centre of the city and decrease by varying amounts out wards;

(ii) Land values are higher along major traffic arteries in the city;

(iii) Local peaks of higher value occur at the intersections of major traffic arteries defined distances away from the city centre.

Superimposition of these three components results in a general surface of land values similar to that shown diagrammatically in figure 2.1. Garner (1977), has however contented that the land value surface is essentially within a direct reflection of accessibility within the urban area.

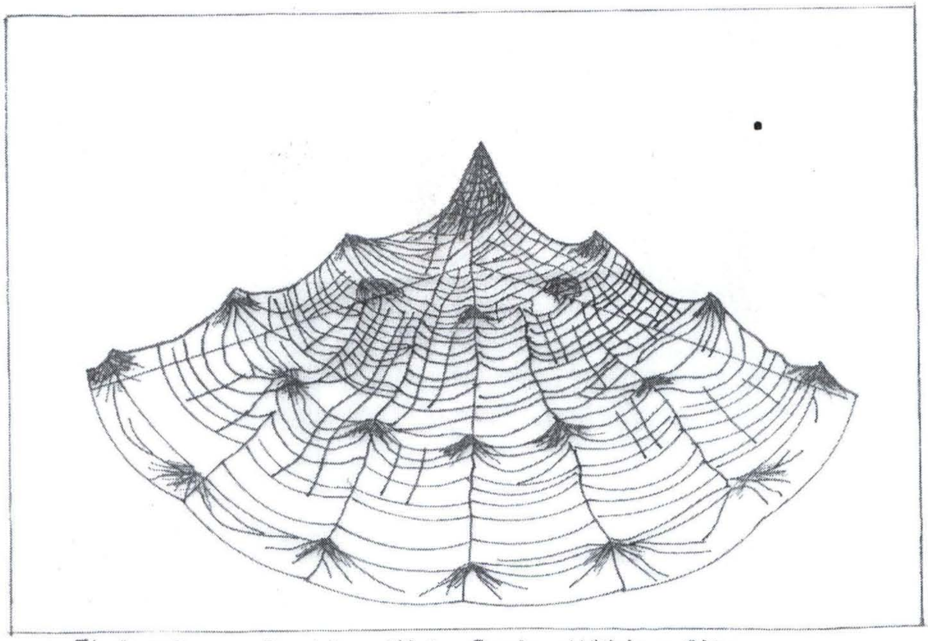


Fig 2.1: Generalized Land Value Surface Within a City
SOURCE: Garnet (1977).

2.2.3 Size and Shape of Urban Fields

An urban field is the sphere of influence around a town. The degree of attraction is greatest close to the centre, and may diminish farther away, so that if more than one centre of attraction exists, there may be overlapping at their borders (Green, 1950; Whynne-Hammond, 1979).

Usually, towns/cities do serve their surrounding rural areas in various ways (schools, hospitals, markets, several other urban facilities and statutory bodies such as police, fire service, electricity and water boards) and they (towns) do in turn receive produce to sustain them. They are therefore interdependent. So, one cannot do without the other. The extent to which such an influence goes makes the urban field of a given town.

Urban fields do not have regular shape and population and functions of their central places do not determine their sizes. According to Webber (1964); Green (1950); and Whynne-Hammond (1997); some urban fields are determined in form by relief and may be elongated along valleys or truncated by mountains, rivers or coast lines; some are shaped around communications, broadening near railway station or extending along main roads to become star – shaped. Some urban fields are small, others very large. Some towns have strong functional links with their surrounding regions, and others have weak links. In the words of Hagatt et al (1997:51):

> *"Some fields are severely truncated, others are distorted, still others are fragmented (Fig.2.2)"*

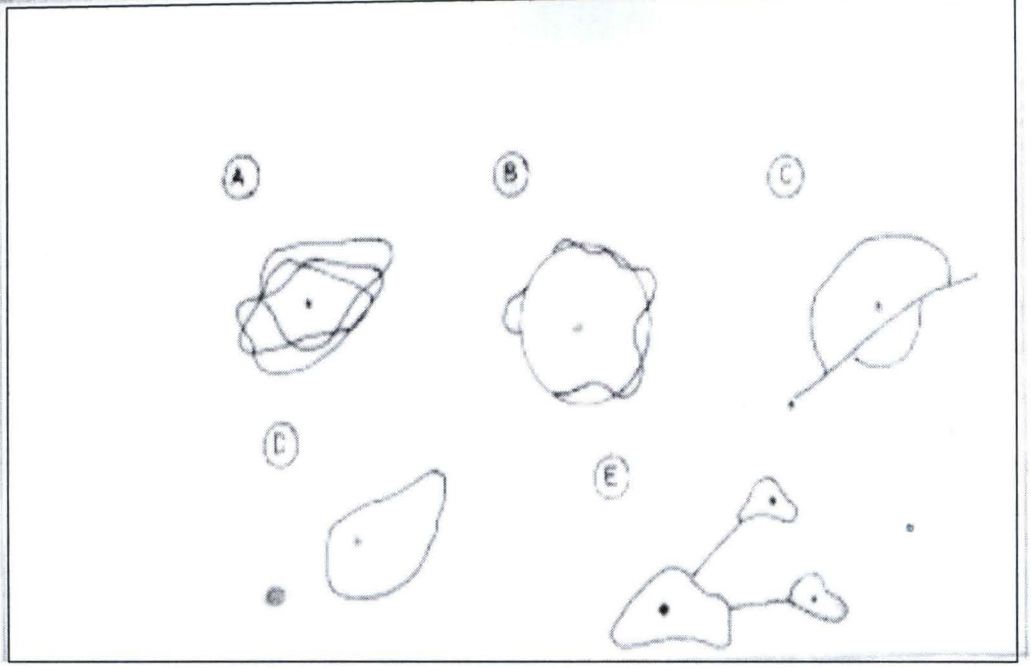


Fig. 2.2: Alternative Type of Movement A Amoeba B Circular Field C Truncated Field D Distorted Field E Fragmented Field.
Source: Haggett et al (1977).

Clark (1982) gives two alternative ways in determining the extend of influence of settlements as:

(i) to ask firms and public utilities in the town about the boundaries of the areas to which they send out their goods or services.

(ii) to ask individuals in rural villages to tell us which centre they use to supply their day-to-day and indeed, their occasional needs. In neither case will one draw very precise boundaries around the sphere of influence which one distinguishes.

2.2.4 Breaking Point Theory (BPT)

However carefully field work is undertaken for urban field delimitation, and which ever indices are used, various problems arise when spheres of influence are actually mapped thus creating a sort of confusion in the process of delimitation. These confusions, according to Whynne-Hammond (1979; 175-176) occur:

(i) when urban fields between two towns fail to meet, creating a vacuum in which inhabitants are apparently not served by either town. In figure 2.3, Burnham-Highbridge is in such a vacuum;

(ii) when two urban fields overlap, so that some people will use two towns equally and those towns will compete for the patronage of those people.

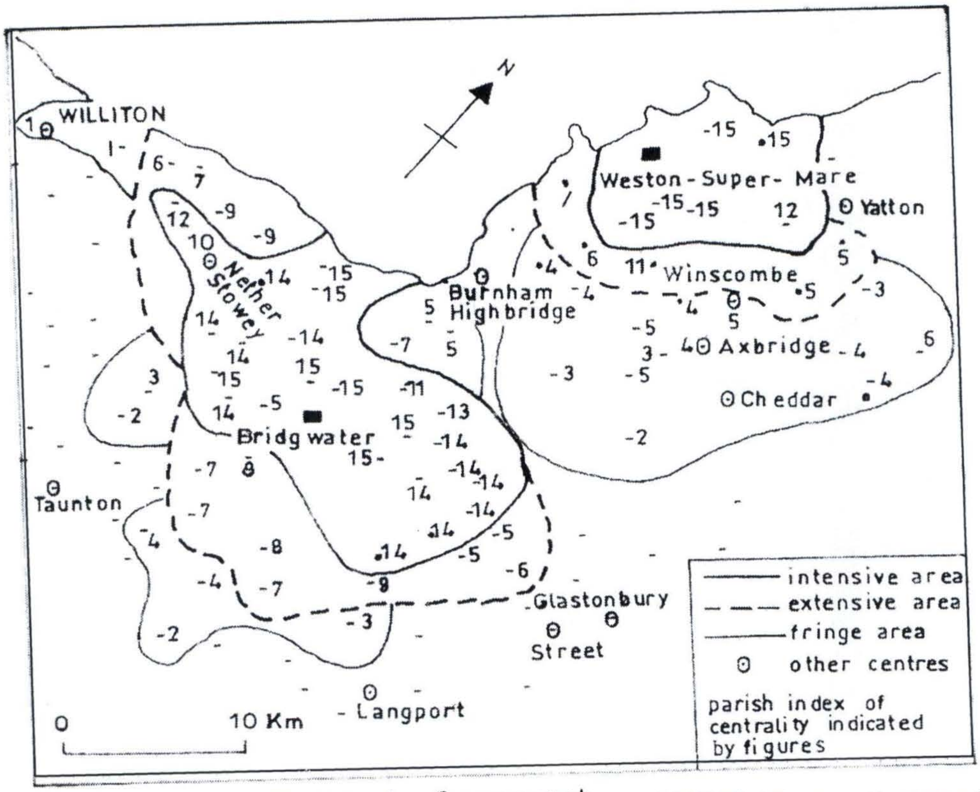


Fig2·3 : Urban Fields in Somerset SOURCE: Whynne-Hammond(1979)

Breaking point theory has been formulated in order to solve problem (ii) above. The BPT employs a gravity model whereby a single line of demarcation can be established. The deduction of the theory according to Whynne-Hammond (1979) is based on the fact that:

(i) the breaking point between two settlements divides those people who will use one town from those who use the other.

(ii) if the two towns in question are of equal size and importance, the breaking point is of course likely to be half way between them.

(iii) if they are not of equal size, the larger settlement will probably have a greater attraction than the smaller settlement and the breaking point will be nearer the later. Therefore, to find the exact point of break, the following formula can be applied

$$\text{Distance of break point from A} = \frac{\text{Distance between A and B}}{1 + \sqrt{\frac{PB}{PA}}} \qquad \text{.............. (2.1)}$$

Where PA and PB are the populations of the two settlements in question.

2.2.5.0 Land Use Models of Urban Growth

2.2.5.1 Definition of Models

Whynne-Hammond (1979) has defined models as generalizations, frames reference, programmes of research and explanations of how systems work. In many respects they are simplified structures, which reduce reality to a generalized form and present standards against which variations can be compared. Being very descriptive, models are more tied to reality than theories. For Lee (1974), a model is a representation of reality. It is usually a simplified and generalized statement of what seem to be the most important characteristic of real-world situation: it is an abstraction from reality which is used to gain conceptual clarity – to reduce the variety and complexity of the real world to a level we can understand and clearly specify. Yet another definition of model by Skilling (1964) in Haggett and Chorley (1977) is that a model can be a theory or a law or a hypothesis or a structured idea. It can be a synthesis of data. Most important from the geographical viewpoint, it can also include reasoning about the real world by means of translation in space (to give spatial models) or in time (to give historical models).

It can however be deduced from these and some other definitions of model by Harris (1967); Haggett and Chorley (1977); Haggett etal (1977); and Cark (1982) etc that the use of models can enable the geographer to find out which is the case. They (model), thus, remove confusion from reality, isolate major components, make possible predictions and generally provide a theoretical framework for understanding the factors involved in human activities.

The internal structure of any city is different from that of another. But in spite of the complexity that might be involved in respect of such structures of individual cities, there is an order of land use pattern, which evolved over the years. Nevertheless, since there is as yet little agreement on the specific nature of this order, a variety of models have been proposed/developed, which attempt to describe and account for intra-urban land use patterns.

Hence, in line with the three basic components identified in the land value surface (see section 2.2.2), the models for consideration in this study will be discussed under concentric, sector and nuclei headings by identifying certain spatial characteristics, which are common to towns and provide some understanding of the processes, which bring these about.

2.2.6.2 The Concentric Zone Model

The concentric zone model, which was developed by EW Burgess in 1925, was an attempt for a better understanding of a complex urban system (Fig.2.4). Burgess (1927) adopted some of the fundamental concepts used by the plant ecologist (the ideas of competition, dominance, invasion and succession) in their study of plant associations. He envisaged that within the city, people competed for limited space. Those who can pay for them surely get the most desirable locations for their home and businesses. Those individuals and functions with the lowest level of economic competence are usually left with the poorest locations. This process naturally leads to functional zoning and residential segregation within cities. In other words, within different areas of the city, difference single functions form the dominant element (Daniel and Hopkinson 1986 and Garner 1977).

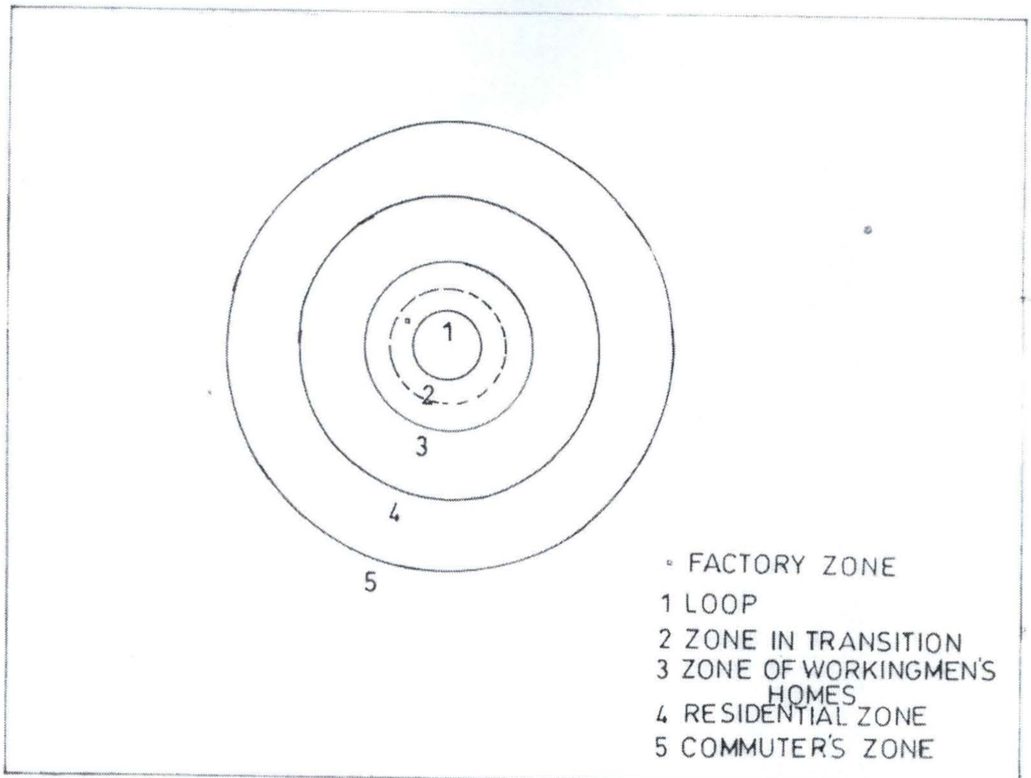


Fig. 2.4 : BURGESS'S CONCENTRIC MODEL OF URBAN LAND STRUCTURES
BURGESS EW (1925)

(i) Central Business District (CBD)

It is usually located in the heart of the city, which forms the commercial, social and cultural hub. It is the most accessible part of the city, being the focus of the urban transport network. Here, there are concentrations of departmental stores, variety goods store and specialist retails outlets, as well as best hotels, and cinemas.

(ii) Zone in Transition:

Surrounding the CDB, there is a zone in transition or deterioration, where the land use is very mixed and constantly changing. It is usually too in-accessible to be sought after by prosperous commercial enterprises and too near to the noise and grime of the city to provide sizes for anything but the poorest residential buildings where the most derived social groups live. However, since it is a zone of change, it can probably include many large and formerly fine houses.

(iii) Working-Class Zones

This zone contains some of the older residential buildings in the city. These originally housed families who move from poorer quality property in the zone in transition, but who were still compelled by traveling costs and rents to live near to their places of work.

(iv) Middle Class Zone

Burgess describes the zone as zone of better residences. Some light industry will also probably be situated here.

(v) Commuters' Zone

It is located beyond the continuous built-up area. Though, essential urban functions are also situated there. These include public utility, such as sewages disposal plants and refuse tips, and recreational facilities, such as golf course. There functions will probably be interspersed with non-urban land use such as agricultural land and woodland.

As good as Burgess's model looks, a number of criticisms have been level at it. These include the fact that: (i) the model emphasizes clear cut boundaries between the concentric zones, which is not tenable any where, (ii) the model pays scant attention to the distribution of industry. It could be argued that in any model of urban structures, greater consideration should be given to the location of industry within the urban system, (iii) it considers ground floor functions only and attention is paid to the height of building and variation function on different floors. Interestingly, Burgess acknowledged however that the model would probably not hold for all cities throughout the world.

2.2.5.3 The Sector Model

According to Hoyt (1939), one of the basic characteristics of the sector model is that residential areas of a particular class, develops outwards from the city centre in the form of wedges or sectors (Fig.2.5). Thus, a residential district of a particular class in one sector of the city will migrate outwards in that direction by new growth on its outer edge.

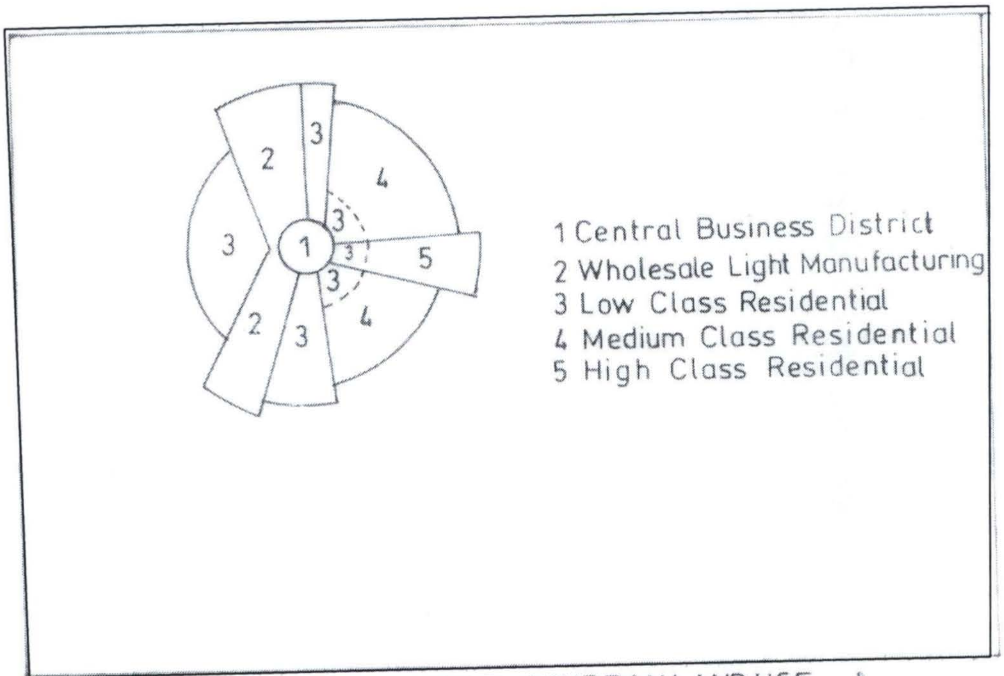


Fig 2.5 HOYT'S SECTOR MODEL OF URBAN LAND USE
SOURCE: HOYTS H (1939)

He further suggested that because the high-income groups could afford to pay for the most desirable sites the high-grade residential areas pre-empted the most desirable space and were powerful forces in the pattern of urban growth·(Hoyt, 1939). Other grades of residential areas were arranged around the high grade-areas the poorest occupying the least desirable land in the one in transits or adjacent to manufacturing districts.

Hoyt (1939) suggested that sector; rather than concentric zones develop because of differences in accessibility from outlying districts to the city centre. The high-class housing estates were built in those sectors where transport link with the city were particularly good as for example, along suburban railway line. Hoyt contended that sectors were most likely to develop in towns, which had a radial network of routes diverging from the city centre. He also found that sectors of high-class residential areas were particularly well pronounced towards (i) high grounds and open spaces (ii) existing outlaying smaller settlements (iii) the home of influential leaders within the community.

The sector model has been criticized on the ground that it is constrained by its narrow focus on housing and rent. Against this background, Morril (1970) has extended the scope of the model by suggesting that a variety of complimentary uses occurs within each sector with the intensity of land use decreasing with distance from the CBD.

2.2.5.4 The Multiple Nuclei Model

As the name of the model connotes, Harris and Ullman (1945) believe that there can be several centres in a city from where development can originate and then grow outwards in a city (Fig 2.6). The number of such focal points will depend on the size, and general development and growth of the city. Harris and Ullman (1945)'s idea is therefore in contrast with both the concentric and sector models, which hold the belief that zones develop outwards from a single centre-the CBD. According to Garner (1977); Daniel and

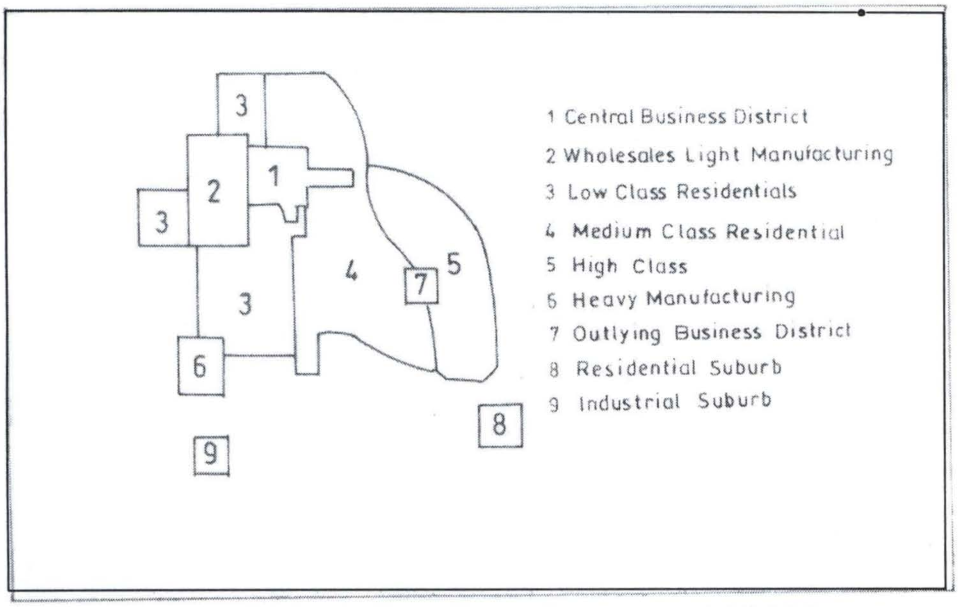


Fig 2.6 HARRIS & ULLMAN'S MULTIPLE NUCLEI THEORY OF URBAN STRUCTURE
SOURCE:-HARRIS CD & ULLMAN (1945)

Hopkinson (1986), some of the nuclei, such as some of the suburban shopping centres could be quite recent developments, while others will have been former village and small town centres, which have been enveloped by the city growth.

Harris and Ullman (1945) hold the view that the factor for the development of several zones could be as a result of the fact that shops and stores need to be accessible to their customers and the industry requires vast and cheap area of land. Moreover, there is tendency for the like activities to group together. Other factors are the possibility of repulsion of some activities by others; and the differences in the ability of various activities to pay rent and rates.

From the review of the models, it has been glaring that there have been some sort of modification in the models one after the other. For instance, concentric zone model can be seen to be a point of reference for much later research into urban structure, the most notable example being the Hoyt's sector model. On the other hand, Harris and Ullman (1945) built on the idea of sector model to develop the multiple nuclei model.

It is however possible that each model has a limited descriptive value to apply in some, but certainly not all circumstances. The models can therefore be seen as complementary rather than competitive. In other words, the models are not completely independent of one another. So, one might expect any given urban land use pattern to show traces of the Patterns proposed in all the models (Smith, 1962; Haggett, 1966; Mabogunji, 1968; Robson, 1975; Ayeni 1976; Olorunfemi, 1979; Daniel and Hopkinson, 1986).

In Nigeria, as in many other African countries, the morphology of many traditional urban settlements does not conform to any of the classical urban models. Rather, they are as a result of western and native cultures. This is clearly seen where a basically western city has been grafted in a pre-existing indigenous city. Such "mixed" cities are features of the former colonial countries where old and new urban developments have been juxtaposed and serve as a visible indication of distinctiveness of two cultures (Johnson, 1972). The interplay of two cultures can be seen in the morphology of such settlements whereby the indigenous portion is inhabited predominantly by a population of local origin with high residential densities and commercial activity in the form of tranditional markets. On the other side of this core are usually modern commercial and residential areas.

The 1897 radial pattern of the growth of Ilorin (Fig.5.1), which is reviewed in this work is for instance at variance with Burgess (1925)'s model. Others such as sector and multiple nuclei models also appear to be relevant to this work.

2.2.6 Historical Changes in City Size Distributions

Urban land use is so dynamic in nature that it has been the focus of research interest of urban geographers and town planners. According to Idris (1988), the intent of most of these research works is an examination of where different activities are located within the city and what generalization can be made about their locational patterns and arrangement.

The structural development of cities evolves over time and not just á matter of days. The frequency in structural changes in cities is often likened to a chameleon that changes its colour at will. A number of historical models have therefore been proposed to examine

(i) With the study of some cities in the United States over the period 1790-1950, the authors related the logarithm of population size to rank order (Fig. 2.7A). The parallelism of the 17 lines suggest relatively constant Pareto function, which has been sometimes regarded as evidence of allometric growth, that is, maintenance of a stable equilibrium between city sizes over time.

$Pi = a\,(i)^{-b}$ -------------(2.2)

In this equation, the population of the ranking city (Pi) is a function of that rank (i), and a and b are constants.

(ii) If the cumulative percentage of cities over a given size threshold is plotted against city size, the size distribution will become increasingly linear as a result of economic development. Case in hand is author's study of Israel over the period 1922-1959 (Fig. 2.7B).

(iii) The authors plotted the value of the b coefficient in the equation

$Pi = a(i)^{-b}$ ------------(2.3)

against time to give the changes in the slope value for Australia over the period 1861-1971 for five top ranking cities (Fig.2.7C). Interestingly, this model clearly conforms with Berry's (1967) model (Fig. 2.8) as the primate pattern progressively drifts towards the rank-size position of b = 1.0.

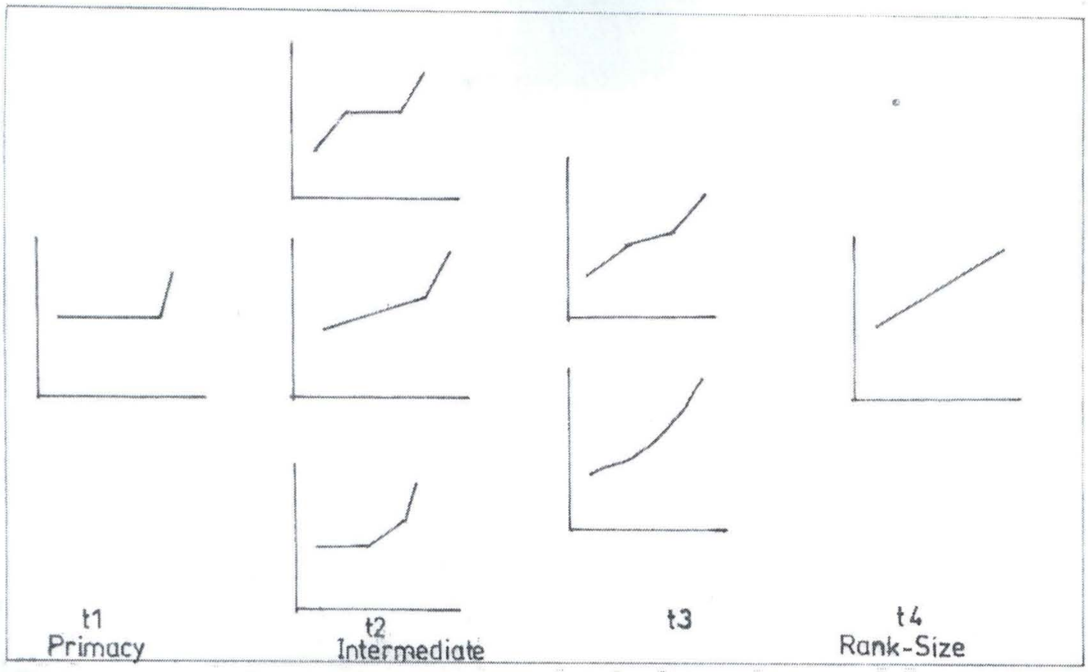


Fig:2·8 Berrys Development Model for City-Size Distributions
SOURCE:-HAGGETT ETAL (1977)

The idea of this subsection (i.e 2.2.6 iii) has been used to plot/show Ilorin city size distribution for the period 1976-2004 (Fig 5.10).

2.2.7 Changes in the Role of Individual Cities

In the preceding section, changes in the development of cities over time as a complete system have been briefly reviewed. The growth of individual cities on their own merit is examined here. Cities change structurally and in roles they perform from time to time, economic situation being a major determinant.

Robson (1973)'s work on the change in rank order for towns in England and Wales between 1801-1911, are shown in figure 2.9. It can vividly be identified that London retained its rank through out the period while Leicester rose (appreciated) and Exeter fell (depreciated). The results clearly show dramatic shifts in the fortunes of these cities in terms of their growth/strength. Clearly, the crossing of trajectory lines in plots (Fig.2.9) indicates the degree of instability with the growth process, and completely stable system in which each city held exactly the same position over time would consist of a series of parallel vertical lines, also as in figure 2.9. Other similar works are those of Madden (1958), and Lukermann (1966) in their respective studies of the United States urban system.

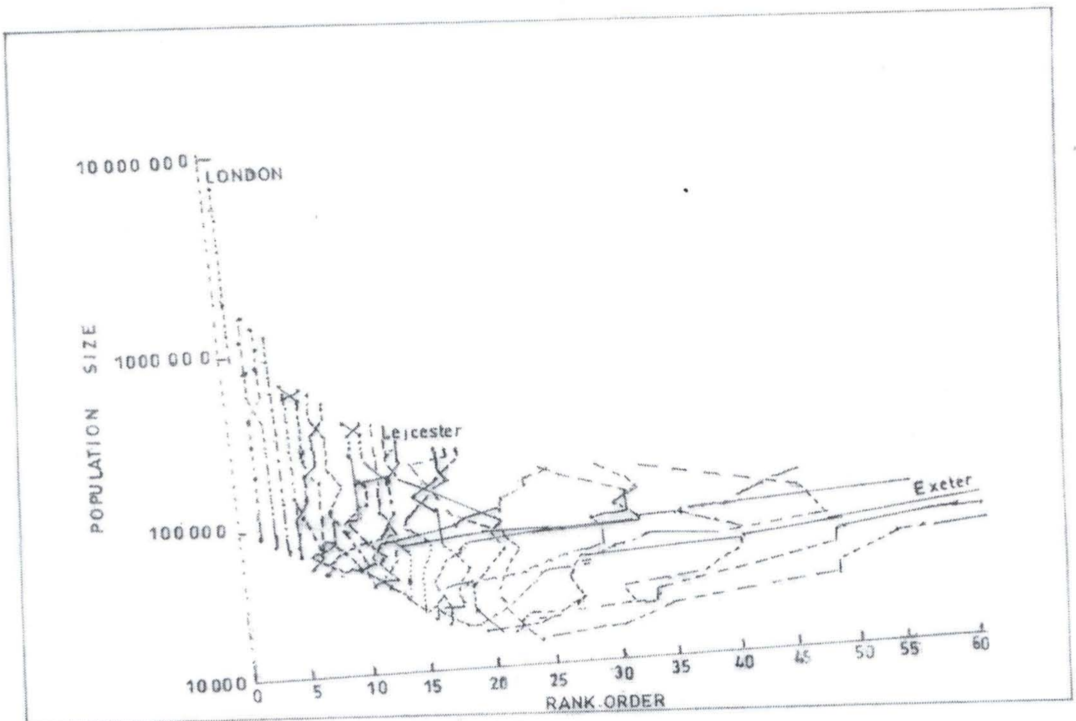


FIG: 2.9 Changes in rank order 1801-1911

SOURCE:-HAGGETT ETAL(1979)

2.2.7.1 Biproportionate Matrices

An urban system may comprise several cities. Each of these cities definitely has its unique characteristics that differentiate it from the others. The city may for example be distinctive in terms of population, size, structure etc. In the light of this understanding, Bipproportionate matrices, according to Haggett et al (1977) disentangle the relations between the growth of individual cities and the growth of the whole urban system of which they form a part. In Bipproportionate matrices, the values (xij) in an mxn matrix are scaled so that each roll sum is equal to n. Then the columns are scaled so that each column sum is equal to m. This process of column and row adjustment is successively repeated until adequate convergence to an equilibrium solution is obtained as:

$$\begin{bmatrix} Xii & X12 \ldots\ldots Xij \ldots\ldots Xin; \\ X21 & X22 \ldots\ldots X2j \ldots\ldots X2n; \\ ; & ; \quad ; \quad ; \\ Xil & Xi2 \ldots\ldots Xij \ldots\ldots Xin; \\ Xml & Xm2 \ldots\ldots Xmj \ldots\ldots mn; \end{bmatrix} = \begin{bmatrix} n & + & e \\ n & + & e \\ & & \\ n & + & e \\ n & + & e \end{bmatrix} \ldots\ldots (2.4)$$

$$= (mte \quad mte \ldots\ldots mte \ldots\ldots mte)$$

Where:

E is an allowable tolerance term. The procedure produces a standardization of the matrix values over the rows and columns of the matrix.

Haggett et al (1977) give two advantages of Biproportionate matrixes on second order changes in growths within an urban system by relating Xy to a city's performance.

(i) over all cities in the system at a given time, and

(ii) to its own performance over all time periods.

2.2.8 Rank-Size Regularities

Going by whatever means of yardstick, cities are not equal. While some are for instance, highly populated, large and structurally compacted, others are thinly populated, small and very spacious with open spaces here and there. But it might not be possible to facially quantify the ranking order of these cities especially in terms of population and size. It is against this background that model of rank-size regularities, which is the graphical relationship between the large number of smaller places and fewer number of larger places in a region was proposed.

According to Garner (1977), when all cities in an area are ranked in decreasing order of population size, the size of settlement of a given rank appears to be related to size of the largest or primate city, in the region. The regularity, generally known as the "rank-size" rule, can be expressed by the formula:

$Pr = P1/r^2$.................................... (2.5)

Some other works, which give a plausible explanation and review of rank-size regularities are those of Simon (1955), Vining (1955); Isard (1956); Berry and Garrison (1958) and Haggett (1965). The general assessment of many writers on this city relationship is nevertheless summarized in the words of Garner (1977:327):

> *"Although it may be borne out exactly in reality the rank size regularity provides a useful frame work within, which generalization about the population distribution of region can be made".*

2.2.9 Population Estimation Model

In developing countries, such as Nigeria and in many of the developed nations head count is often carried out through decennial method. Though, derived data through the method have been used for developmental programmes of different levels, they (data) are usually inadequate for planning of rapidly changing areas – especially urban centres. It is the recognition of the defects of the decennial census that led to the development of population estimation models based on remotely sensed data. Broadly, three estimating models based on remote sensing are:

i. Dwelling/housing unit method

ii. Land use model

iii. Correlation method

2.2.9.1 Dwelling/Housing Unit Method

This method is based on the assumption of a close relationship between dwelling/housing unit and population. According to Olorunfemi (1982), the basic concept of this method is based on the principle that if the number of people living a house and the number of houses in the area are known, by simple multiplication, the total population of the area can be estimated. On this method, Sada et al (1983:14) wrote:

> *"With the appropriate aerial photographs,*
> *this method can be employed to estimate*
> *population in Nigeria especially in the rural areas.*
> *In this context, instead of estimating dwelling units*
> *(house hold) individual residential building may be counted".*

2.2.9.2 LAND USE MODEL

This model is basically based on relationship between land use types and their population densities. In this regard, Nordbeck (1965) in Lo and Welch (1977) in a discussion of relationship between area and population in term of the law of allometric growth, concludes that the built-up area (A) of a settlement should be proportional to the population (P) raised to some power (b) or

$A = ap^b$ .... (2.7)

In order to establish the application of this concept to Chinese cities, Lo and Welch (1977) computed this representative equations ($r=ap^b$) for a sample of cities in Taiwan and Mainland cities. In conclusion, they affirmed that in the absence of current census data, population estimates for Chinese cities of 500,000 to 2,500,000 people could be generated from measurements of the built-up urban areas (A) on Landsat images.

Sada et al (ibid) gave three steps of the models as:

(i) The classification of land uses in different categories on images

(ii) The calculation of the area extent of each land use category

(iii) The determination of the characteristic population density for each land use category.

2.2.9.3 Correlation and Regression Model

The basic assumption of this model is that there is a close relationship between the built-up area of a settlement and population such that

$P = C + bA$ or $P = Ca^{b}$..........................(2.8)

Where:

P is the predicted population

A is land area

'b' a scale

'c' a constant

The model has generally been accepted to be suitable for gross urban population estimation and for comparison of urban population growth (Sada et al, 1983). Holz et al (1969) and Ogrosky (1975) both successfully used this technique with aerial photographs and demonstrated that regression equations were only marginally improved by expanding variations beyond built-up land area.

The basic assumption of correlation and regression model, which is the existence of a close relationship between the built up area of a settlement and it's population, has been blended with the land consumption rate (LCR) and land absorption coefficient (LAC) methods to analyse the city growth of Ilorin (Fig.5.9). Thus, these models are of great relevance to this work.

2.3 LITERATURE REVIEW

2.3.1 Introduction

The prime objective of remote sensing is to extract environmental and natural resources data related to the earth (Lo, 1986). Much data have been generated through this tool over the years by the technique which are of much benefit to man. The benefits of such data to man are derived through the application of such data to many fields of human endeavour such as Agriculture, Mining, Forestry, Geology, Soil, Military, Urban Studies etc. Indeed, Rudd (1974), notes that if remote sensing lives up to its potential, there will be few people in this world whose lives will not be affected by it.

The use of remote sensing technique to monitor land use/cover changes of an environment is a necessity. This is so, because, reliable and up-to-date data are required for proper land development, planning and management. Series of researches are therefore being carried out on land use/cover change detection at different levels with a common goal of making proper and maximum use of land. In other words, such researches aim against misuse of land through human activities and climatic factors for a better living of inhabitants of a given area. This sole objective can only be achieved if governments at all levels, private organizations, corporate bodies, public agencies and other stake holders endeavour to implement the aftermath of such researches. It is against this backdrop of desired need for data that relevant available literatures at our disposal are reviewed in this study.

2.3.2 Concept and Development of Remote Sensing

2.3.2.1 Definition and Physical Basis of Remote Sensing

Remote sensing has been defined in many ways by various authors. Remote sensing has been defined, for example, as the science and art of gathering information about an object, area or phenomenon through the analysis of data acquired by recording device that is not in physical contact with the object, area or phenomenon under study (Barrett and Curtis, 1976; Rhind and Hudson, 1980; lillesand and Kiefer, 1989). Murthy (1974) defined remote sensing as the methodology for characterizing the nature and condition of natural resources of the earth by means of observations and measurement from space platforms. Sabins (1978) sees remote sensing as being restricted to the method that employs electro magnetic energy (including light, heat and radio waves) as the means of detecting and measuring target characteristics. Yet, another definition of remote sensing is the use of electromagnetic radiation sensors to record images of the environment, which can be interpreted to yield useful information (Curran, 1988).

These definitions and similar ones by Lintz and Simonnet (1976); Short (1982); and Fischer (1975), however have certain features in common, which are information (data) generation, a defined phenomenon of interest, application of electro magnetic energy, data analysis, sensors and platforms. All these are efforts geared towards the satisfaction of the end user.

Obtaining clear information about an object does not just occur by accident. Rather, contain processes in form of model (tagged remote sensing model) have to be followed (Fig. 2.11). The main components of the model according to Kairu (1982) are:

(i) The source/emission of radiation (for passive remote sensing, radiation originating from the sun is exclusively use);

(ii) The attenuating of the radiation by air bone constituents within the atmospheric path;

(iii) The radiation/target interaction normally at the earth/atmospheric interface;

(iv) The interaction between the sensor and the reflected (by the target) or emitted radiation.

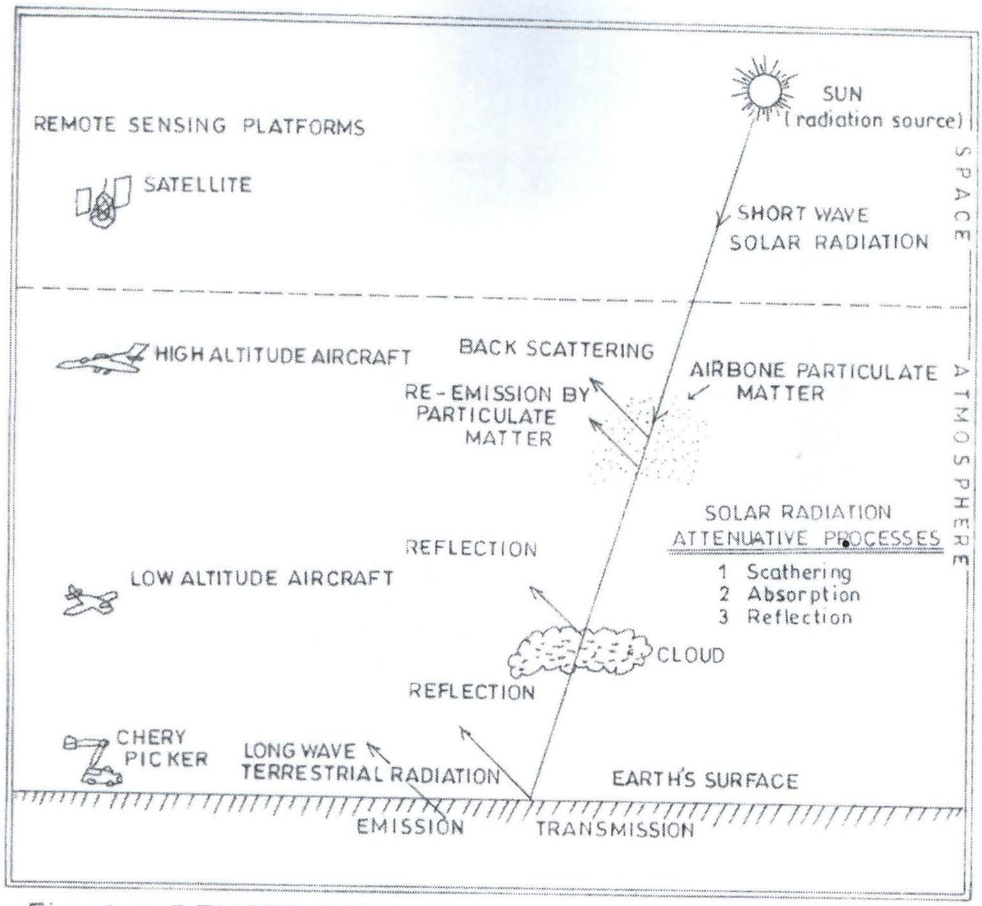


Fig:- 2·11 REMOTE SENSING MODEL SOURCE:- KAIRU (1982)

2.3.2 Development and History of Remote Sensing in Geography

The desire to make maximum use of the environment has always prompted man to put to good use his natural systems, composed of the fives senses (hearing, seeing, smells, taste and feeling). However, his quest for mastery over nature has rendered such natural system quite inadequate as means of obtaining the information he requires about the complex environment. To overcome this handicap, man has developed and put to effective use such devices as: Cameras, infrared detectors and radio frequency receiver to detect electromagnetic energy; seismometers to detect acoustical energy, scintillation counter to detect radio activity and magnetometers and gravity meters to measure force fields. This has been the background to the development of phrase remote sensing (Kairu, 1982).

The ultimate purpose of geography is to understand the entire surface of the earth. This may seem ambitious but it is an attainable goal, which the discipline must strive to achieve. Remote sensing is seen as the technology that facilitates the attainment of this goal.

According to Stone (1974), as soon as the practice of photography started in 1839, the benefit of remote sensing in geography was the utilization of several photographs for mapping various physical and cultural elements of the earth's surface. This later developed into the use of air-photo interpretation for spying during war periods such as the American civil war.

The use of remote sensing for urban studies dates back to 1858 when Tournachon used a camera carried aloft in a balloon to study parts of the city of Paris. In his photographs of the villages of Petit Bicetre, the houses could be clearly seen (Idris, 1988). Since then, there has been progressive use of the imagery of urban morphology to identify and classify urban features at different levels.

The World War I boasted the use of aerial photography as lieutenant Lawes of the British Flying Forces took the first pictures of enemy territory. There was however, a transfer of 'technology' by some geographers associated with World War I military units into peacetime applications of photos in geographical endeavours such as archeological uses and more detailed mapping of roads, buildings and fields, swamps and rock outcrops.

The early space photography from Gemini and Appollo missions and the expanded activities of satellite for meteorology and communication has provided great impetus for the planning of first manned satellite to observe and monitor the earth resources. As a result of intensive research and development, the first Earth Resources Technology Satellite (ERTS-1) was launched in 1972 by NASA (later renamed LANDSAT–1). LANDSAT-1, 2, 3, 4 and 5 have subsequently been launched and later came the French Satellite – SPOT that was launched in February 1986. The Indian Remote Sensing Satellite (IRS-IB) was launched on 17 August 1991. The Nigeria Sat-1 was launched on 27 September 2003 (plate 2.1) and has a ground control station in Asokoro, Abuja. The launch is undoubtedly the fulfillment of an expected advancement in the growth and development of remote sensing technology in Nigeria. The successful launch will definitely go along way to address the desired growing needs for resource information, which is the bedrock for total development.

The Landsat programme has therefore become the major source of data, which is being used by the scientific community interested in the earth resources. Development in this direction (i.e in landsat programme) has indeed been gradual and steady as it went through the use of kites, pigeons and airplanes to rockets. Reinforcing this position, Harris (1987:1) notes.

> *"The subject matter of satellite remote sensing is expanding at a very rapid and exciting pace. In only two and a half decades the exacting technology of Earth observation satellite has progressed from experimental and limited to quasi-operational and global. The next decade will see yet more operational satellite systems for Earth observation, with developments such as the polar platform and imaging radar systems. By the next century, this little planet will be closely and continuously monitored by a band of satellites and sensors in space".*

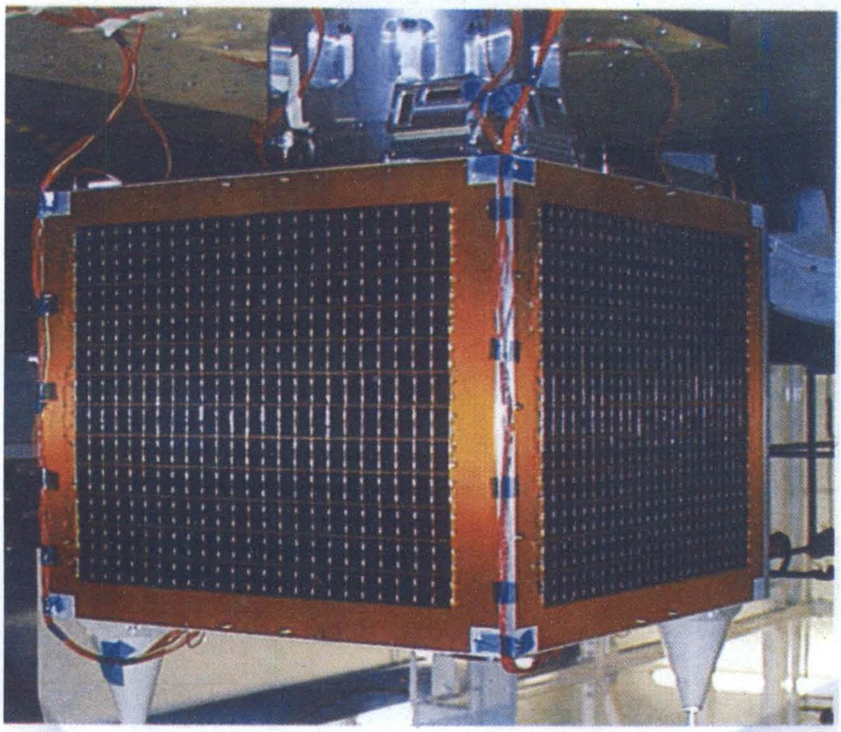


Plate 2.1: The Configuration of Nigeria Sat-1

Source: National Space Research and Development Agency, 2003.

2.3.3 Historical Analysis of Urban Growth

It is not known for sure why the first towns appeared in the world or when they were built. Some probably grew out of villages, as is demonstrated by the fact that they developed in the heart of fertile agricultural areas; others probably originated as commercial centres, and developed in places where farming was difficult but where trade or commerce or industry was possible.

For Whynne-Hammond (1979), the first truly urban settlements were made feasible during the Neolithic age when agricultural improvements (such as the introduction of the wheeled cart and ox-drawn plough) together with technological progress (including the development of sailing boats, canal systems irrigation and metallurgical skills) permitted some groups of people to leave farming. Only when agriculture is efficient enough to produce a surplus will populations diversify their occupations – to include hand manufactures, trade and community organization and begin to live in towns.

The earliest urban settlements appeared in Mesopotamia sometimes between 5000BC and 3000BC. They grew up around temples or places and developed commercial functions under the auspices of the priests. The southern part of the Tigris and Euphrates basin in particular had a dense population at that time and its chief city, Babylon, grew to have over 80,000 inhabitants (Whynne–Hammond, 1979; Clark, 1982; Daniel and Hopkinson, 1986).

The growth of Greek civilization (8^{th} and 7^{th} centuries BC) further spread the idea of urban life as cities like Athens set up daughter settlements around the Mediterranean towns such as Cumae, Syracuse, Massilia and Alexandria. New technological advances took place and thus improved ships, implements and weapons and the introduction of coinage, which alone did much to encourage trade and urban growth.

The rise of the Roman Empire extended economic progress and new administrative systems over a wider area and it was not long before towns appeared all over North-West Europe (e.g Bordeaux, Cologne, Lynons and Paris).

From the 11th century onwards trade spread, new industries and crafts developed and population grew. Some old Roman towns were rebuilt and enlarged, but many new towns were founded from scratch. It was also during the middle ages that towns first appeared in the New World as a result of European exploration and colonization. The earliest were no more than small coastal trading posts, but this soon developed their own hinterlands and expanded accordingly as commercial centres. New Amsterdam (later renamed New York), Sydney and Virginia were amongst the first.

The greatest extension and expansion of urban settlement the world had ever known came during the 18th and 19th centuries (period of industrial revolution). Improvements in agriculture, increased trade and more efficient communications all had the most profound influence on towns increasing their size, speeding their growth and transforming their characteristics.

The use of new raw materials, fuel supplies and machinery (collectively the out come of the industrial revolution) resulted in the appearance of the first real industrial towns. In spite of the influence of industrial revolution (world wide) of the 18th and 19th centuries on urban expansion, Africa is the last continent to join the rapid march towards urbanization. This can simply be explained by the fact that natural increase and massive immigration are primary component of growth in African cities during the last 1950s and 1960s. African towns/cities act as magnets to their surrounding populations because of their social facilities. Few educated ones rush to towns in search of jobs, which they may not even secure after all. To quote Clark (1982:68):

> *"The third world city is a symbol, drawing in massive immigrant streams, especially of young men, from overcrowded rural areas, only to find rural poverty replaced by urban poverty".*

A similar observation of African urban people was made by Salami (1994:73)

> *"………….Visit to the village has become rare, and when they visit home, it is surprising that their aged parents contribute money to finance their trips back to the cities. Not only that, they go back with sacks of gari, rice, guinea-corn, and tins of palm oil".*

The urbanization process in Nigeria was boosted with the attainment of independence in 1960. The general rise in the level of aspirations and social expectations among the population became intensified. Because many modern facilities were located in large urban centres, the process of rural-urban migration received a great impetus. In addition, the successful rural migrants into town/cities are usually rated higher and therefore accorded a befitting respect (than the home base dwellers) whenever they visit the village. When they finally return home as a result of retirement or for whatever reason, they are made the spokesmen/leaders of the community. The youths are thus becoming more challenged than ever before to move out emeses of their rural environment for a similar or higher recognition. The creation of states at various political periods of Nigeria greased the process of urbanization in Nigeria. Each of the 36 state capitals automatically assumes the responsibilities of a city and in most cases other urban centres eventually develop like some local government capitals.

2.3.4 Application of Various Sensors Approach to Land Use and Land Cover Evaluation and Monitoring

2.3.4.1 Aerial Photography

From the history of remote sensing, it is clear that the technology takes its root from aerial photographic interpretation. It is therefore, the oldest of the remotely sensed imageries. Aerial photography is also simple, reliable and inexpensive means of acquiring remotely sensed images. It has been used to make images from very low altitude and from earth satellites so that it can be said to be one of the most flexible strategies for remote sensing. Aerial photographs form the primary source of information for compilation of many maps, especially large-scale topographic maps. Likewise, vertical aerial photographs are valuable as map substitutes or supplements (Lo, 1986).

Remote sensing techniques have been employed at various research levels to study urban morphology and the general planning of the urban centres. For instance, Witestein (1956) made use of aerial photographs to acquire land use information for planning purposes.

This was in the town of Rockville, Maryland (U.S.A.) where there was a planning problem to expand the facility of the existing Central Business District (CBD) to meet population explosion from the country metropolitan area.

Laliberte et al (2000) made use of large-scale (1:4000) aerial photos of 1979 and 1998 combined with GIS/GPS techniques as a tool for stream discharge analysis of Catherine Creek in northeastern Oregon. The result revealed amongst others that the area of change (3.65ha) was slightly larger than the area of no change (3.2ha). Number of islands and island perimeter decreased while the island area increased.

Olorunfemi (1985) with the use of aerial photographs of 1963, 1981/1982 of different scales of 1:12,000, 1:10,000 and 1:6000 respectively, monitored the areal extent of Ilorin through those years. The study concludes that there were increases in land consumption rates in hectares of urban land of different periods, which was attributed to the changing economic base of Ilorin. Nkambwe (1984) has also carried out some studies on the physical urban growth of Ile-Ife, using multi-data sequential photographs and his conclusion of urban expansion further straightened the utility of remote sensing in urban studies.

Nevertheless, Ạdedibu et al (1998) have demonstrated the use of photo-mosaic of 1963, 1973, and 1982, and cadastral maps as base to monitor the growth of Ilorin over time. Specifically, the grid square method was used on the images and maps to obtain the physical development of factors responsible for variations in the development of various parts of Ilorin. In another study, Aderamo (1997) used sequential aerial photographs of 1963 on a scale of 1:2000, 1973 on a scale of 1:10,000 and 1982 on a scale of 1:6,000 to monitor the growth of Ilorin. He adopted overlay system to detect the required changes in land use types. The areal extent of each land use type was also calculated using the dot grid method. Through the method, an updated land use map of Ilorin for 1988 was produced.

Another development in the usefulness of photography for urban land use change detection is the census cities project by NASA in conjunction with the Geographic Application Programme (GAP) of the U.S. Geological Survey (USGS)). The USA and France weather services and NASA's manned spacecraft .centre acquired multi spectral, high altitude photography from twenty cities. The ultimate goal of the census cities project was the production of an Atlas of urban and Regional change, accommodating many types of data presentation, photo-mosaics, conventional maps, computer printed maps, tabulated data and text. In a pilot study for the city of Boston, a 24-category land use classification was employed. The minimum cell size was about 10 acres. The land use data were computer processed to make them compatible with 1970 census data.

Adeniyi (1980) used a computer-based approach to detect urban morphological changes in Lagos using aerial photographs of 1962 and 1974 on scales 1:40,000 and 1:20,000 respectively. For the purpose of analysis, he devised nine major land use and land cover categories with 45 subcategories. Using a minimum mapping unit area of 100 x 100cm cell, a computer programme was written to:

(i) compare each major land use category for the two periods on a cell-by-cell basis.

(ii) provide information about the location, type and amount of changes.

(iii) produce land use change map with the drum plotter.

The result obtained shows a rapid increase of the residential land uses and a strong lateral expansion of the urban area of Lagos. A similar work has been carried out by Ikhuoria (1993) using 1967 and 1977 black and white sequential aerial photographs at a scale of 1:40,000 and 1:25,000 respectively to interpret map of vegetation and land use changes in the rainforest ecosystem of north eastern Edo State, Nigeria. For the sake of analysis, he employed a standard manual or visual interpretation of land use types on the photographs using 0.5 hectare minimum mapping unit. Photographic interpretation elements, such as size, shape, tone, texture, pattern as well as cultural and traditional cover type attributes and associates aided in the interpretation process.

Computer/GIS assisted interpretation (computer program) would have given more accurate results of Ikhuoria's study than the manual interpretation he employed. This is really a gap this study is attempting to fill, in the sense that the major tools for data analysis inform of both hardware and software is being adopted. Nevertheless, the results of Ikhuoria's study indicate that within a decade, the ecosystem experience drastic depletion of forestlands, rapid territorial expansion of settlements and tremendous increases in agricultural farmlands.

Patrick (1987) used aerial photographs and rainfall data to assess the impact of gully erosion in parts of Adamawa and Bauchi States. He concluded that aerial photographs are useful tools for monitoring erosion hazard and land cover.

In a related development, Patrick and Abdulhamid (1989) also used photographs, complemented by questionnaire administration to assess the impact of dam construction on the down stream morphology and agricultural productivity in Kano state. The use of aerial photographs in mapping and predicting floods, water logging and erosion risk has also been discussed in the work of Abdulkadir (1986).

Although, many authors have attempted the evaluation of the applicability of aerial photographs for land use classification, the work of Omuta and Ikhuoria (1994) is unique in the sense that it (work) consisted as many as five different urban centres as its focus, which makes the work more comprehensive as compared to several similar works that have less settlements as focus.

In their (Omuta and Ikhuoria, 1994) study, sequential black and white photographs taken in 1982 which consisted of stereoscopic pairs of photographs at a scale of 1:10,000 were employed in the interpretation of the residential land use characteristics in Ekpoma and

Uromi, while 1979 and 1977 photographs at scales of 1:6,000 and 1:10,000 were used for Benin City, Warri respectively. A 1981 Orthophoto Mosaic at a scale of 1:10,000 was employed for Kaduna. The method of data generation was the interpretation of urban residential land use characteristics from aerial photographs. The result shows that about 18 percent of the residential area in all the urban centres is blighted. There were also indications that blighted neighbourhood consists mainly of residential class. On a specific term, the results show that 15.4 percent of residential neighbourood in Kaduna, 16.8 for Benin City and 17.8 for Warri are blighted.

2.3.4.2 Synthetic Aperture Radar (SAR)

The potential of Synthetic Aperture Radar (SAR) for tropical forest change detection and monitoring has received attention for two main reasons. One reason relates to the fact that microwave is pervious to cloud cover, which is persistent in the humid tropic and in mountainous areas of tropical and subtropical regions. The other reason concerns the prospects of deriving information about forest structure (height, stem diameter and frequency, canopy roughness, and above ground biomass) from SAR backscatter measurements (Armond and Steven, 1986). The all-weather capability of radar has stimulated interest in its possible applications for urban analysis.

In a study carried by Birnie and Gauld (1982), it was found that synthetic aperture radar (SAR) was more useful than aerial photography in a land cover survey in Scotland. This was due to the fact that SAR is unaffected by cloud cover giving the system an all-weather application quality very rare with other system (i.e photographic system), even with optical enhancement.

In another attempt to evaluate K-band imagery, a map of gross land use was prepared for the city of Lawrence Kansas. Well-defined areas such as the CBN and major industrial districts, are accurately delimited but light industrial, commercial and areas of mixed land were almost impossible to separate (Peterson, 1969). As reliable as this (Peterson's) research looks, its attempt to separate commercial land uses from similar land use types has not been successful.

The Nigerian Radar Project (NIRAD) through the Motorola Aerial Remote Sensing Inc. (MARS) of USA acquires SLAR of the country. The Hunting Technical Service Limited of the United Kingdom handled the interpretation and mapping and thus 69 vegetation and land use maps covering the whole country wee produced in colour (Adeniyi, 1985). The most important findings of the NIRAD project is that in the Sahel and Sudan savanna areas of Nigeria, the interpreted radar units indicated that many boundaries did not relate to the significant vegetation differences in a consistent manner. This situation arises as a result of the sparse vegetation cover of the area, which in turn allows large proportion radar energy to be back scattered from the bare soil and rock. On the other hand, in southern Nigeria, with its more humid climate, the anomalies and inconsistencies experienced in the interpretation and mapping of vegetation in the Sahel Sudan and guinea savanna areas of the country were less apparent owning to high vegetation density. From the experience of the NIRAD project, it is pertinent to note that SAR is not very useful for vegetation mapping at least for the central and northern parts of Nigeria.

Nevertheless, as a tool for identifying built-up (urban) areas, radar displays somewhat greater utility. In one test of radar imagery, it was found that all cities of over 7000 inhabitants, 80 percent of settlement over 800 in population and 40 percent of settlements between 150 and 800 inhabitants were identifiable (Simpson 1969).

2.3.4.3 Landsat Satellite

The potential for obtaining repetitive coverage of landsat for extensive area offers a means for monitoring and observing other changes in forest cover and land use types over time.

Significant research efforts have revealed tremendous urban land use and cover application of landsat data. For instance, Barret and Curtis (1982) have discussed that in UK, the Department of the Environment (DOE) investigated the use of landsat MSS digital data to assist with the monitoring of urban growth. Landsat MSS data for five towns were used. The ground checking data were provided by 1:60,000 scale aerial photography. Landsat data were first transformed by principal components analysis and then classified using a maximum likelihood classifier. The result showed that urban area were correctly classified with an accuracy typically in the range of 70-80 percent and the rural areas in the range of 80-95 percent.

Kuleli (2005) used landsat TM imageries of 1992 and 2000 to monitor land use and land cover changes in northeastern Mediterranean coast, Turkey. He made use of post-classification change detection to compare two independently prepared classified images. Two supervised classifications were produced using the same information classes to facilitate a comparison of two images. The result indicated that there was a decrease of 25.87% from 1991-2000 in the wetland surface. Moreover, an increase of 53.27% and decrease of 49.95% were determined in the shallow of wetland and sand dune respectively. The increase of 43.10% in agricultural areas was mostly obtained from sand dune and on a smaller scale from shallow water. Kuleli submitted that in order to prevent this rapid change, sustainable agricultural policies and ecosystem restorations were indispensable for the region.

In another study, Harris (1987) revealed that the Ontario Centre of Remote Sensing (OCRS) in Canada has used landsat data for forest inventory and mapping of Ontario North of 52^0N, which cover an area of more than 200,000km^2. The OCRS had produced terrain maps at sales from 150;000 to 1:250,000 on a UTM project which show the classifications of black spruce, jack pine and popular and white birch forest areas and water, wet land and forest areas.

Singh (1986) had assessed the value of landsat data for determining forest cover changes in northern India. But Singh (1986)'s study would have been more comprehensive, if the identification of the nature of changes and above all else, the estimation of the areal extent of the changes were incorporated. However, our study has taken care of these deficiencies in its analysis.

Wu et al (2005) conducted land use/land cover change detection, monitoring and modeling (for North Ningxia, China) by utilizing the multi-temporal remotely sensed data (landsat TM dated 1987, 1989 and ETM 1999) and country-level socio-economic and meteorological data. Multi dimensional synthetic method from space to ground and from human activities to environmental changes was applied in the research. Image differencing was followed to produce the general change maps of the study area. Complemented with visual comparison, the detailed country level land use changes were distinguished.

Jibril (1994) mapped and interpreted vegetation and land use categories around Gummi in north-western part of Nigeria from landsat satellite of 1975/85. For the purpose of analysis, he developed a classification scheme based on the Federal Department of Forestry's vegetation and land use classification scheme. It was designed to encompass built-up areas, rural lands, vegetation and agricultural land uses. The study identified and mapped the major land use categories, provides information about the location, types, amount of changes and above all else, produce land use maps using the overlay system. By and large the main direction of change is the conversion of forest use to agricultural land use. An indication that agricultural is the dominant occupation of the inhabitants.

Omojala and Soneye (1993) have applied remote sensing and Geographical Information Sub-system techniques for land use and land cover mapping in the middle Sokoto River, North Western Nigeria. Their study demonstrated the visual analysis of landsat imagery for the generation of land use and land cover information in their study area.

According to Barret and Curtis (1982), Landsat imagery has been processed to give land use map of urban change at scales from 1:250,000 upward. One such programme has brought together the Planning Intelligence Department of UK Department of the Environment (EOD) and Image Analysis Group at the UK Atomic Energy Authority (UKAEA) at Harwell, Barks.

Several landsat imageries of the middle east have been utilized in providing valuable environment information in land use and vegetation evaluation and monitoring. Such studies include those by Kinsley (1974): Allan (1977); Allan and Richards (1983) and Vass (1983).

According to Kim (1980), Landsat MSS data recorded in computer compatible tapes (CCT) can be used to monitor suspended sediments in water using bands 4.5 and 7. Also Hughes (1982) used landsat MSS digitized data to map suspended solids and salinity status in some irrigated lands in Atcha Falaya Bay area. He used band 5 and 6 to assess salinity status, while band 7 for suspended solids. He found a high covariance between salinity and suspended solids. In a related study, Abdulkadir (1986) has found that landsat MSS data provides a very rapid and reliable means of mapping soil conditions for irrigation planning.

2.3.4.4 Multi-Stage and Multi-Sensor

Panikkar (2008) has demonstrated the utility of GIS/Image Processing System to monitor changes (between 1930-1990) in the forest cover around Dehradun and Mussoorie in Uttar Pradesh, India. He did this, through data collected from the topographical maps and remote sensing media (IRS Data). It was observed that in 1930, the forest cover accounted for about 45% of the total study area of 445km^2. By 1960, it was reduced to 150km^2 (34% of the area). Between 1960 and 1990, there was a drastic reduction in the forest cover to about 82km^2 (18.7% of the study area). The maximum forest cover was said to haven been removed for the economic value of sal, banj, pine and fir. In this study, Panikkar mapped the occurrences of land slides using aerial photographs. The result showed that 60.27% of the landslides were in non-forested areas that were forested in 1930.

Since Panikkar's study analysed changes in land use/land cover for over a long period of 60 years (1930 – 1990), the results of the work would have been more meaningful if numerical values of annual changes for the period under focus were computed. This, in conjunction with the other results of the work, would have allowed for more detailed information for proper land use practices in depleted forest of Dehradum and Mussoore.

It is thus, the intention of our study, in a way of filling this gap, to compute the numerical values of annual changes for the period 1976-2004.

Sogunle and Fagbemi (1990) made use of French Spot image photograph of Ibadan city to monitor its land use changes. The spot image data were acquired in December 1986 at the scale of 1:400,000. On the other hand, the aerial photograph of the project area was at the scale of 1:29,000 taken in March 1973. The Federal Survey topographic map sheet 261 of Ibadan N.E at a scale of 1: 500,000 was used as base map.

It was however discovered that the change in land use involved mainly a shift from farm to urban use. Also the forest has experienced a substantial reduction in land area. For instance, the forestland at the central strip of the study area fell from 40.56 to 26.91km^2. The results of the study would have been more appreciated if they (results) were represented in bi-charts, graphs, and maps for cartographic comparism. A production of a land use change matrix table could have defined more clearly the occurred changes in land use and land cover. These lapses are equally the focus of this work.

Muijosukojo (1992) also demonstrated the use of landsat MSS and Spot XS data for mapping and monitoring mangrove in Java, Indonesia. The results showed that on the enhanced colour composite landsat imagery, the different vegetation types become more distinct. That, the colour composite of Spot imagery gave nearly the same result by showing good dense mangrove coverage especially in the eastern part of the study area.

(Multispectral) and P (Panchromatic) recorded on 8th June, 1986 and 10th September, 1986 respectively to study per-zone classification of urban land cover for urban population estimation. The Spot HRV XS and panchromatic data were combined to preserve the spatial and spectral information of the data sets. The results indicate that per-zone classification method is considered as a viable means of increasing the accuracy with which remotely sensed data can be classified in an urban environment and thereby form the basis of urban population estimation programmes.

Similarly, Koopmans (1982) carried out comparative assessment of LAR and air photograph images for geomorphic and geologic interpretation. He found that photographs and radar images are important tools for mapping land features and they can complement one another. Vink (1982) in his study concludes that landscape ecology can be mapped so easily and within a short duration using aerial photographs and radar images.

2.3.5 Applications of Models in Remote Sensing

Use of model (as an innovation) aids the viability of remote sensing technology in various application areas (be it agriculture, cartography/surveying, census surveys, population estimation, forestry, water resources, land use, regional and urban studies, military and alike). In other words, models test the applicability of remote sensing to any area. To quote an anonymous source in Lee (1974:135):

> *"Men would never attempt to send a space ship to the moon without first testing the equipment by constructing proto-type models and by computer simulation of the anticipated space trajectories. No company would put a new kind of household appliance or electronic computer into production without first making laboratory tests. Such models and laboratory tests do not guarantee against failure, but they do identify many weaknesses, which can then be corrected before they cause full-scale disasters".*

The work of Stewart (1958) is a living example of the application of the rank-size idea to large cities. From the comparison of the populations of the largest and second largest cities in seventy-two different countries, he found that the relationship was more varied than expected from the formula of rank size regularities. According to Stewart (1958), for all countries sampled, the largest city was characteristically three and a quarter times rather than twice, the size of the second largest city. Ratios varied from as high as 17.0 for Uruguay to 1.5 for Canada. The only regularity that he could find was that larger countries had lower ratios.

Similarly, Cliff and Robson (1976) have related long term changes in city-size distributions (i.e a complete city systems over time) to the maximum entropy notion (the most likely state of a system). The methodology adopted by the author was that they took the rank-size distribution for all urban centres in England and Wales with a population in excess of 2,000 for each census from 1801-1911, fitted the Whitworth-Cohen models to these data. The result indicates that:

(i) the observed population share-size distribution was markedly non-random through out the nineteenth century, with an increasing concentration of the population into the larger cities.

(ii) the fit of the models became consistently worse with the passage of each census through the century.

(iii) 1901 census represented a turning point in that the fit of the models to the data improved for the first time and 1911 registered yet another improvement. It is worth pointing out that form the 1969 Redcliffe-Maud Report, rank-size distribution for administrative regions was largely random. Moreover, Cliff and Ord (1973) have confirmed the presence of an important random element in settlement patterns in the Tonami plain, Japan. There has been an attempt by Curry (1964: 1967) to provide a theoretical justification for a significant random component in the settlement patterns. These findings together reinforce the fact that settlement patterns are mostly in random form.

In another development, a curve model was used by Aderamo (1998) to trace the trend of the change in growth morphology (rate of growth) of the city of Ilorin over time. The curve (Fig.2.12) shows that between 1963 – 1973, the city witnessed spatial expansion. Between 1973 and 1982 Ilorin experience further growth. There was however a decline in the growth between 1982 and 1988. According to Brown and Cox (1972); Casetti (1969) in Aderamo (1998), such a pattern of growth can best be described by three components

Amongst others, curve models are being used in this work to trace the history of the change in growth pattern of the study area. From the resulting figures (of the changes that were involved over the years), appropriate graphs and chats were drawn to practically demonstrate the nature and strength of changes that were involved (Figs. 5.10 and 5.11).

Following the land consumption rate (LCR) and land absorption coefficient (L.A.C) method of Yeates and Garner (1976), Adedibu et al (1998) carried out a work on the trend of physical growth of Ilorin and in their attempt to show the relationship between physical growth of the city and its increase in population, they made use of the formula:

Land Consumption Rate (LCR=A/P)-------------2.10

Where:

A is the area covered by the urban are (in km^2)

P is the population of the urban area

On the other hand, the land absorption coefficient is calculated by the formula:

$$LAC = \frac{A_2 - A_1}{P_2 - P_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(2.11)}$$

Where:

$A_1 - A_2$ are the areal extent (in km^2) for early and later years, and P_1 and P_2 are population figures for the early and later years respectively.

Their results indicate that there has been a gradual increase in the land consumption rate (LCR) of Ilorin, for instance, in 1897, the LCR was .0007 hectares per person and in 1983, it increased to .01 hectares per person. On he other hand, a figure of .037 hectares was recorded as LAC between 1897 and 1960 in it (LAC) reduced to .0096 hectares for 1960 – 1972 period and then increased to .025 hectares for 1973 – 1983 period. These flunctuations, the authors argued, were due to change in status of Ilorin to a capital city.

Similarly, Olorunfemi (1985) and Idris (1988) made use of the technique in conjunction with aerial photographs as tools to monitor the areal extent of Nigeria cities of Ilorin and Zaria respectively through time. The studies provided quantitative information on the land consumption rate as an index of the rate of population growth and data on the land absorption coefficient in the study areas.

In addition to the above, other studies that demonstrated the used of models in remote sensing applications include those of Anderson et al (1973), which used aerial photographs of 1966 at scale 1:20,000 for population estimates by humans and machines of 23 small settlements in Eastern Kansas, USA. The study based the population-estimation model on the correlation and regression models. IDECS and five human interpreters on the used photographs measured the area extents of the 23 settlements. The authors then obtained the population data for the year 1966, which were then fit into both linear and curvilinear modes in the forms Y=1+ b x and Y = a x b respectively. It was found out that the estimated population based on IDECS and those of the five interpreters for the 23 settlements vary differently from the published results by 10.89 (which was an underestimation of the 23 settlements) and by 7% (an overestimation) respectively. Although, the authors note the role of humans in the interpretation of images, they nevertheless remarked that the use of IECS enhanced the rapidity with which area of settlements can be measured.

Singh (1986) employed digital change detection techniques to analyse landsat data for 150 sites of the tropical forest environment of north-eastern India. The study established amongst others that land cover changes caused by shifting cultivation could be detected in a tropical forest environment, using landsat MSS data.

Martin et al (2002) have evaluated and compared thirty-six of such growth models in terms of their data requirements and have applied the Clark's urban growth model (UGM) in the simulation of urban growth in Santa Barbara, USA. According to the authors, the models have shown their potential to support planning and management decisions in the understanding of the dynamics of urban systems, forecast of future changes or trends of development and in the assessment of the impacts of future developments.

The work of Jinadu (2004) is a more recent example of the use of urban growth model based on remotely sensed data. He used information from the 2001 satellite image (landsat – 7) to determine the areas and the perimeters of Abuja city and the selected satellite settlements. Following the rating method of Rao (1995), the author computed the influence rate of built-up area of the settlements (IR) and attraction potential rate (APR) of Abuja. He later used IR and APR values to calculate the growth potential (GP) values of the settlements. In the study, the growth potential of settlements for 1987 and 1994 were also computed along side that of 2001 and the average was used in the final computation to account for growth fluctuation over the years.

It is worth noting that the available works reviewed in this research have over looked the processes (factors) that produce land use patterns. Because of the importance of such processes in land use change detection, this work has paid attention to it (processes). Attempt has been made to address other observed gaps in the literature so far reviewed (section 2.2).

2.3.6.0 Change Detection Algorithms (CDAs)

2.3.6.1 Classification Based CDAs

Classification Based CDAs are techniques that principally aim at assigning individual parcel to a land use class. Parcel, here means categories of features, which are recognized and delineated from examination of digital satellite data.

CDAs are information extraction processes that analyze the spectral signatures and then assign pixels to categories based on similar signatures (Jensen, 1996; Curran, 1988; Lillesand and Kiefer, 1987; Lark, 1995a, 1995b). The two general types of classification schemes according to them are: (i) Supervised (the technique, which this work made use of) and (ii) Unsupervised classification.

2.3.6.1.1 Supervised Classification

The scheme uses independent information to define training data that are used to establish classification categories. The independent information may be spectral reflectance data for the classification categories. Another source of information is knowledge of the location of areas within the image that typify each of the desired classification categories. Such localities are known as training areas. To put in another way, the image analyst "supervises" the pixel categorization process by numerical descriptors of the various land cover types present in a scene. Each pixel in the data set is then compared numerically to each category in the interpretation key and labeled with the name of the category it "looks most like" (Lillesand and Kiefer 1987). It is worth noting that supervised classification is the most accepted and therefore widely used than the unsupervised scheme.

2.3.6.1.2 Unsupervised Classification

According to Lark (1995a, 1995b); Jensen (1996) and Curran, (1988), this approach defines the classes objectively by multivariate statistical techniques and after classification, the analyst assigns a given spectral class or group of classes to a known land cover class. This method is potentially useful for classifying images where analyst has no independent information about the scene. Thus, the fundamental difference between these techniques is that supervised classification involves a training step followed by a classification step. In the unsupervised approach, the image data are first classified by aggregating them into the natural spectral grouping or clusters present in the scene. Then, the image analyst determines the land cover identity of these spectral groups by comparing the classified image data to ground reference data (Lillesand and Keifer, 1987).

2.3.6.1.3 United State Geological Survey (USGS)

The USGS classification has many attractive unique features. According to Jensen, (1987) and Curran (1988), it is prepared specifically for use with remotely sensed imagery. Its categories are appropriate for information interpreted from aerial images and it has hierarchical structure (i.e ordered classes) that lends itself for use with images of differing scales and resolutions. Additionally, the fact that it is left open-ended is an added advantage. This is because various levels of government, for example, may have flexibility in developing more detailed classifications at the third and forth levels. Such an approach permits various agencies to meet their particular needs for land-resource management and planning and at the same time remain compatible with the national system (Avery and Berlin, 1985).

The classification has therefore been successfully used not only within the US but in other countries of the developed and developing world with light modification. In the words of Avery and Berlin (1985:252):

> *"The expandable system devised by the US Geological Survey (USGS) (Anderson et al, 1976) represents a national classification scheme that has achieved widespread acceptance and it is being used in a number of operational mapping programs".*

Inspite of the good attributes of the supervised and unsupervised classification approaches, several studies have attempted to refine classification techniques to improve accuracy or to solve special problems related to land cover classification. Case in hand is Jensen (1979)'s layered classification strategy that used different decision criteria at different levels in the classification hierarchy. However, whichever approach used, each classification is supposed to suit the needs of the user because there can hardly be users that will be satisfied with an inventory that does not meet most of their needs.

2.2.6.1.4 Maximum Likelihood Classifier

Maximum likelihood classifier works by calculating the mean vector, variance and correlation for each land cover class in the training data, on the usually valid assumption that the data for each class are normally distributed (Gaussian) (Castleman, 1979). With this information, the spread of pixels around each mean vector can be described using probability function. Pixels from the whole data set are allocated to the class with which they have the highest probability of membership. As every spectral response has a probability however low, of representing a class, no pixels are left out in the cold (Curran, 1988). Change of a few pixels in a classification would be much more difficult to detect, especially with some pixels in the images (Howarth and Wickwave 1981).

Though maximum Likelihood classifier has been described to be the most expensive, it is also said to be the most accurate classifier (Tomlins, 1981).

To improve the accuracy of maximum likelihood classifier for particular application, it is possible to interactively weight each class (Hajick and Simonett 1976; Strahler, 1980; Lillesand and Keifer, 1987). According to them, such manipulation is justified in two situations. First, when the training set does not represent the proportion of the classes in the total scene. For example, as the class "Urban" was probably over represented in the training set (Fig.2.13), it would be permissible to reduce the probability of classifying "urban" pixels in the whole data set by reducing the "urban" weighting. Second, when all pixels in a given class must be classified as belonging to a given class, even though this would mean large errors of commission. For instance, if all forest must be recorded, the weighting of the "forest" class could be increased.

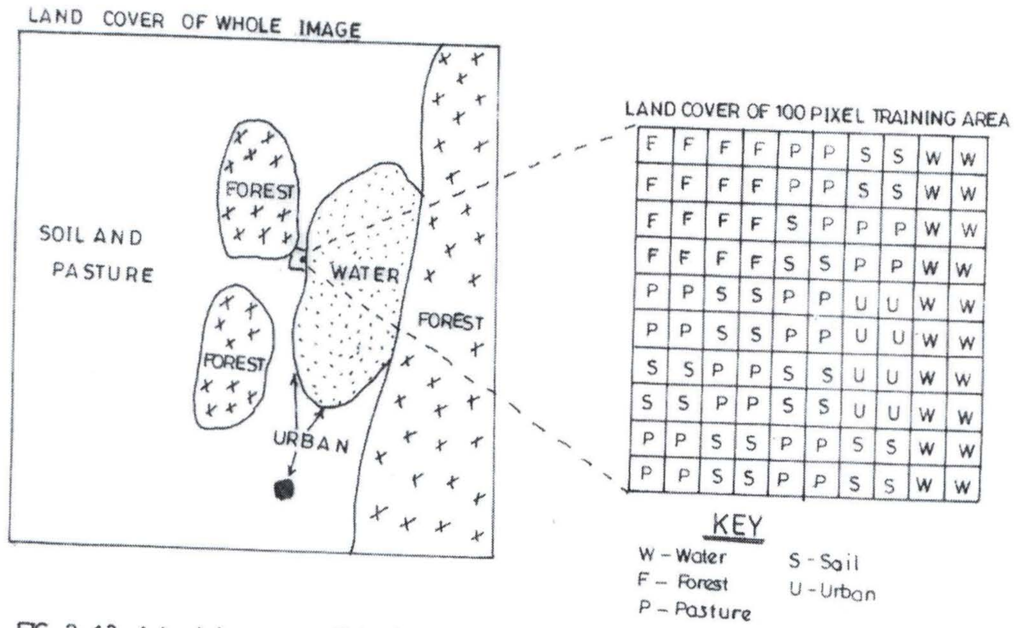


FIG. 2.13: A training area 10 X 10 pixels in size extracted from a hypothetical Landsat MSS image.
SOURCE Curren 1988

To improve the speed and therefore reduce the cost of this classifier, it is possible to restrict the search area for each class using information gained during training (Eppler, 1974). Once defined, these restricted search areas can be incorporated as "look-up" tables for implementation on similar data sets (Brooner et al 1971; Moik, 1980).

2.3.6.1.5 Minimum Distance to Means Classifier

It can be deduced form the phrase of this classifier (i.e minimum distance to means classifier) that a pixel is assigned to the mean pixel only on the basis of shortest distance to the later (mean) pixel. Curran (1988) has noted that a data boundary is located around the mean vectors (pixels) such that if a pixel falls outside of this boundary, as has pixel pii in figure 2.14a, it will be classified as "unknown".

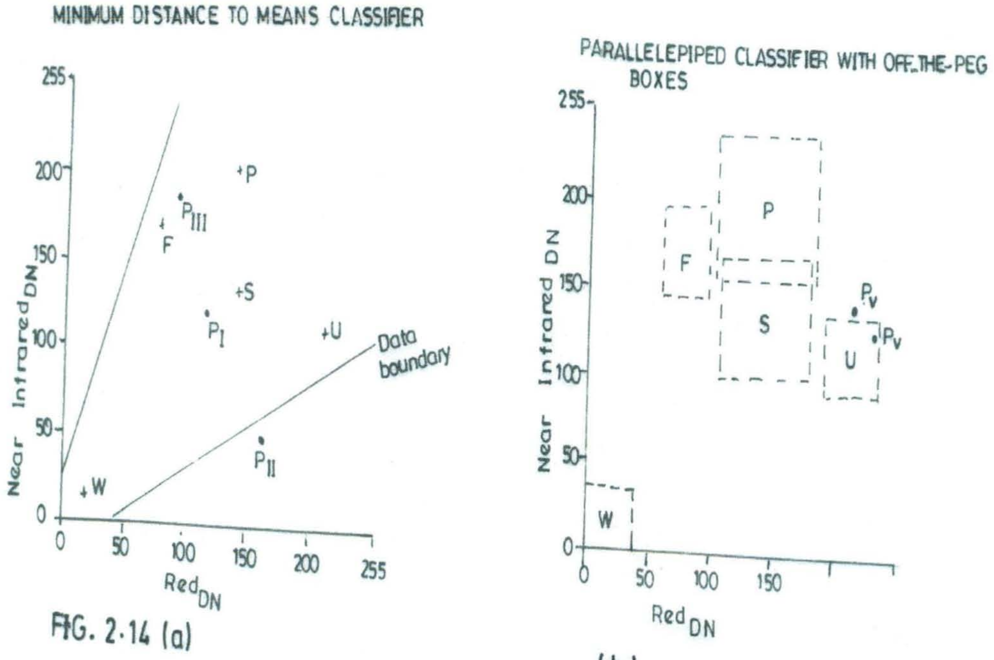


FIG. 2·14 (a) (b)

Two classification strategies used in supervised classification to extrapolate training data over the whole data set
SOURCE: Curran, 1988.

2.3.6.1.6 Parallelepiped Classifier

It involves the use of DN values of a satellite data in isolating the pixels of similar spectral attributes into spectral classes. This (i.e separation of pixels) is done by means of lines (or boxes) drawn in parallepiped shapes (Abubakar, 1998). These boxes can be placed around each class in the training data and the pixels in the total data set can be classified by the box into which they fall. For example, in figure 12.14b pixel piv falls into the "urban" box and would be classified as "unknown' (Curran 198).

2.3.6.1.7 Post-Classification Comparison

Here, multi data digital imagery data sets are independently classified and then compared, either on a pixel – by – pixel basis, or on polygon-by-polygon basis (Wickware and Howarth, 1981; Jensen, et al; 1993).

Post-classification change detection is used (as in this study) to compare two independently prepared classified images. Two supervised classifications are produced using the same information classes to facilitate a comparison of two images. This procedure not only allows areas of no change to be identified, but in areas where change has occurred, the nature of the change can be determined (Howarth and Wickware 1981).

Comparison of data sets after classification removes much of the effect of the differencing properties (e.g differences in scale or resolution) of the two compared data types. This allows each data to be classified into desired land cover classes, based on the inherent characteristics of the data (Jakubauskas, et al, 1990). Furthermore, this removes the need to normalize images to each other and holds any inherent data defects within the single data set, which may, in part, compensate for the differing condition of vegetation during the two seasons, being compared (Howarth and Wickware, 1981). Thus, by properly coding the classification results for times t1 and t2, the analyst can produce change maps which show complete matrix of changes.

Singh (1989) has outlined three main advantages of this algorithm:

(i) selective grouping of classification results allows the analyst to observe any subset of changes which may be of interest.

(ii) it minimizes the problem of normalizing the two data sets for atmospheric and sensor differences;

(iii) it eliminates the need for having the two images being compared: accurately-co-registered.

Martin and Howarth (1989) have observed that the algorithm overlooks land conversion, if the land development stage appears between the dates of image capture. Also, since every classification system is associated with errors (especially those of misclassification and non-classification), errors margin tends to increase as the algorithm is applied to long term monitoring of changes. In most cases, it is also not easy to produce comparable classifications from one data to another (Toll, et al, 1980).

Additionally, the algorithm is computationally extensive and it does not use any coincident ground information for comparison purposes. Thus, creating a chance of interpreting misclassification as a land cover change (Rutchley and Velcheck, 1994).

2.3.6.2.0 Enhancement – Based CDAs

Image enhancement is all about improving the visual interpretation of an image by increasing the apparent distinction between the features in the scene (Lillesand and Kiefer, 1987). So, since classification based CDAs have numerous problems (section 2.3.6.1). Howarth and Boasson, (1983) amongst others have suggested that enhancement based CDAs can be used either alone or in league with classification-based CDAs to improve the reliability of a change detection exercise.

The use of enhancement-based CDAs as outlined in Abubakar (1988), have the following advantages:

(i) they eliminate the need for adopting a classification scheme, even though, the pixels that have been identified to have changed can themselves be classified.

(ii) afford a situation where a change detection exercise is conducted within a relatively shorter computing time.

(iii) increases sensitivity to change identification and affords easy data manipulation and detection and therefore could determine the nature and extend of change.

(iv) since only the changes rather than the whole features on an image are enhanced, enhancement-based CDAs are considered as economically viable interms of compute space.

Moreso, Singh (1989) has suggested that significant increase in change detection speed and accuracy can be achieved by representing only the changes rather than exposing the analyst to whole information on the images being compared.

A major problem of image enhancement according to Curran, (1988), Lillesand and Kiefer (1987) is that most enhancement operations distort the original digital values. It is thus, not done until all the other processing steps are complete.

2.3.6.2.1 Image Differencing

It is a means whereby one digital image is taken from another digital image but must be of the same area acquired at a different date. The two images are then aligned and compared pixel by pixel to generate a third image indicating the extent of change on per-pixel basis. Where no change has occurred, the difference becomes zero. To put in another way, the values that are near zero show pixels, which have same or similar spectral value and in such a situation, it is assumed that the pixels have experienced no change between the two periods/dates. Normally, constant value, which Abubakar (1998) has defined as the highest DN value of the bits category is added to eliminate negative value. For example, a constant like 130 for 12-bit (12^{12}) data is usually added to the difference (which can either be positive or negative). As earlier pointed out, this is aimed at eliminating negative values. The pixels are then carefully separated based on the selected threshold, into two groups first, is the category of pixels that experience change and those pixels, which have not changed in land use and land cover.

Jensen et al, (1993); Jensen (1981, 1982, 1996); Singh (1986; 1989) reported that image differencing is among the most accurate change detection algorithms. But that it is not equally effective in detecting all forms of land use and land cover. Not only that, but two sets of different absolute values can have similar difference values, and such may be interpreted as similar pattern of changes. For example, 980 – 950 =30, and 540 – 510 =30 and in such a case, loss of substantial information can hardly be avoided. A possible solution to this, according to Abubakar (1998), is to convert all difference values into percentages. If this is done, 980 – 950 will indicate 3% while 540 – 510 will indicate 6% change.

2.3.6.2.2 Image Ratioing

Ratio images are enhancements resulting form the division of DN values in one spectral band by the corresponding values in another band (Lillesand and Kiefer, 1987). In other words, the pixel values of time t1, are divided by those of t2, pixel by pixel. And this is computed using the following equation:

$$RxijK = \frac{BVxijK(t1)}{BVxijK(t2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2.12)$$

Where:

R = denotation for ratio value

Xij = Ratio of pixel X at row I, column

K = band being used in the ratioing

BVx = brightness value of the pixel

(t1) = time one

(t2) = time two

Pixels of no change will give a ratio of 1.0 and medium grey tones, while those of change will have values either higher or lower and will be displayed in either light or dark tones (Howarth and Boasson, 1983). If ratios of 2 sets of bands are assigned 2 or 3 colour guns, colour enhancement can be used to show areas of changes and non changes in distinct colours. In such situation, a change histogram is produced.

Image ratios are important in change detection because they can standardize for variations in illumination (chiefly differences in sun-angle due to different dates). And this can permit more accurate detection of spectral changes. Ratio images show the variations in slope of the spectral – reflectively curves between the two wave length bands. These variations are useful for distinguishing among rock types because the main spectral differences in the visible and photographic IR regions occur in the slope of the reflectivity curves (Wolfe et al, 1978). A disadvantage of ratio images is that differences in albedo are suppressed. Thus, dissimilar materials with different albedos, but similar slopes on their spectral reflectivity curves, may be inseparable on ratio images. Moreover, the algorithm has also been criticized for the non-Gausian (not normally distributed) distribution it gives of change values. If the distribution is non_Gausian in nature and functions of the standard deviations are used to delimit change from no-change, the areas delineated on either side of the mean are not equal (Singh, 1989).

2.3.6.2.3 Principal Components Analysis (PCA)

It is often difficult to understand many multi spectral images of a scene taken at two different dates. This is because they may appear very similar (Like twin babies) as they almost portray the same information. This problem can be eased if the information, which is particular to each image, is combined into a new image by means of a statistical transformation of Principal Component Analysis (PCA) (Short, 1982). This technique (PCA) aims to replace the original wavebands, which describe the data with new orthogonal axes that better describe the particular scene under study (Curran, 1988). The compression algorithm therefore, summarizes the information contained in an original spectral (n-channels) data set to form refined/clearer components, which are now used in change detection exercise. According to Bryne et al (1980), PCA has an advantage of separating changed areas from no-change areas. On the other hand, a disadvantage of PCA is that when it is applied to a multi temporal data set the proportion of change area in an image must be relatively small in order for the technique to produce meaningful results (Singh, 1986). Abubakar (1998) is therefore, with the view that for large area application in which large scale vegetation changes have taken place, the algorithm is likely to produce an accurate results.

2.3.6.3 Simulation-Based CDAs

This algorithm is based on the principle that it is possible to form models, which can give useful information from spectral satellite data (images). One of such models is the Li-Strahler Invertible Forest Canopy Reflective (IFCR) model. It (IFCR) was designed to estimate the size and density of tress from remotely sensed imagery (Li and Strahler, 1985). The model assumes that satellite measurements (pixels) are larger than the size of individual tree grown, but smaller than the size of forest stand. The signal received by the sensor is thus, modeled as consisting of the sunlight reflected from the tree crowns, the background and the tree's shadow in the IFOV of the sensor (Macomber and Woodcook, 1994). Estimates of crown cover for two data sets calculated using this model, can be compared to detect changes in vegetation (Abubakar, 1998).

Following from the review of the Change Detection Algorithms (CDAs) in this work, it can be deduced that:

(i) no CDA is independent of the others. Rather, they are complementary to one another, depending on the nature and/or degree of dullness (complication) of an imagery.

(ii) all the CDAs have the common task of making an image to be free of any ambiguity that can make it to be uninterruptible and/or unreadable.

(iii) the common aim of the CDAs is thus, to ease the work of the analyst and to give total satisfaction to the end user of the remotely sensed images.

2.3.7 Conclusion

An attempt has been made so far to review the relevant literature within our reach for this study. In the process of this effort, it has been discovered that a review of this nature is practically inexhaustible as many writers on a continual basis produce volumes upon volumes of literature on the concepts and applications of remote sensing in various fields of human endeavour.

It is however our hope that with further discoveries of more powerful sensors, platforms and improvement in handling techniques of the remote sensing materials/products, its applications to explore the earth's surface features will be more intensified for the benefit of man, because more relevant products of the technology will be readily available and access to them will be less difficult especially for the developing countries, such as Nigeria.

The fact that even the developing countries such as Nigeria, South Africa and Indonesia have started to place satellites in the orbit, would mean that in no distance feature, no earthly resource may go untapped. This is because, "satellite light" will be beamed all over the globe in search of even the smallest atom of resource – be it natural and/or artificial. And this will in effect, at long run, improve the economic base of nations all over the globe.

CHAPTER THREE

3.0 GEOGRAPHY OF THE STUDY AREA

3.1 Introduction

This chapter presents a description of the geography of the city of Ilorin with the break down as follows: location; geology and soil; climate; drainage and vegetation. The other aspects considered are the economic characteristics, occupation and ethnic composition. Also, some discussions of the historical development of the city were given.

3.2 Location and Physical Setting

The study area is located approximately between latitude $8^{0}31^{1}39^{11}$N – $8^{0}36^{1}00^{11}$N and longitude $4^{0}23^{1}31^{11}$ – $4^{0}39^{1}12^{11}$E on the grass plains of the southwestern Nigeria (Fig.3.1). Igneous and metamorphic rocks of the basement complex underlie the Ilorin region. Rocks of the basement complex, which occur in Ilorin, are mostly gneisses, granites and schists, which have thoroughly weathered. Over this bedrock, lateritic outcrops are common, (Udo, 1978: Iloeje, 1980).

The morphology of the area over which Ilorin is built is a gently undulating terrain about 300 metres above sea level (ASL) but rises up to 394 metres (1300ft) above the general surface of the land in the northwestern part (Iloeje 1980)

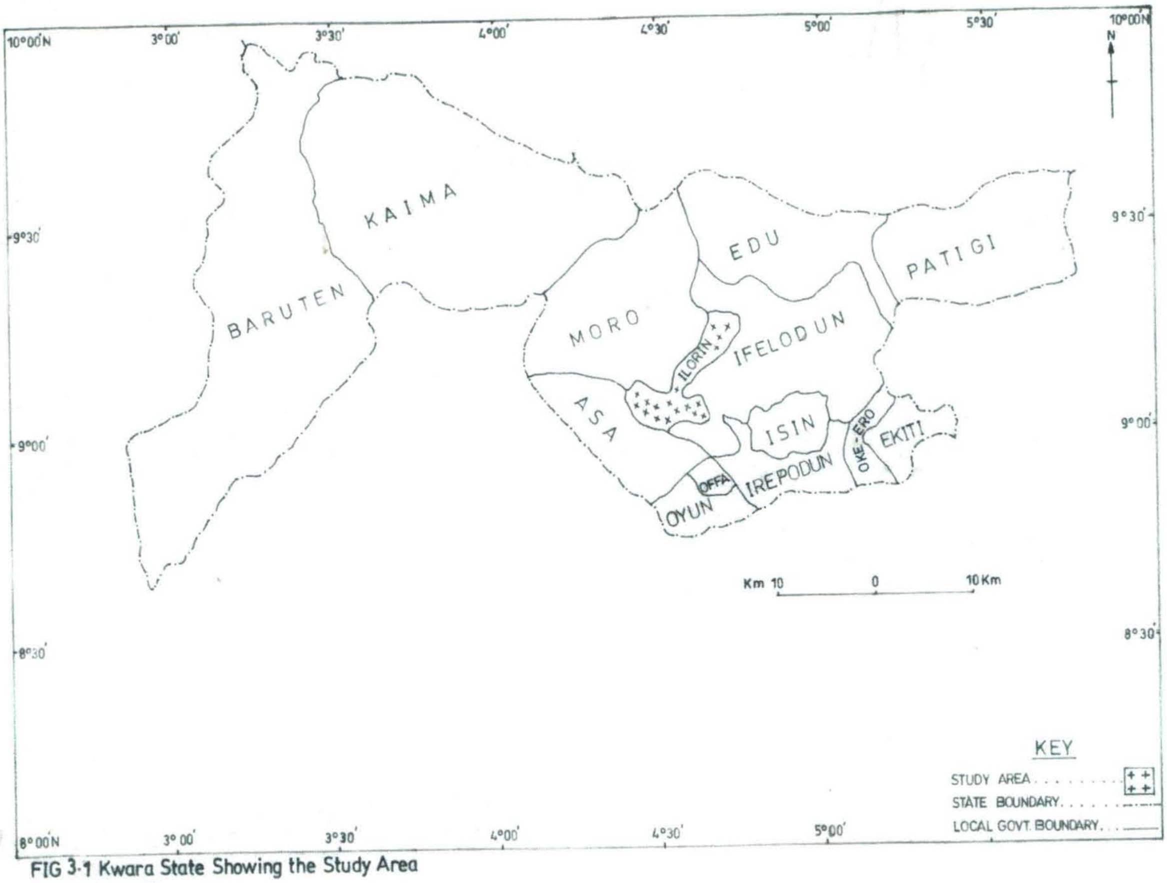


FIG 3-1 Kwara State Showing the Study Area

SOURCE : Oloru, 1998

This upland is locally known as Sobi hill. During the field work stage of this study, it was found out that Sobi hill serves as a place of worship for lots of people and attracts educational visits and tourists. Also, some parts of Ilorin can be viewed from the top of the hill.

3.3 Soils

According to Courtney et al (1989), the soils in Ilorin are lateritic. The soils are deeply eroded and grey or reddish in colour. They are generally sticky. The red colour and the clay are products coming from the breakdown of the schists. Quartzite and quartz stones are also prominent on the surface and indeed throughout the soil profiles. On the hilltops as in Shao, and upper slopes, the soils are shallow, well drained with few outcrops of iron pan and are therefore poor for intensive cropping (Udo, 1978; Iloeje, 1980). Deep wash soils, which are usually sandy and free from ironstone gravels, are found in the lower slopes and in association with alluvial soil in the valley bottoms as along the valley of Asa River and Abga and Asa dams environs. Such areas are considered suitable for intensive cropping.

3.4 Climatic Setting

Ilorin experiences tropical micro thermal (CA'w) climate (Money, 1980). The dry season commences in November and ends in March. Days are very hot during the dry season. From November to January, temperatures typically range from 33^0c to 34^0c, while from February to April; values are frequently between 34.6^0c and 37^0c (Oyegun and Olaniran; not dates, Oloru, 198). This high temperature is attributable to little or no cloud cover during the day. The Harmattan period, which is cold, misty (in the morning), haze (in the afternoon) and dry through its period, sets in by November and ends by early January. During this period, the thirsty winds quickly dry up anything wet, and then the humidity falls to about 40% (Iloeje, 1980).

The wet season lasts for seven months beginning from April to October with mean annual rainfall of about 1318mm (51.9ins). It rains for an average of 11 days per month, during this period, except in September when it rains at least once in two days. A rainy day is here defined as the last 24 hours with at least 0.25mm rainfall. The rainfall peak is in June-August. The heavy cloud cover of the period reduces the intensity of the sunshine from the mean daily range of 14^0c in the dry season to 8^oc in the rainy season. The relative humidity in Ilorin is about 80 percent during the month of June, July and August (Oyegun and Olaniran, not dated). A basic characteristic of the rains in Ilorin are their variability at the on set, and abrupt end in some of the years. It is however interesting to note that the climate of Ilorin is not extreme because it is free from the scorching heat of the interior north and the very damp nature of the south.

3.5 Drainage and Vegetation

Ilorin city is drained by Asa Rive that flows in a south-north direction. The river divides the city into two parts: the western part, which is the core of the indigenous area of Ilorin and the eastern part where the Government Reserved Area (GRA), the Government Secretariat and the main campus of the University of Ilorin are situated. Both the western and eastern parts slope towards the Asa River valley but the eastern part is comparatively steeper (Oyegun and Olaniran, not dated). The area occupied by the Asa basin is about $731km^2$. Also the basin stream frequency is about 0.66 channels for every km^2 and the drainage density is 0.956. Close to the mouth of Asa River are Agba and Asa dams (Jimoh, 1997). As a perennial river, Asa is fullest towards the end of the rainy season and experiences low flows towards the end of the dry period. River Asa is very important to the people of Ilorin for water supply, farming in the basin, local fishing as well as for disposal of wastes from households and industries.

The natural vegetation in Ilorin falls within the guinea savanna belt and there is a considerable variation in floristic composition and structure in the region. Cultivation, burning, grazing, cutting of wood for fuel and above all, the city expansion are largely responsible for the differences between the present biotic vegetation and it's past climax vegetation. Along the river valleys, poorly drained sites usually support fringe forests, since they are only cultivated occasionally and are rarely disturbed by fires. During the rainy season, the trees and grasses, whose heights range from 3-36meters and 6-7meters respectively, are green and luxuriant. On the other hand, in the dry season the vegetation becomes brown and dry. It is at this time that bush fires are most common (Udo, 1978; Iloeje, 1980). Locust bean trees, sheabutter trees and bamboo tress are amongst the commonest trees in Ilorin, which the farmers do much adore for their economic importance.

3.6 Economic Activities/Occupation

The urban economy of Ilorin has under gone some remarkable changes since the establishment of British Colonial Administration in the country. During the pre-colonial period, the economy of Ilorin was characterized by farming. Indeed, a considerably large percentage of the population took to farming not merely on a subsistence level, but really as a profession as the vast savanna grassland is highly conducive to the production of yam, cassava, guinea corn, maize and cotton. Some people engaged in craft production such as weaving (done by men), pottery (done by women) and basket and mat making (done by both men and women). Ilorin is the traditional home of popular local textile, "Aso Oke", leather works, embroidery and dyeing. Some of the workshops where these activities take place offer good tourist attractions, e.g. the Dada pottery of Alagbado street. Though, these traditional (local) business, which are still being practiced in the indigenous parts are almost fading away as a result of competition from imported cloth and plastic containers, they may continue to generate employment opportunity for the citizenry of Ilorin. Moreover, the social values of these traditional products are significant as means of preserving the culture of Ilorin. (Kwara State Government, 1968: Onokerhoraye, 1982; Oyebanji, not dated).

The establishment of colonial administration in the country introduced new forms of economic activities in Ilorin, which were designed along the line of the typical western economy. This development brought about some modifications to the traditional system of production. In 1952, about forty-two (42) percent of the urban labour force in Ilron was engaged in agricultural activities (Onokerhoraye, 1982). This shows a remarkable decline from the pre-colonial patterns where the vast majority of the labour forces were involved in agricultural and other primary production activities (Mabogunje, 1968). The steady decline in the proportion of labour force engaged in agricultural activities in Ilorin over the years suggest that a large variety of new economic activities have emerged in the town.

With the Nigerian independence, and the later creation of Kwara state in 1967, many more people of Ilorin were employed in Government service and in the private sectors like Bank Insurance Companies, Hospitals, Pharmaceutical Centres, Hotels, Motels and a host of others. Ilorin also has a wide range of light industries, which include block making, tailoring, bicycle repairs, saw milling, vehicle repairs, house hold goods, servicing and laundering, to mention but a few (Oyebanji, not dated). In addition, many large-scale industries have been established over the years in Ilorin, which also provide employment for the people. Such industries include Cocoa Cola; Pepsi Cola plants, United Match Company and Philips Morris etc (section 1.2).

Another major development in the economy of Ilorin in recent years has been the involvement of a large number of people in trade and commerce. The traders, most of whom are women, tend to carry out their businesses largely in the market places but many now have modern shops in the streets of Ilorin. Those of them who have got no space in covered stalls stay in the open where they use umbrellas to protect themselves from either the scorching sun or light rainfall. It can be inferred from this that the Ilorin women are highly enterprising.

These trends in the economic development of Ilorin over the years has led to the physical expansion of the city, rapid increase in population, material and economic progress, more efficient and specialized services, development of new technologies and skills and higher living standards amongst others.

3.7 The People of Ilorin

Ethnically, the people of Ilorin are mainly Yoruba but the Fulani hold a more powerful political position. This is not unconnected with the fact that the traditional ruling house is only composed of Fulani descendants. As it is being practiced in most of the major towns in the north, a basic qualification to become an Emir is to be a descendent of Shehu Usman Danfodio or/and his flag bearer. Thus, this completely rules out the possibility of any person from any other tribe to be enthroned as Emir of Ilorin. Other tibes in Ilorin are Hausa, Nupe, Bariba and Bassa-Nge, Igala, Igbo and Gbagi.

3.8 History of Ilorin at a Glance

The term "Ilorin", is said to have been derived from two contending root words, namely: Ilo-Irin, from the large stone where implements were sharpened; and "Ilu-Erin", "town of the elephant", (Kwara State Government, 1968: Oni, 1980).

Before the advent of the Fulani Jihadists, there was no paramount ruler in Ilorin. The town was rather ruled right from Oyo by the Alafin. Ilorin, therefore, developed from a number of scattered settlements such as Okesuna hamlet headed by Solagberu, Okelele with Ojo-Isekuse as the head and Idi-Ape, headed by Afonja. Others were Gaa hamlet headed by Olufadi and Gambari with Sarki Gambari as the head (Kwara State Government, 1977).

The civil wars, which took place in various parts of Yoruba land during the later years of the eighteenth century, had remarkable effects on the history of Ilorin. In the early nineteenth century, the Oyo Empire began to disintegrate as a result of these wars. And in Ilorin, the commander of the Yoruba army and government of the town, Afonja, rebelled against his overlord, the Alafin of Oyo forces. Afonja sought the help of a Fulani Mallam and a flag bearer of Usman Danfodio from Sokoto called Alimi. In the encounter that followed, the Yoruba army was defeated but one of Alimi's sons, Abdul Salami, was ambitious and consequently murdered Afonja declaring himself the first Fulani Emir of Ilroin in 1831. This event is of major importance in the socio-cultural and political history of Ilorin as the town has since then been subjected to Fulani and Islamic influences. Thus, the social and political organization of the town has been quite different from those of other major Yoruba towns that are still solely under the political, socio-cultural and religious influence of Yoruba. (Mabogunje, 1962)

Ilorin was the headquarters of Ilorin province of Northern Nigeria, a status it retained even after the creation of Kwara State in 1967. It also served as the headquarters of Ilorin Division as well as Ilorin Emirate council, which is now made up of five Federal Government approved Local Council areas viz, Asa, Moro, Ilorin West, Ilorin East and Ilorin South.

The present traditional ruler of Ilorin emirate Council is Alhaji Ibrahim Gambari, the 13th Emir of Ilorin and the Chairman, Kwara State Traditional Council of Chiefs.

The secondary data were collected from Survey Division, Federal Ministry of lands and Survey, Ilorin, Statutory Boards, Parastatals and Remote Sensing/GIS Centre, Federal Ministry of Rural Development Kaduna, and Department of Geography, University of Ilorin. Other vital information was derived from library books (texts), journals, thesis and published reports.

Table 4.1: Reference Data and Their Characteristics

Data Type	Date of Production	Scale	Identification No/Code	Acquisition Source
Ilorin-West L.G.A. Map	2001	1:50,000		Survey Div. Kw. State Min. of Lands and Surveys, Ilorin.
Ilorin and Environs Street Guide Map	1987	1:20,000		Survey Div. Kw. State Min. of Lands and Surveys, Ilorin.
Topographical maps of Nigeria Sheets:				Federal Surveys, Kaduna.
Ilorin NW	1966	1:50,000	Sheet 223	
Share SW	1964	1:50,000	Sheet 202	
Igbeti SW	1967	1:50,000	Sheet 201	
Ogbomosho NE	1966	1:50,000	Sheet 222	
Ilorin	1968	1:250,000	Sheet 50	
Nigeria	1970	1:500,000	Sheet 21	
Land Use and Infrastructure Map	1983	1:150,000		Kwara State Agricultural Development Project Ilorin.

Source: Compiled form the assorted maps used, 2006

4.1.3 Primary Data

Primary data were obtained directly from the field through two basic methods:

(i) Structured questionnaire administration (appendix 1)

(ii) Oral Interview with:

(a) Officials of relevant Kwara State Government Ministries and Parastatal/Statutory Boards in Ilorin.

(b) Traditional Ward Heads

4.1.3.1 Structured Questionnaire Administration

Under this category, two steps were involved in the selection of samples for the survey. In the first place, the built-up area in the city was demarcated into a number of units. The traditional boundaries of the existing wards in the city of Ilorin, which covered all its continually built-up parts, were used to identify eighteen units (strata). These administrative units have been used by Onokerhoraye (1982) in his study of pubic services in Ilorin. Two of these units namely Baloguns Aḷanamu and Ajikobi, were each re-divided into two units because of their large sizes. Thus, a total of twenty (20) units which covered both the old and new parts of Ilorin were defined for the purpose of data collection (Fig.4.1).

Seven out of this number (35%) were selected as sampling areas. These included Balogun Gambari, Magajin Ojunneku, Magajin Oloje, Adewole, Zango, Sabon Gari and Magaji Baderi, which were chosen through a random sampling process. That is, the name of each of the twenty wards was first written on a piece of paper. Then, these pieces of paper (20) were individually squeezed, put in a container and shuffled. One out of these was picked at a time after which the remaining were shuffled before the next pick. This process was followed through out the selection exercise, which led to the emergence of the seven Sampling areas (wards) stated above.

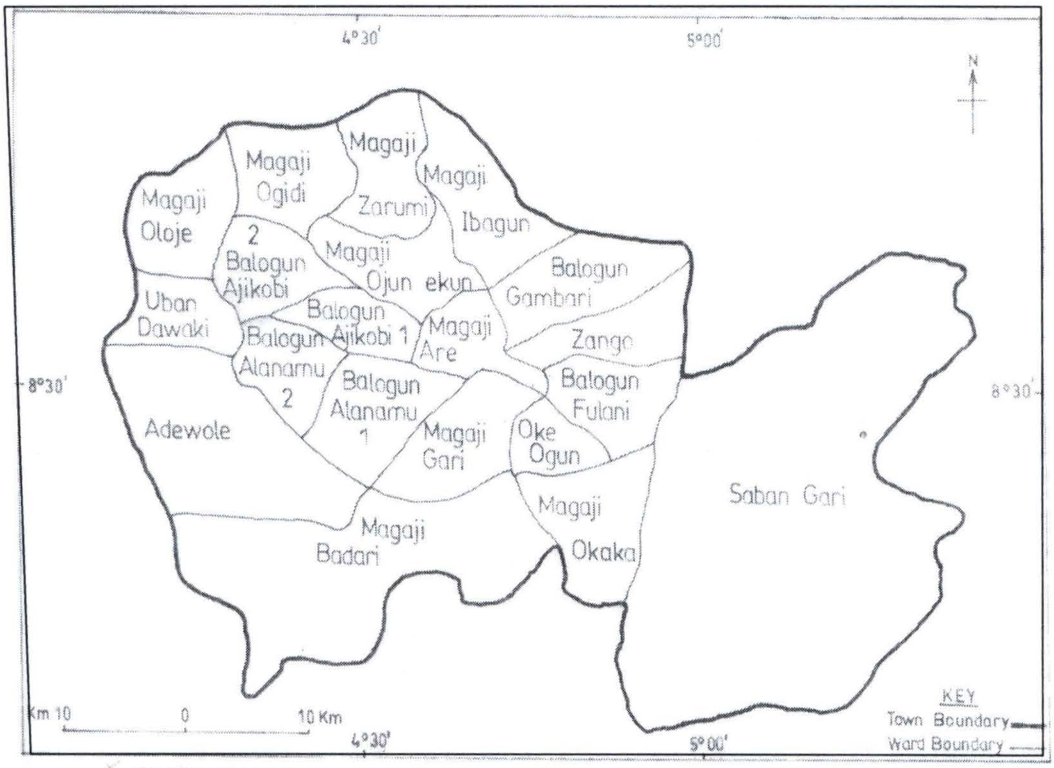


FIG4.1:SUBWARDS OF ILORIN.
SOURCE: ONOKERHORAYE (1982).

At the second stage of the survey, the total number of compounds in each and all the seven wards selected, served as the sampling frame for purposes of actual questionnaire administration.

Questionnaire administration was done after the population had been stratified based on the formal units of aggregation earlier alluded to. Both random and systematic sampling methods/procedures were used in picking the actual samples.

In old Ilorin, the names of the traditional compounds were used as a guide. But in new Ilorin, where there were more or less planned streets, such existing street/road systems were used as a guide. The fact that the streets were officially designated, served as an added advantage. On each of the streets, the first sample member compound or residential unit was chosen randomly in both old and new Ilorin based on name of compound or street number as the case may be. Subsequent residential units were selected according to a regular interval. The interval was determined by applying a formula, which was used by Jinadu (2004:16) as follows:

CL = Th/Ss----------------------------- (4.1)

Where:

CL = Class interval

Th = Total number of compounds (30,000)

Ss = Sample size (3,000)

.. = 30,000/3,000 = 10

Cl = 10

This indicates that if the starting sample number is determined to be 3, the subsequent selections, which will be added to 3 will be based on the class interval of 10 e.g 13, 23, 33, 43, 53 etc.

As earlier stated, the questionnaires were administered on household heads in the sampled compounds on "first encountered" basis. That is, where a selected compound contained more than one household, head of the first to be encountered by the researcher was picked and interviewed.

Ten percent of the total number of compounds (30,000) in the seven wards was drawn to obtain the sample size of 3,000. Thus, 3,000 copies of the questionnaires were distributed in the seven wards on the basis of their respective population sizes (Table 4.2). This means that Zango, with the highest population (47,241) of the seven sampled wards, received the highest number of questionnaires (741) as reflected in Table 4.2.

Table 4.2: Order of Questionnaire Distribution

S/N	Ward	Ward Population	No. of Compounds	% Overall Sample	Actual No. of Questionnaires
1	Balogun Gambari	29,156	4,098	13.66	410
2	Magajin Ojunnekun	26,093	3,024	10.08	302
3	Magajin Oloje	15,088	2,371	7.90	237
4	Adewole	37,008	5,346	17.82	535
5	Zango	47,241	7,412	24.70	741
6	Sabon Gari	40,923	6,506	21.69	651
7	Magajin Baderi	6,789	1,243	4.14	124
Total			30,000	100	3,000

Source: Field Work, 2006

However, only 2005 questionnaires were analyzed due to the following reasons:

* the respondents did not properly fill some questionnaires, such were out rightly rejected;
* several of the respondents could not be found at home, even after several visits, so completed questionnaires could not be retrieved from them;
* some of them returned theirs without being filled through minors. No explanation for such attitude was offered;
* few of the respondents requested for money, which was not given to them. In the course of filed work, it was discovered that they (such household heads were with the view that the questionnaire administration was a contract job for which the field assistants were paid a lump sum amount of money;
* some others denied being given copies of the questionnaire at all.

These problems were mostly encountered in old Ilorin.

4.1.3.2 Oral Interview

In late February to early part of March, 2006, we conducted oral interviews at two different levels to compliment the data, which were collected from the remote sensing/GIS, reference sources and structured questionnaire administration;

(i) Kwara State Ministries/Parastatals

(ii) Traditional Ward Heads

4.1.3.2.1 Kwara State Ministries/Parastatals

At this stage, interviews were organized with Kwara State Ministries of Agriculture and Natural Resources, Information and Home Affairs, Lands and Survey, Works and Housing and Parastatals/Statutory Boards such as Urban and Town Planning, the State Agricultural Development Project and Kwara State Water Corporation (specifically, the Engineering Section of Asa River Dam). These ministries and parastatals/statutory Boards were used for interview simply because they were the most relevant source of data for this work.

In each of the ministries and parstatals, interviews were conducted in the conference or Board rooms as the case may be. In all cases, the permanent secretaries/chairmen of the ministries/parastatals wee represented by very senior staff. Heads of Departments of each ministry/parastatal and their Deputies amongst others were in attendance. Each of the interview sessions, thus, made a "full house".

During the interview seasons, questions were posed one after the other from the author's prepared list, which were answered by the appropriate departments. For example, questions that were related to farming activities in the suburb of Ilorin were answered by the Department ǒ Extension Services, Ministry of Agriculture.

In a few instances, some questions had to be debated amongst the interviewees for the most appropriate answer and clarity.

4.1.3.2.2 Traditional Ward Heads

This second lap of the oral interview was conducted with the seven traditional ward heads who were considered by the author to be knowledgeable about the physical and economic development that have taken place in their respective wards.

At this level, the heads directly preceded over the interviews. They and their respective heads of localities and other relevant functionaries were the respondents in the interaction. For instance in Zango ward, some of the localities represented in the chief's palace (compound), which was the venue of the interview were Fate, Kunlende and Oyun. Ambiguous answers were thrown open to the audience by the chief (i.e ward head) for clarification. This allowed for free and popular participation.

The sampling methodology, which was applied in choosing/selecting the wards for the structured questionnaire administration was adopted at this stage of oral interview. This follows that the seven wards, which were sampled for the questionnaire administration were as well used at this level (section 4.2.1). The only step of deviation was the use of locality heads to assist the chiefs instead of household heads in the case of questionnaire administration on the sampled compounds. This was done to avoid rowdy interview sessions.

4.2 Method of Data Analysis

The data collected from the social survey through questionnaire administration were analysed using Tables and percentages.

4.3 Data Analysis

Data Analysis was required and therefore carried out in order to achieve the following tasks:

(i) static-temporal variation in size and pattern of Ilorin

(ii) composite growth pattern of Ilorin

(iii) analysis of the relationship between population growth and land use change

(iv) development of classification scheme and interpretation key.

(v) production of change maps.

The detail procedures used in achieving the above tasks in this study are as follows:

4.3.1 Static-Temporal Variation

This work has classified the evolution of Ilorin into four (4) periods based basically on the availability of base maps and satellite imageries at the disposal of the author.

These periods are:

(i) The 1976 Growth

(ii) The 1987 Growth

(iii) The 1994 Growth

(iv) The 2004 Growth

The satellite images were interpreted to obtain the growth in size of each of the patterns.

4.3.2 Composite Growth Pattern, 1976-2004

The growth trends of Ilorin over the years (1976-2004) were shown in graphs and Tables under appropriate sections and subsections of the work. The trends could be attributed to government policies and economic growth among other factors.

Logistic curve equation (after Brown and Cox, 1972):

$$P = \frac{U}{1 + e^{a-b}} \quad \text{.........................} \quad (4.2)$$

Where:

U is the Total Built-up area of each year

e is the Mathematical Constant 2.7183

a is the Rate of Change of the year

b is the Slope of the Graph

t is the Difference between 1976 – 2004

is used in this work to further vividly explain the processes of diffusion in the urban growth of Ilorin.

4.3.3 Analysis of Relationship between Population Growth and Land Use Change.

The land Consumption Rate (LCR) and Land Absorption Coefficient (L.A.C) (After Yeteas and Garner, 1976) were estimated using the relation:

$$L.C.R. = \frac{A}{P} \quad \text{.................(4.3)}$$

Where A is the areal extent of the city (in km^2) and P is the population and

$$L.A.C = \frac{A_2 - A_1}{P_2 - P_1} \quad \text{....................(4.4)}$$

Where A_1 and A_2 are the areal extents (in km^2) for the early and later years, and P_1 and P_2 are population figures for the early and later years respectively.

4.3.4 Classification Scheme and Interpretation Keys

Land use and land cover classification is a systematic means of grouping similar categories of land uses together (Jibril, 1994). Classification scheme is meant to guide image interpretation. The classification scheme developed for this study (Table 4.3) arises from a close study of imageries and reconnaissance surveys (field visits) of the study area and made use of the United States Geological Survey (USGS) designed by Anderson et al (1976) as a guide. In other words, the Landsat MSS, 1976, Landsat, TM 1997, Spot XS, 1994 and Nigeria Sat-1, 2004 positive image transparencies were digitally classified using maximum likelihood classification option of the supervised method. Thus, a five category of land use scheme was designed for use in the interpretation. The level 1 of Anderson et al (1976)'s classification scheme (ACS) is most appropriate for this study and therefore takes no recognition of their level 11 classification scheme. This is simply due to the fact that the sub categories under level II (of ACS) are not the focus of this work.

Table 4:3: Classification Scheme

S/N	Land Use/Land Cover Categories	Component Features
1.	Built-up Area	Residential, Commercial, industrial and other buildings, developments along highways, transportation, utilities and services.
2.	Cultivated Areas	Cropland and pasture, orchards, groves and vineyards, nurseries and ornamental horticultural areas, and confined feeding operations.
3.	Vegetation	Forest, scrubs, range-land, grassland and plantation
4.	Water Bodies	Rivers, streams, dams, canals, lakes, ponds and reservoirs
5.	Routes	Expressways, trunk A, other township roads and paths

Source: Anderson et al (1976) and Jinadu (2004)

Interpretation keys were generated from the images basically using the various colour tones and patterns (Table 4.4). This enabled identification of the various land use/cover classes. Moreover, interpretation key helps the interpreter evaluate the information presented on images in another organized and consistent manner. To put in another way, it provides guidance about the correct identification of features and/or conditions on either the photographic or satellite imageries (Lillesand and Kiefer, 1987).

Table 4.4: Interpretation Key Used in the Study

S/N	Land Use/Land Cover Categories	Component Features
1.	Built-up Area	Polygon features light grey reflectance, with major roads connecting them.
2.	Cultivated Areas	Polygon features, in light-green
3.	Vegetation	Polygon features in sky-blue
4.	Water Bodies	Polygon features, deep green
5.	Roads	Line features, looking brownish.
6.	Streams	This line features, which are identifiable through their meandering, bluish are found all over the maps.

Source: Anderson et al (1976) and Jinadu (2004)

4.3.5: Production of Change Maps

The process that led to map production was carried out in nine stages; which are as follows:

(a) Image Rectification

The images were geo-referenced to the same projection (UTM). In other words, the images (used for this work) were appropriately registered/aligned using well established land marks such as road junctions and other such features. These land marks served as ground control points for the rectification process using ERDAS IMAGINE version 8.3.1.

(b) Visual Interpretation

Visual interpretation of the Spot XS, 1994 printed (hard copy) image was carried out for the identification of land use/land cover categories of interest (i.e built-up and cultivated areas, vegetal cover, water bodies and roads). The printed copy was used for interpretation because the digital data (image transparency) was not available for use. The visually interpreted layers from the printed satellite image were digitized using calcomp AO digitizing tablet. The use of visual interpretation clues such as shape, size, pattern, tone and associated features as well as local knowledge of the study area were of paramount importance at this stage, as they made the recognition of the features easy. The soft copy images (landsat MSS, 1976, landsat TM, 1987 and Nigeria Sat-1 2004) were interpreted directly using the onscreen digitization function of the ERDAS IMAGINE Version 8.3.1.

(c) the various types of interpreted features as in 'b' above, were digitized through the use of Arcview version 3.2a and 3.2 calcomp AO digitizing tablet.

(d) additional data on railway, roads, built-up area etc were also digitized from existing topographic maps using Arcview 3.2 and GIS.

(e) projection and transformation of all layers wee carried out using Arc Info version 7.21.

(f) there was then a coverage editing and coding of all layers, also through the use of ArcInfo.

(g) **Mapping of Features**

the classes of features for this work (built-up area etc) were carefully delineated using the onscreen digitization function of the ERDAS IMAGINE Version 8.3.1 The spectral characteristics of the features wee discerned from the tonal appearance representing various categories of land use/land cover types (Fig 5.5).

The method has made it possible for us to specifically restrict our study to the class of our interest, which is level one (1) classification.

(h) analysis of change detection was carried out through the use of Arcview. In the first instance, digital layers of land use/cover for the years under focus (1976, 1987, 1994 and 2004) were obtained. The layers were then overlaid and the results (were) displayed, which allowed comparison to identify changes. The layers were queried to generate statistics in land use/cover classes.

(i) finally, maps were printed (Arc/view soft ware) by A3 colour printer model HP desk jet 1280.

4.4 Ground Truthing Exercise

Several ground truth exercises were carried out at different stages of this study. This was to ascertain areas where there were doubts (unresolved cases) in respect of the characteristics of the features. However, finalization of land use/land cover maps was done only after incorporating necessary corrections and modifications following ground truth exercise.

4.5 Tools for Analysis

The two varieties of tools used for the analysis of the data are:

(i) Hardware

(a) Calcomp AO digitizing tablet

(ii) Software

(a) ERDAS IMAGINE Version 8.3.1

(b) Arcview Version 3.2a and Arc/Info Version 7.1.2

(c) Statistical Package for Social Services (SPSS)

(d) IDRISI for window Version 2

CHAPTER FIVE

5.0 Analysis of City Growth and Land Use/Land Cover Changes

5.1 Introduction

This chapter is concerned with the analysis of both city growth and land use/land cover changes of the study area. The former section dwells on the historical evolution of Ilorin and her static-temporal variation in size and pattern. These are then followed by sections 5.4 and 5.5, which are devoted to composite growth pattern and the analysis of the relationship between population growth and land use change respectively. The land use and land cover change analysis section considers the nature of land use and land cover changes that have occurred in the study area between three periods of 1976 – 1987, 1987 – 1994 and 1994 – 2004.

5.2 Historical Evolution of Ilorin

Several authors have written on urbanization in Nigeria (Mabongunje, 1968; Ayeni, 1976; Okpala, 1979; Onokerhoraye, 1982; 1995 and Ogunsanya, 2002). The evolution of each urban centre however differs from one another. While some evolved as a result of agricultural improvements, industrialization and market potentials, some others evolved as a result of increased service activities, increased education, transport improvements and natural population growth.

As for Ilorin, her growth is closely associated with increased service activities and improvement in her economic base. As an administrative centre during the colonial period, Ilorin attracted some basic amenities such as postal, educational, health, water and electricity supply. So, in view of Ilorin's administrative status and coupled with the already concentrated population in it, the town, according to Onokerhoraye (1982), was classified as a second-class township in 1919. Unfortunately, inspite of this classification, Ilorin experienced relatively little development in terms of its economic base and physical expansion during the period of British colonial rule.

Since Nigeria became independence in 1960, certain developments within the middle belt area as well as in other parts of the country have turned the area from a back ward to a more progressive region. These include the production of more food crops, improvement in communication in terms of transport, the gradual elimination of tsetse fly, which had made it possible for the region to breed some livestock and the establishment of Kainji Dam (Adeniyi, 1976). The later establishment of the Nigerian Sugar Company Limited (NISUCO) Bacita and Paper Mill at Jebba are also contributing factors. All these developments had implications for the growth of Ilorin since the mid – 1960s.

In a similar vein, Onokerhoraye, (1982); Olorunfemi (1983); Emielu (1991) and Aderamo (1997) when referring specifically to the growth of Ilorin noted that the creation of Kwara State in 1967, as a result of Decree No.4 and the choice of Ilorin as the state capital resulted in its rapid population increases and areal expansion. These population explosion and areal expansion of the city of Ilorin are very likely to continue because of the centrality of the city to other parts of the country.

CHAPTER FOUR

4.0 RESEARCH METHODOLOGY

4.1 Data Collected and Used in the Analysis

In a general term, information was sought on the morphology (i.e form, size and shape) of the study area as well as sites or locations of the features of interest for this work. The features include routes, water bodies, built-up and cultivated areas and vegetation cover. In a specific term, two main sets of data were collected and used for this study. These were the remote sensing/Geographical Information System (GIS) and reference data.

4.1.1 Remote Sensing/GIS Data

The basic characteristics of the satellite imageries that were used for this work include the following:

i. Landsat MSS Image of 1976

Satellite:.	Landsat 2
Sensor:	Multispectral Scanner (MSS)
Resolution:	79 Metres
Bands:	4
Projection:	Universal Transverse Mercater (UTM)
UTM Zone:	31
Spheroid Clarke:	1880
Acquisition Date:	November, 1976
Acquisition Source:	Remote Sensing/GIS Department, Federal Min. of Agric. and Rural Development Mando, Kaduna.

ii. Landsat TM Image of 1987

Satellite:	Landsat 5
Sensor:	Thematic Mapper (TM)

Resolution:	30 metres
Bands:	7
Projection:	Universal Transverse Mercater (UTM)
UTM Zone:	31
Spheroid:	Clarke 1880
Acquisition Date:	January, 1987
Acquisition Source:	Department of Remote Sensing/GIS Fed.Min. of Agric and Rural Development Mando Road, Kaduna.

iii. Spot XS Image of 1994

Satellite:	Sport - 3
Sensor:	High Resolution Visible (HRV)
Resolution:	20 Metres
Bands:	3
Projection:	Universal Transverse Mercater (UTM)
UTM Zone:	31
Spheroid :	Clarke 1880
Acquisition Date:	3rd December, 1994
Acquisition Source:	Department of Remote Sensing/GIS Fed. Min. of Agric. and Rural Development Mando, Kaduna.

iv. Nigeria Landsat-1 Image of 2004

Satellite:	Landsat 1
Sensor:	Thematic Mapper
Resolution:	32 Metres
Bands:	3
Projection:	Universal Transverse Mercater (UTM)
UTM Zone:	31
Acquisition Date:	NA
Acquisition Source:	National Space Research Development Agency (NSRA), Abuja.

4.1.2 Reference Data

The reference data used for this study include other supportive, supplementary conventional data such as thematic, topographic, street guide and land use maps (Table4.1).

As a result of Afonja and Alimi conflicts in late 18th century for political hegemony over Ilorin, four war lords eventually emerged in the city under the overall leadership of the Emir. The four war lords became the heads of the traditional wards of Balonguns Ajikobi, Gambari, Fulani and Alanama. These wards encircled the Emir's palace, the administrative headquarters, from where all routes radiate our wards. According to Aderamo (1997), the spatial pattern of the growth of Ilorin began with this small compact core (Fig. 5.1).

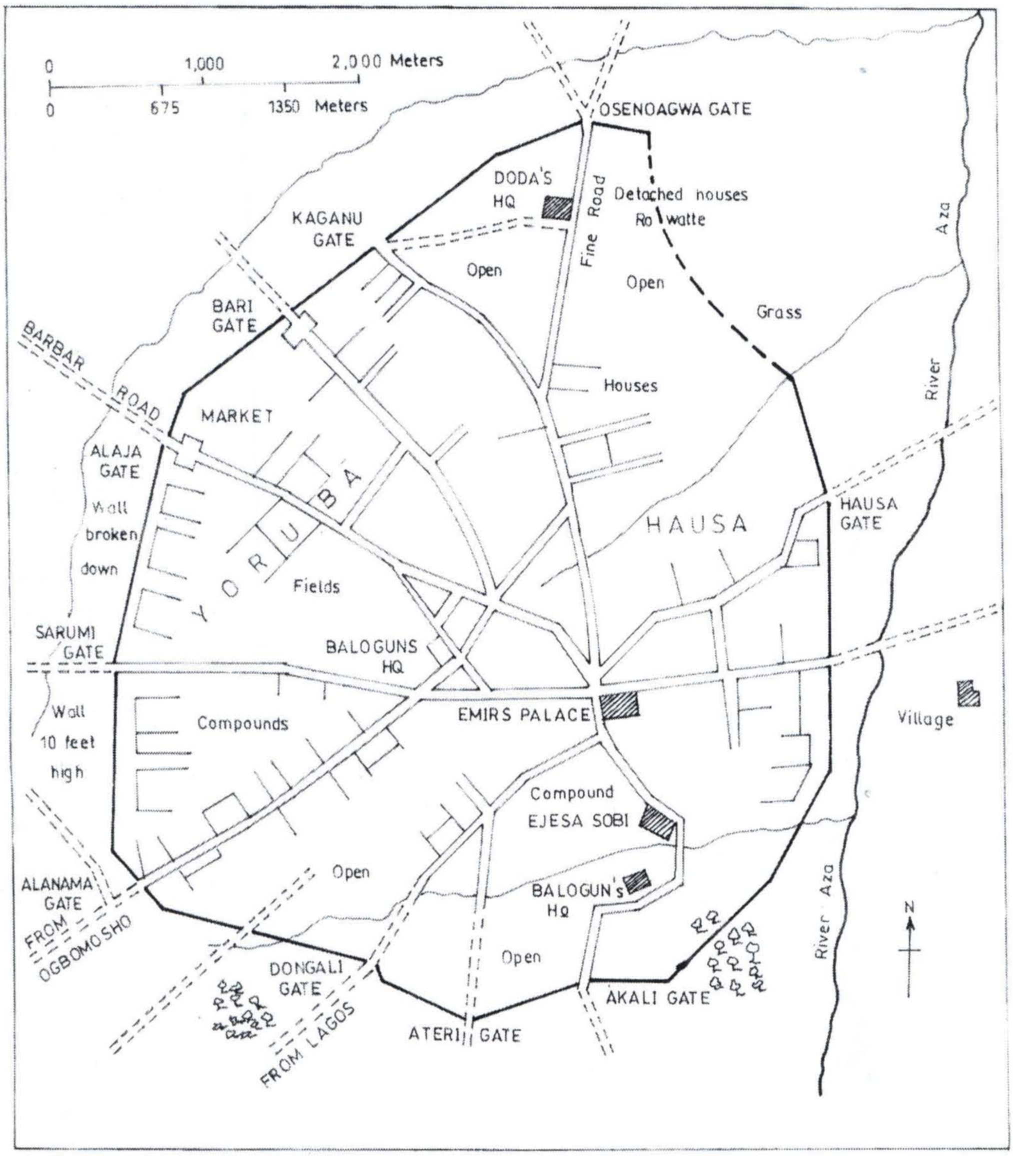


FIG. 5.1 : THE PLAN OF ILORIN 1897
SOURCE: OLORUNFEMI (1985).

This radial pattern is at variance with Burgess (1925)'s concentric zone model, which according to him leads to functional zoning and residential segregation within cities (see section 2.2.5.2 for details).

5.3 Static-Temporal Variations in Size and Pattern of Ilorin

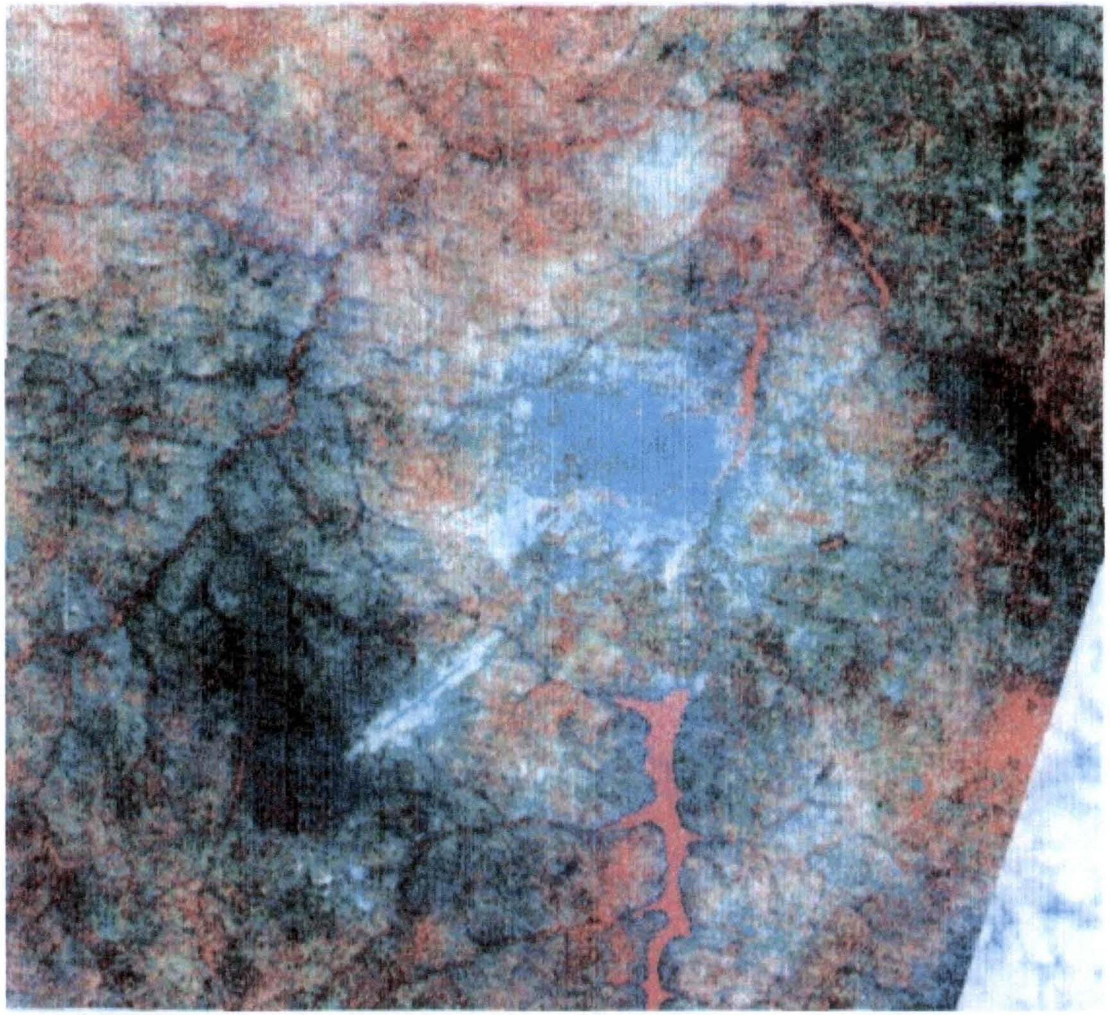
Based on satellite imageries and maps at our disposal, this study has classified the evolution of Ilorin into four periods, which are:

i. the 1976 growth
ii. the 1987 growth
iii. the 1994 growth
iv. the 2004 growth

(i) The 1976 Growth

Kwara state came into being and Ilorin as capital in 1967. Landsat MSS image of 1976 (Fig.5.2) with spatial resolution of 79 metres was thus used as the base year data so as to give a substantial appreciation of the influence of the state creation on the areal expansion and population growth of the study area.

The 1976 land use/land cover map of Ilorin (Fig.5.3) reveals that the city growth is concentrated along the major roads radiating from the city centre (i.e Emir's Palace). These roads are Offa to the south-east, Jebba to the north-east, Shao to the north, Kaiama to the north-west and Ibadan on which the International Air Port is located to south west.



Scale: 1 : 190000

Figure 5.2: Landsat MSS, 1976

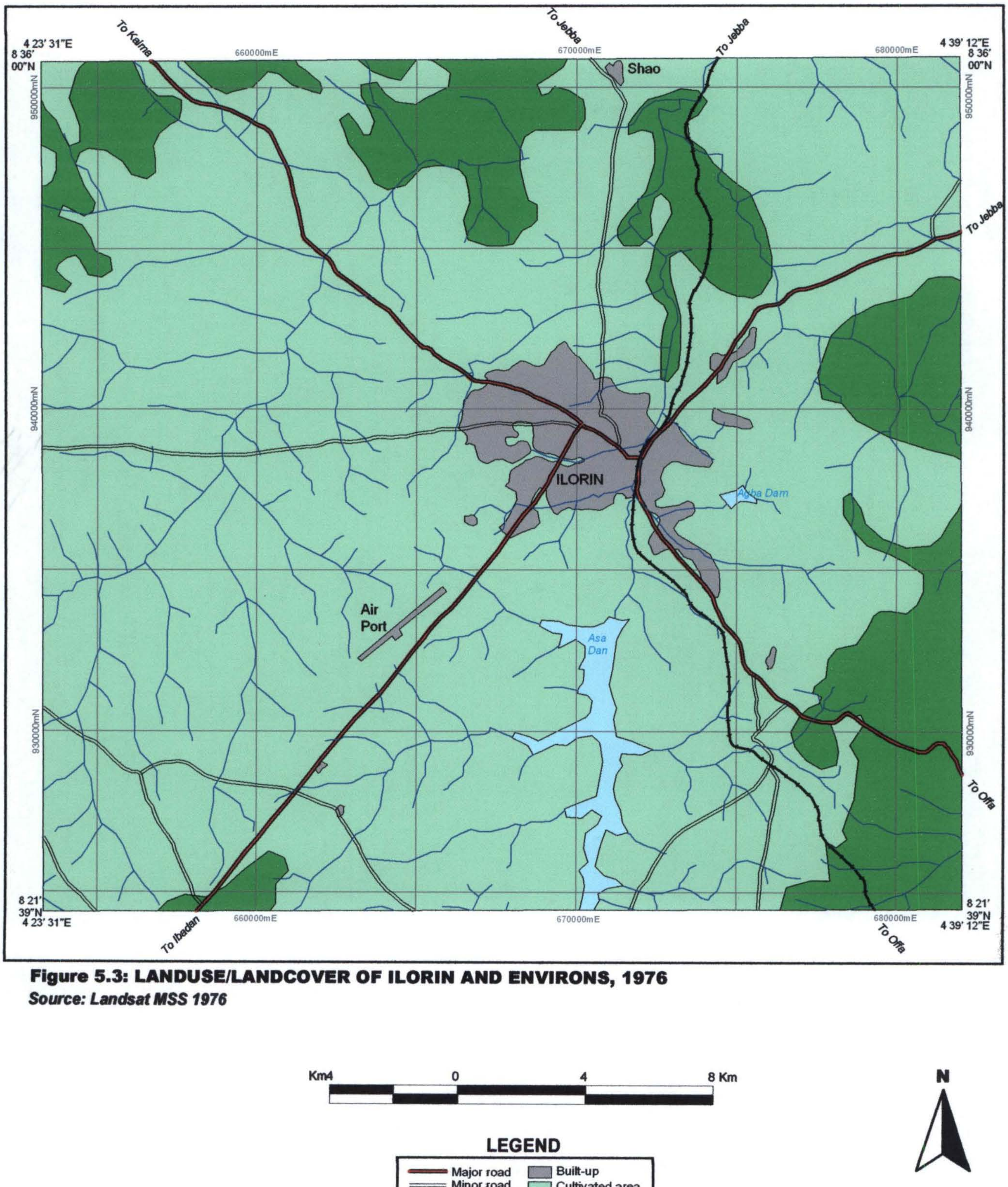


Figure 5.3: LANDUSE/LANDCOVER OF ILORIN AND ENVIRONS, 1976

Source: Landsat MSS 1976

Map statistics generated using the statistical function of Arc/view show that the areal extend of built-up area was 45.743km^2, which is 6.0 percent of the total area. At the time, cultivated area featured more prominently than any other class as it covered 584.340km^2 (76.77%) of the total areal coverage (Table 5.1). This indication confirms earlier assertions and write-up that during this period, agriculture supported a large number of people in Ilorin and the farmers commuted daily from the town to their farmlands (Onakerhoraye, 1982). Information about the other classes as regards the areal and percentage coverage is also presented in Table 5.1 and the statistic work in appendix 2.

Table 5.1: Land Use/Land Cover Statistics of Ilorin, 1976

S/No	Land Use/Land Cover Class	1976 Area (km^2)	% of Total
1.	Built-up Area	45.743	6.0
2.	Cultivated Area	584.340	76.77
3.	Vegetal Cover	121.787	15.9
4.	Water Bodies	9.3133	1.22
	Total Area (Km^2)	761.183	100

Source: Author's Data Analysis, 2006.

Table 5.2: Land Use/Land Cover Statistics of Ilorin, 1987

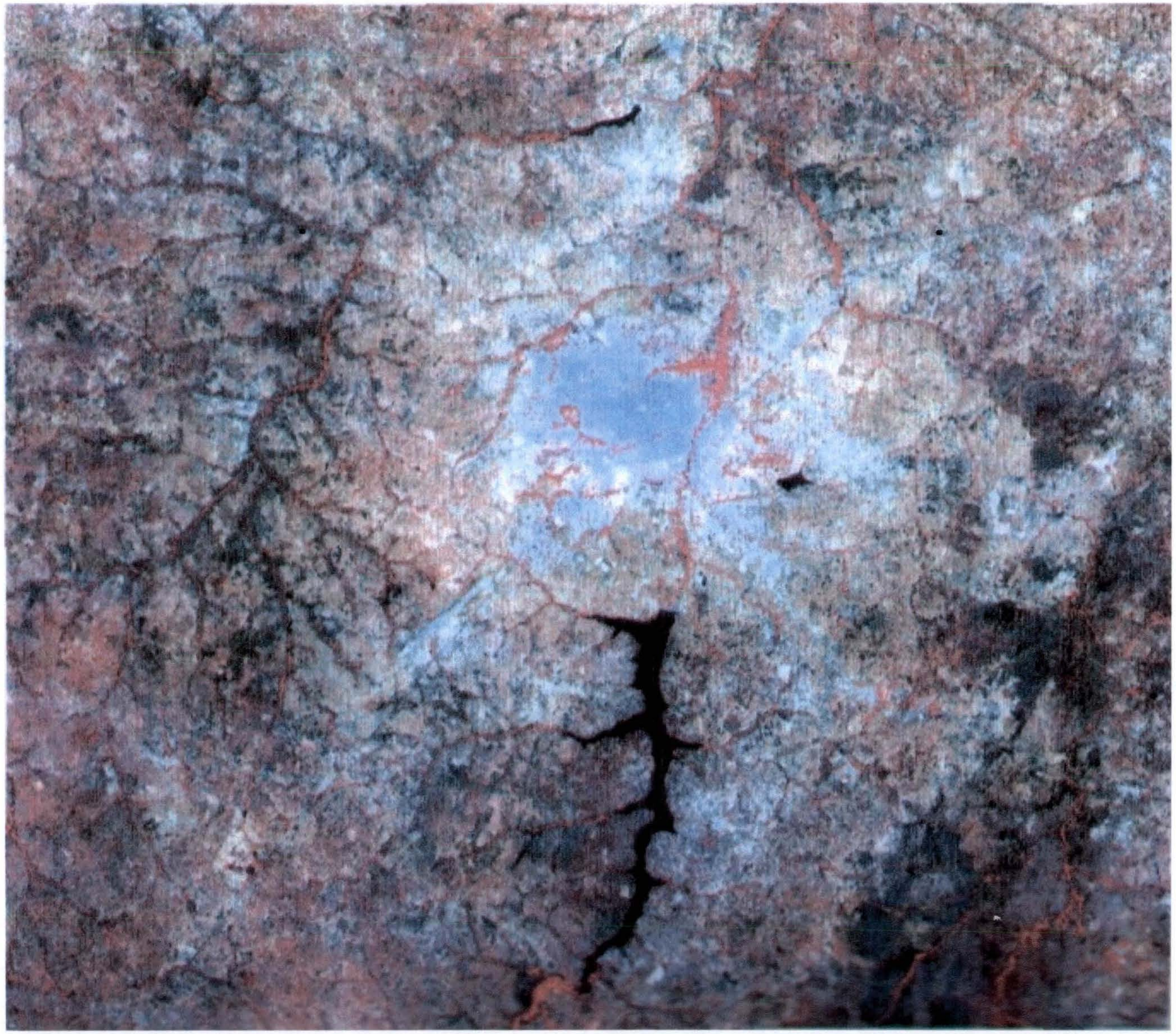
S/No	Land Use/Land Cover Class	1987 Area (km^2)	% of Total
1.	Built-up Area	60.096	7.9
2.	Cultivated Area	667.722	87.7
3.	Vegetal Cover	23.553	3.1
4.	Water Bodies	9.811	1.3
	Total Area (Km^2)	761.183	100

Source: Author's Data Analysis, 2006.

(ii) The 1987 Growth

The 1976 growth in size of Ilorin changed in 1987. For example, while the built-up area of the former year (1976) was 45.734km^2 (6.0%), that of the later year was 60.096km^2 (7.9%) (Tables 5.1 and 5.2). This was attributed to the fact that Ilorin annexed some villages/hamlets in tts country side. Examples of such captured settlements are Kulende, Eleyangan, Kwara Polytechnic and even almost extending to Oke–Oyi all along Jebba road to the north east. Along Offa road, the settlements that have been engulfed by the physical expansion of the city are Gaa Akanbi, Ero-Omò, Olunlade, Ita Alamu, Gamo and Amoyo to the south-east. There are also submerged settlements along Ibadan road and these include Agunbelewo, Aiyetoro, Odota and Eiyekorin. Along Kaiama road to the north-west, the expansions have enveloped Ogidi. Along Shao road to the north, Sobi barracks has been absorbed.

Landsat TM image of 1987 (Fig.5.4) was interpreted to obtain the above information for the 1987 city expansion. Outlines of the absorbed settlements as indicated in the analysis could not be identified as entities on the TM satellite map (Fig.5.5). Such settlements have been completely submerged by the city of Ilorin to the extent that the built-up area is in a strip or continuous form. No distinction could be made between the captured settlements and the main city. However, the map statistics (Table 5.2) shows that vegetation covered an area of 23.554km^2 (3.1%). More so, water bodies covered 9.91km^2 (1.3%). The increase in water body areal coverage is due to the construction of Sobi dam in 1984.



Scale: 1 : 180000

Figure 5.4: Landsat TM, 1987

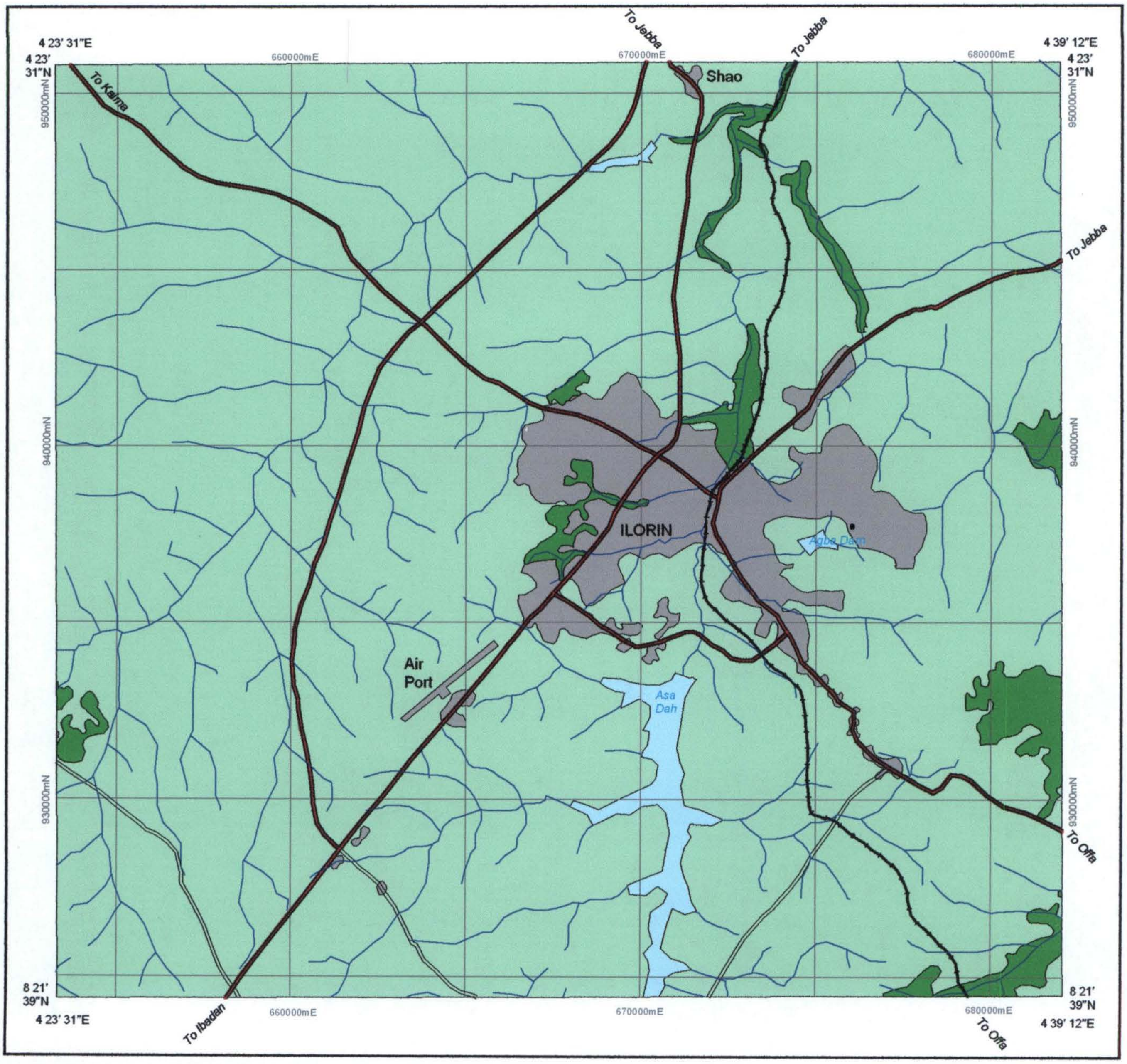


Figure 5.5: LANDUSE/LANDCOVER OF ILORIN AND ENVIRONS, 1987

Source: Landsat TM 1987

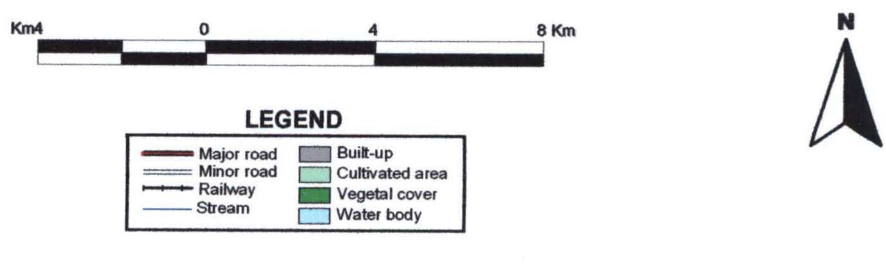


Table 5.3: Land Use/Land Cover Statistics of Ilorin, 1994

S/No	Land Use/Land Cover Class	1994 Area (km^2)	% of Total
1.	Built-up Area	75.816	9.9
2.	Cultivated Area	665.087	87.1
3.	Vegetal Cover	12.469	1.7
4.	Water Bodies	9.811	1.3
	Total Area (Km^2)	761.183	100

Source: Author's Data Analysis, 2006.

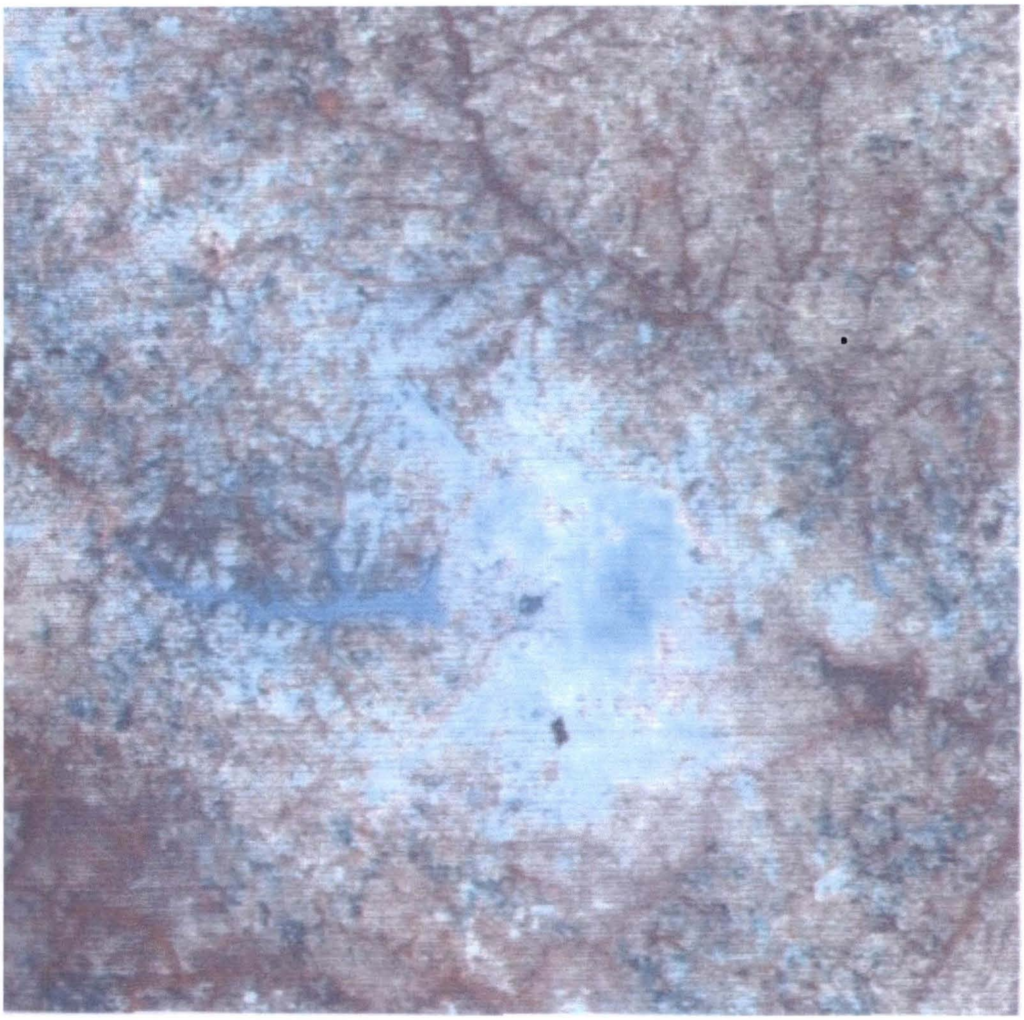
Table 5.4: Land Use/Land Cover Statistics of Ilorin, 2004.

S/No	Land Use/Land Cover Class	2004 Area (km^2)	% of Total
1.	Built-up Area	126.461	16.9
2.	Cultivated Area	593.489	77.9
3.	Vegetal Cover	31.422	4.2
4.	Water Bodies	9.811	1.3
	Total Area (Km^2)	761.183	100

Source: Author's Data Analysis, 2006.

(iii) The (1994) Growth

Spot XS image of 1994 (Fig.5.6) was interpreted to obtain Fig.5.7. From the statistics generated from these figures, the built-up area covered 75.816km^2 (9.9%). The areal coverage of the cultivated land is the largest of the land use/land cover types (663.087km^2; 87,1%), while the vegetal component is the second lowest (12.496km; 1.6%) (Table 5.3). Thus, the vegetal spots could only be identified on the satellite map (Fig.5.7) in few places such as in the north-east, south-east, south-west and along Ibadan road.



Scale: 1 : 250000

Figure 5.6: SPOT XS, 1994

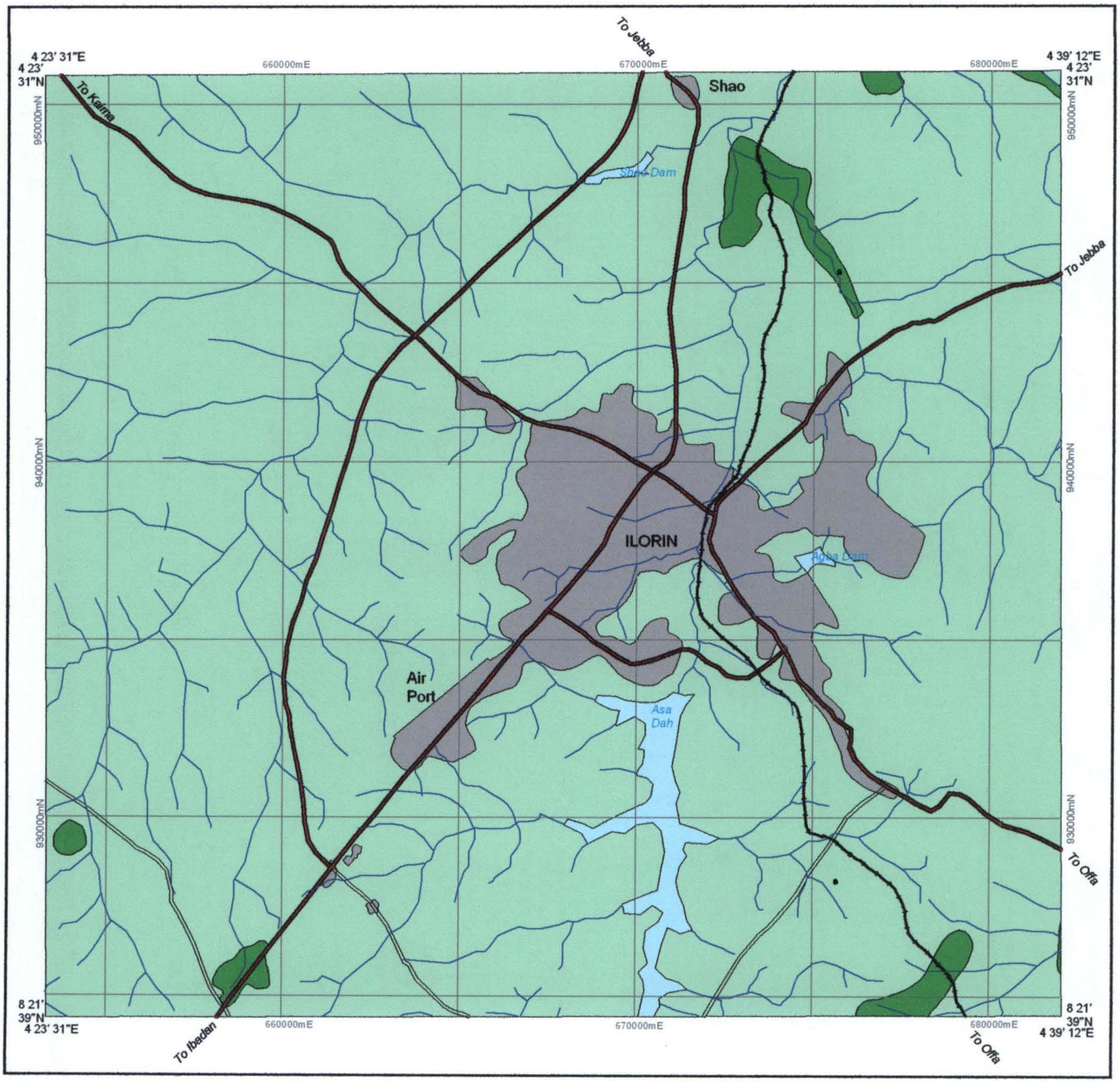
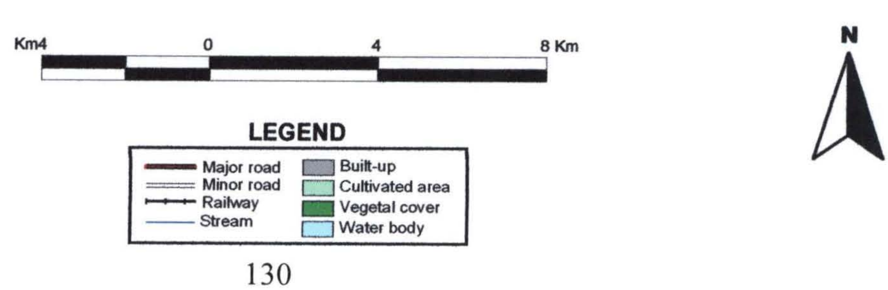


Figure 5.7: LANDUSE/LANDCOVER OF ILORIN AND ENVIRONS, 1994
Source: SPOT XS 1994



Iv) The 2004 Growth

When the 2004 Nigeria Sat-1 imagery (Fig.5.8) was interpreted, it gave limited information on roads, railway and vegetation. This was due to its poor resolution of 32km. But since information on these classes were required in order to obtain urban sprawl of Ilorin, complementary information had to be sought from other sources such as topographical maps of Ilorin NW, SW, Igbetti S.E. and Ogbomosho N.E. The required layer on these features were digitized in Arc/View software and thereafter converted into Arc/Info coverages in order to perform error correction, editing and symbolization. The data were then geo-referenced and transferred back to the Arc/View shape for map production.

The built-up area was mapped to be 126.461km^2 (16.6%), and the water bodies were mapped to cover 9.811km^2 (1.3%) (Table 5.4). During one of the ground truth exercises, it was discovered that the available three dams were mainly used for domestic and partially industrial purposes. Agba dam, the oldest (1952) of the three, and located in the western Ilorin was almost engulfed by buildings (Fig.5.9). In fact, during a field survey exercise, it was discovered that most of such buildings were office complexes within the dam premises and the Central Bank staff quarters was not far from the dam. On the satellite map of 1976 (Fig. 5.3), Agba Dam was far off the built-up area. This indicates the rapid rate at which Ilorin city has expanded over the years.

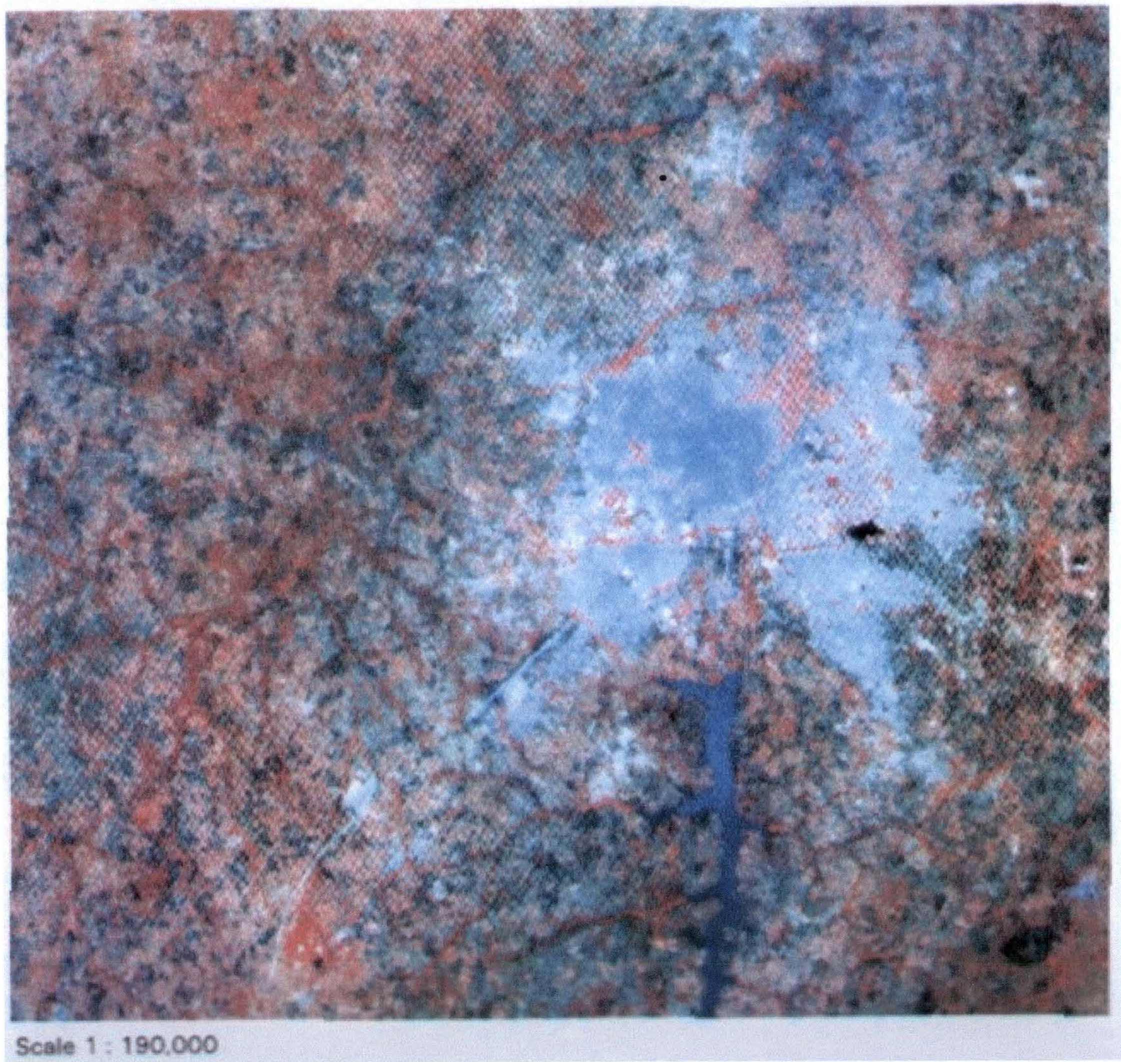


Figure 5.8: Nigeria Sat1, 2004

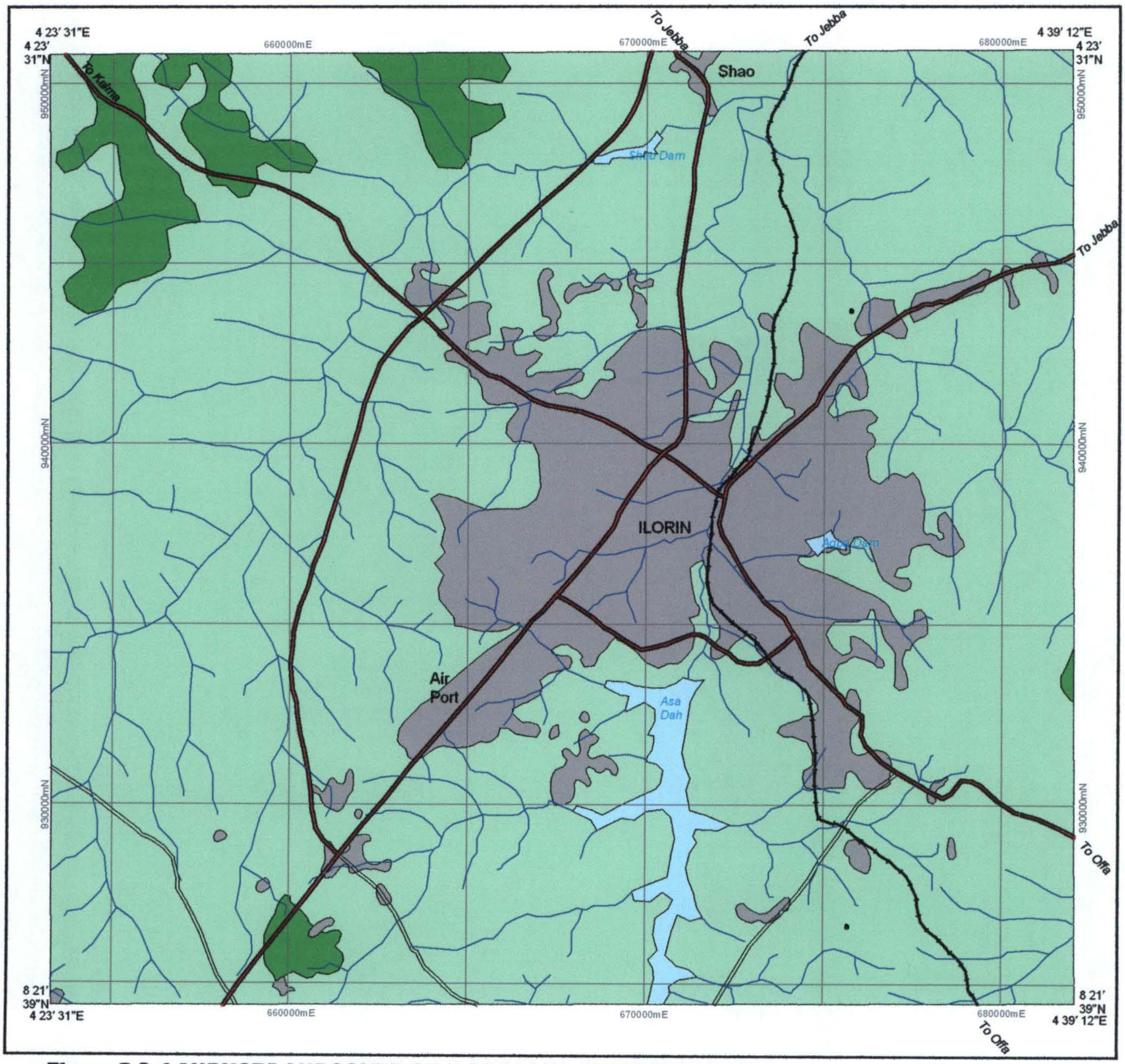
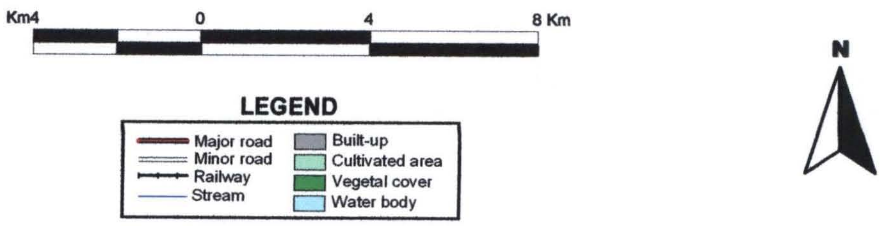


Figure 5.9: LANDUSE/LANDCOVER OF ILORIN AND ENVIRONS, 2004
Source: Nigeria Sat1 2004



The map produced from the 2004 Nigeria Sat-1 (Fig.5.9) reveals that vegetation covered 31.422km^2 (4.2%) of land while the cultivated area occupied 593.489km^2 (77.9%) (Table 4.4). Cultivated area here means the land that are presently being farmed and those under fallow!

5.4 Composite Growth Pattern, 1976-2004

A cursory look at the 2004 land use/land cover map of the study area (Fig.5.9) reveals that the city is divided into two distinct blocks. These are the western and eastern blocks. Coincidentally too, River Asa and railway line are respectively the natural and artificial boundaries between the two blocks of the city. The western block represents the core of indigenous Ilorin and the eastern block developed mainly as a result of influx of migrants into the city from all parts of the country. Several authors have referred to the two blocks as old and new Ilorin (Olurunfemi, 1985; Aderamo, 1997; Emielu, 1991).

In a similar vein, Aderamo (1997:48) when specifically referring to the morphology of Ilorin, described it as "a two-in-one structure".

Table 5.5: The Growth in Size of Ilorin, 1976-2004.

Year	Total Built-Up Area (km^2)	Absolute Change	Percentage Change	Rate of Change
1976	45.7434	-	-	-
1987	60.09628	14.35288	31.38	2.9
1994	75.8159	15.71962	26.16	3.7
2004	126.46099	50.64509	66.80	6.7

Source: Author's Data Analysis, 2006.

The growth of Ilorin is further illustrated by assessing the rate of change of urban land between 1976 and 2004 (Table 5.5). The Table shows that the total built-up component of the study area in 1976 was 45.7434km^2 while the rate of change of urban land for the city between 1976 and 1987 was 2.9 percent per percentage was 31.38. In the same vein, the total built-up area of the city in 1994 was 75.8159km^2 while the rate of change between 1987 and 1994 was 3.7 percent per annum with the percentage change of 26.16. Similarly, the total built-up part of the study area for 2004 was 126.46099km^2 while the rate of change of urban land for the city between 1994 and 2004 was 6.7 per annum, which translates into 66.80 percentage change. Comparing the rates of change for the period 1976 – 2004, it is observed that the rate of growth of the city increased between 1976 and 1987 by 2.9 percent and a further increase was experienced in the growth between 1987 and 1994, by 3.7 percent. There was also a tremendous increase of 6.7 percent in the growth in size between 1994 and 2004 (Fig.5.10). The growth in size statistics is shown in appendix 3.

Table 5.6: Respondents Rating of Factors for Highest Rate of Growth between 1994-2004

Factors of Growth	Frequency	Percentage	Cumulative percentage
Rising purchasing power of people	231	20.79	20.79
Government policies	349	31.41	52.20
Increase in agricultural produce (cash and food crops)	263	23.67	75.87
Establishment of industries	168	15.12	90.99
Improvement of communication in terms of transportation	1000	9.00	99.99
Total	1111	100	

Source: Author's Data Analysis, 2006.

Table 5.7: Factors that Induced Changes in Land Use and Land Cover of Ilorin Between 1976 – 2004.

Factors of Changes	No. of Respondents	Percentage	Cumulative Percentage
1. Economic			
(i) Oil Boom	311	15.51	15.51
(ii) Establishment of Industries	162	8.08	23.59
(iii) Agriculture	209	10.42	34.01
2. Geographical Location	205	10.22	44.23
3. Government Policies			
(i) Administrative status of Ilorin at various periods	413	20.6	64.83
(ii) Increase in salaries/wages and the policy of Town Planning Authority	303	15.1	79.93
4. Other Factors			
(i) Population growth due to in-migration	253	12.6	92.53
(ii) Peace in Ilorin (low rate of crime)	149	7.4	99.93
Total	2005	100	

Source: Author's Data Analysis, 2006.

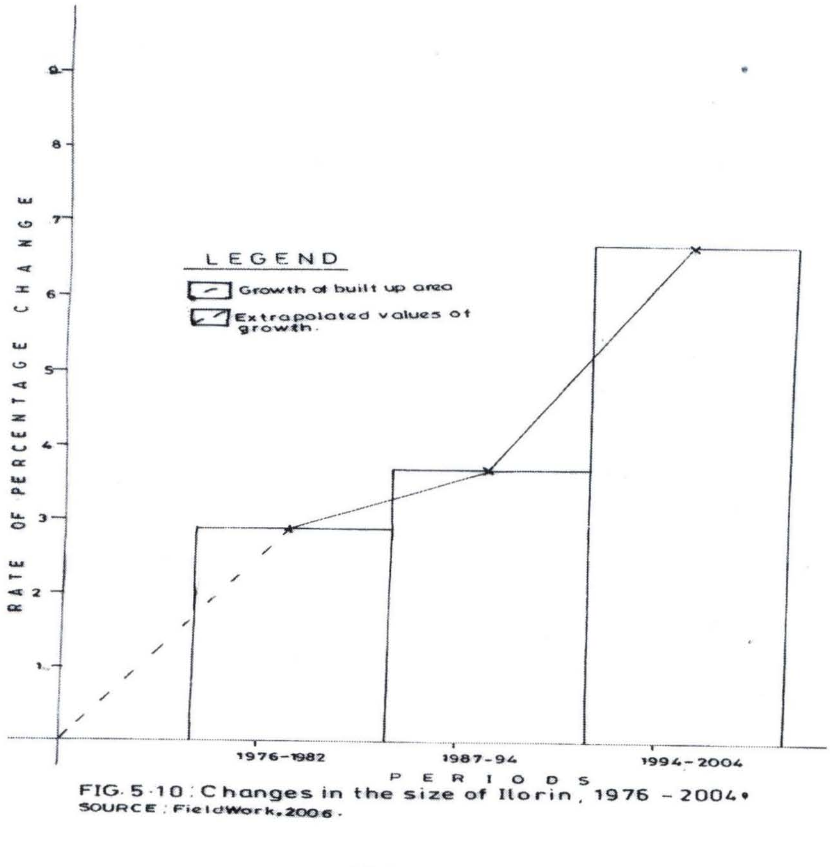


FIG. 5.10: Changes in the size of Ilorin, 1976 - 2004.
SOURCE: FieldWork, 2006.

Using the same parameters (as contained in Table 5.5), the growth in size of Ilorin has also been explained by plotting a graph of the growth of the city over time (Fig.5.11). The figure depicts the growth of built-up area of the city. The curve shows spatial expansion in the rate of change of urban land of the study area between 1976 and 2004.

The respondents to the structured questionnaire (Appendix 1) rated government policies as the highest factors (31.41%) responsible for high spatial expansion of the built-up area of Ilorin between 1994-2004 (Table 5.6). Presently, for instance, the study area comprises of three local government councils, a fact, which in itself is a factor of growth and development. Moreover, the respondents argued that the policy of the State Town Planning Authority to give considerable open spaces between and around buildings, especially in new Ilorin, gave rise to areal expansion of converted land (Table 5.7).

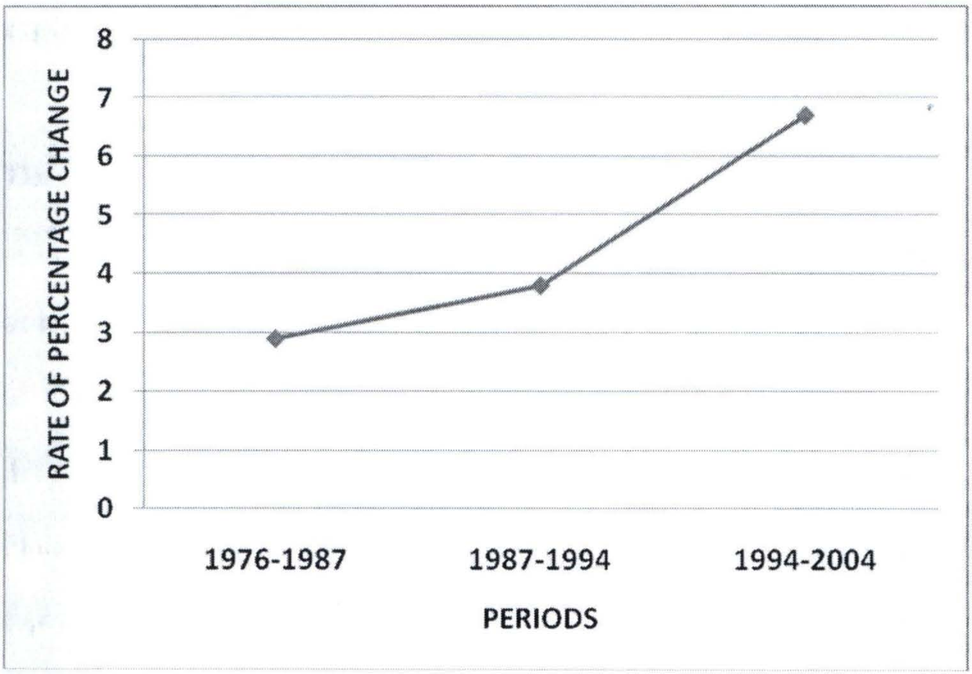


Fig. 5.11: Growth of Built-up Area of Ilorin (Percentage Change)
Source: Author's Data Analysis, 2006.

It is glaring that Table 5.7 singled out increase in salaries of civil servants by the subsequent governments of Kwara State as another factor for high increase of 6.7 percent in the areal expansion of the city between 1994-2004. Other major factors responsible for the trends in the changes in size (Fig.5.10) and growth of the built-up area of Ilorin (Fig.5.11), as rated by the respondents are shown in Tables 5.6 and 5.7. These factors made it possible for the people coming into the city and the city residents alike to have sound economic means of absorbing more land for development.

This pattern of growth, which is **j**-shaped, is otherwise referred to as a logistic curve and is represented mathematically by the equation:

$$P = \frac{U}{1 + e^{a-bt}} \qquad \text{---------(5.1)}$$

Where:

U represents the upper limit of growth

e is a mathematical constant with the approximate value 2.7183.

the constant is raised to the power or exponent **a-bt,** where **a** and **b** are particular values that will change from one diffusion problem to another. The value **a** controls the height above t (time) – axis where the **j**-shaped curve starts, while **b** determines how quickly it rises (Appendix 4).

5.5 Analysis of Relationship between Population and Land Use Change

Land use change in developing countries is very dynamic in nature. This is mainly due to the fact that the terrain structures always undergo transformation to suit modern developments. Unfortunately, the traditional methods of data collection on population and land use change in Nigeria can no longer couple with the rate of growth and development in either of these parameters. As Lo and Welch (1977) put it, studies of urban developments therefore, tend to be highly subjective in the absence of quantitative data.

Against this background, two common indices are often used to evaluate the growth rate of urban areas in terms of physical extent. These indices are the Land Consumption Rate (L.C.R.) and Land Absorption Coefficient (L.A.C). Based on this, the consumption rate and absorption coefficient for Ilorin city is estimated using the relation.

$$L.C.R = \frac{A}{P} \quad \text{-------------------(5.2)}$$

Where A is the areal extent of the urban areas (in km^2), and P is the population; and

$$L.A.C = \frac{A_2 - A_1}{P_2 - P_1} \quad \text{---------------(5.3)}$$

Where A_1 and A_2 are areal extends (in km^2) for the early and latter years respectively, P_1 and P_2 are the population figures for the early 1and latter years respectively (Table 5.8). In this regard, according to Yeates and Garner (1976) in Adedibu (1998) land consumption rate (LCR), which is an indicator measuring the amount of urban land consumed per person at a particular year and land absorption coefficient (LAC) that indicates the amount of new urban land consumed by each unit increase in urban population for the built-up of the study area are computed (Appendix 5) and results tabulated as follows:

Table 5.8: Built-Up Area and Population of Ilorin, 1976, 1987, 1994 and 2004

Year	Areal Coverage (km^2)	Population
1976	45.7434	262,266
1987	60.09628	367,172
1994	75.8159	440,606
2004	126.46099	572,788

Source: Computed by the Author, 2006.

Table 5.9: Land Consumption Rate (L.C.R) of the Built-Up Area of Ilorin, 1976-2004

Year	L.C.R. (Value in km^2 Per Person)
1976	0.00017
1987	0.00016
1994	0.00017
2004	0.00022

Source: Author's Data Analysis, 2006.

From Table 5.9, the increase/decrease characteristics of the land consumption rate of the study area are haphazard. This is at variance with Adedibu et al (1998)'s study of Ilorin, which observed a gradual increase in the land consumption rate (LCR) of the city.

According to this study, the LCR of 0.00017 in 1976 showed that the city of Ilorin had maximally benefited from the effects of the 1976 creation of Kwara state with Ilorin as its capital. Infact, 413 respondents, which translates into 20.6 percent (Table 5.7) rated administrative status of Ilorin city as a factor of rapid growth of the city. At this time (1976), the city has received quite a sizeable migrant community made up of people from all parts of the country. And the migrant population needed land for residence. More so, effects of the oil boom era of 1970s on the economy, which led to an upsurge in the construction of residential, administrative and industrial buildings is also a major factor for the LCR of $0.00017km^2$ in 1976. In fact, Figure 5.7 indicates that 311 respondents (15.51%) rated oil boom as a factor of growth. Also, in the same figure (Fig. 5.7), other economic factors such as agricultural activities and establishment of industries with 10.42% and 8.08% respectively contribute significantly to the growth in size of the built-up area of Ilorin.

On the other hand, by 1987 the LCR had decreased to 0.00016 and increased back to $0.00017km^2$ in 1994 per person. This observed decrease may be surprising, but the factors accounting for the decrease according to the respondents are effects of Structural Adjustment Programme (SAP), which was introduced by Babangida led Military administration, as a strategy for reducing the nation's external dept burden, unemployment and low level of economic development. Other factors that accounted for the decrease (in LCR) are low growth of commercial activities and difficulty in having access to land (Appendices 1 and 6)

Considering the factors of low rate of growth (Appendix 6), the effects of the introduction of SAP was rated highest among several others. In fact, as reflected in appendix 6, 509 respondents (25.04%) were with the view that because of the effects of SAP, which was biting hard on the people of the study area, the rate of housing construction was grossly limited. The results of oral interview conducted in late February to early March, 2006 with the traditional chiefs also emphasized the negative role played by the introduction of SAP in the mid 1980s on the areal expansion of Ilorin. Additionally, the interviewees of some ministries also specifically cited the example of SAP as a factor that retarded growth in the study area. Nevertheless, the year 2004 witnessed the highest LCR as each person in Ilorin had up to $0.00022km^2$ of land to himself (see Table 5.6 for the factors responsible for the high L.C.R).

The land absorption coefficient (LAC) shows that the land absorption by a unit increase in population between 1976 and 2004 increases in a descending order (Table 5.10). The areal expansion of the study area cannot therefore, be divorced/separated from its population. In other words, increase in land area, as per the finding of this study, is a function of increase in population (Table 5.8). The LAC between 1976-1987 was $0.000014km^2$ and being the lowest, the LAC implies that the built-up component of Ilorin was in a cluster form. And what is being suggested by this index is crowding, which means many people were living in small area. To buttress this assertion, it is evidenced from figure 5.3, that building structures are not scattered all over the map. They are rather restrictive to the core of Ilorin city.

For the ten-year period between 1994-2004, the land absorption coefficient was 0.0038 (Table 5.10). This was the highest LAC for the twenty-eight (28) years under review (i.e. 1976-2004). The reasons for this trend are not hard to advance. First, the Abacha led military government pegged the Nigerian currency at ₦22.00 per Dollar and this stabilized inflation in the country. Some other factors, which the respondents felt were responsible for the 0.038 LAC of 1994-2004 are relative peace (low crime rate) in Ilorin and geographical location that has made Ilorin a focal point for regional and national trade (Table 5.7).

Table 5.10: Land Absorption Coefficient (LAC) (in km^2) for Ilorin Built-Up Area, 1976-2004

Year	L.C.R. (Value in km^2 Per Person)
1976 – 1987	0.000014
1987 – 1994	0.000021
1994 – 2004	0.0038

Source: Author's Data Analysis, 20006: After Yeates and Garner, 1976.

5.6 Conclusion

The results or findings of this work as presented in this section revealed that the growth of Ilorin has undergone several configurations over the years. The first pattern of the city, as reviewed here, which dates back to 1897, shows that Ilorin was in a radial form. For the twenty-eight year period between 1976-2004, the growth pattern of the city is radial in nature concentrating mainly along the major and even minor roads. The areal coverage of each feature for this work, such as built-up and cultivated areas, vegetal cover and water bodies were calculated accordingly and each of them was found to vary in size over the years. Case in hand is the built-up area that was 45.743km^2 in 1976 and then increased to 126.46099km^2 in 2004. The observed implication is that, both the cultivated area and vegetal cover are being pushed further to the countryside of the city.

5.7 Land Use and Land Cover Change Analysis

5.7.1 Introduction

The analysis of Land Use and Land Cover Changes that occurred in the study area, was done through the interpretation of satellite image data of landsat MSS of 1976, landsat TM of 1987, Spot XS of 1994 and Nigeria Sat-1 of 2004 (subsection 1.6.1.1 and Figs. 5.2 – 5.9). Image sub-set was then carried out and an area of 761.183 square kilometers was defined by GIS for the study. The study area covers Ilorin city and its immediate environs.

The areal extent of each land use/land cover category between 1974 – 2004 was delineated and the magnitudes of the changes involved were determined. Moreover, efforts were made to consider the consequences of the growth on the study area.

5.7.2 Nature of Land Use/Land Cover Changes

Since there are several advantages that are associated with macroscopic and multi-temporal observation, remotely sensed data are undoubtedly the most ideal data for extracting the land use/land cover information. Having relied on remote sensing applications in this study, our land use analysis reveals that since 1976, a considerable amount of changes have taken place on the land use/cover of Ilorin city and its immediate environs. To realize this (i.e change detection), the traditional approach of post classification comparism aimed at establishing the difference between the classified images of two different dates has been followed in producing the change maps (Figs 5.12 – 5.15).

5.7.2.1 Change in Land Use/Land Cover, 1976 -1987

The degree/level of change between 1976 and 1987 was obtained by simply comparing the values of the features examined in this study as indicted in Table 5.11. Computations were based on the data input i.e, landsat MSS image of 1976, landsat TM image taken in 1987, Spot XS image of 1994, and Nigeria Sat-1 of 2004.

Table 5.11: Land Use/Land Cover Change Statistics, 1976 – 1987

S/N	Land Use/Land Cover Class	Area (Km2)		Increase (+) Decrease (-)	Percentage Change	Annual Change
		1976	1987			
1.	Built-up Area	45.7434	60.09628	+14.35288	23.89	1.30
2.	Cultivated Area	584.3402	667.722	+83.381	12.49	7.58
3.	Vegetal Cover	121.7874	23.554	-98.233	417.05	-8.93
4.	Water Bodies	9.3133	9.8115	+0.4982	5.08	0.05

Source: Author's Data Analysis, 2006.

The study simply superimposed the imageries of 1976 – 2004 (Figs.5.2, 5.4, 5.6 and 5.8) in order to produce four change maps of the study area (i.e Figs 5.12-5.15). But each map shows only the changes that involved a single class (say, for example, water body) for the four years. For instance, while the first change map (Fig.5.12) shows the water bodies for the years 1976, 1987, 1994 and 2004, Figure 5.13 indicates the changes that involved only the vegetal cover for the four years.

On the other hand, Figure 5.14 depicts changes only in cultivated areas over the same four years of 1976, 1987, 1994 and 2004. And lastly, Figure 5.15 is the change map of built-up area, also, for the period 1976-2004.

With reference to these change maps for the period 1976 to 1987, the built-up area increased by 14.35km^2 (23.89%) with an annual change of 1.30km^2. The cultivated area also increased by 83.381km^2 (12.4%) during the same period. These increases were gained from the vegetal cover. Thus, it (vegetal cover) lost as much as 98.233 (417,05%) to both the built-up and cultivated lands. In other words, the major change in the 1976-1987 period was from area of vegetation cover to both built-up and cultivated areas. Moreover, the construction of Sobi dam in 1984 increased the area coverage of the water bodies by 0.4982km^2 (5.08%). Nevertheless, it (water body) recorded the least annual change of 0.05km^2 (Table 5.11 and Figures 5.12-5.15). It then follows that 0.4982km^2 of vegetal cover was converted to water body. (Table 5.12).

Table 5.12: Land Use/Land Cover Change Matrix, 1976-2004 (km^2)

Change Code & Name		1976 – 1987					1987 – 1994					1994 – 2004				
		1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
1.	Built-up Area															
2.	Cultivated Area								4.633			50.645		18.953		69.598
3.	Vegetal Cover	14.353	83.381		0.4982	98.232	15.719				20.352					
4	Water Bodies															
	TOTAL	14.353	83.381		0.4982	98.232	15.719		4.633		20.352	50.645		18.953		69.598

Source: Author's Data Analysis, 2006.

5.7.2.2 Changes in Land Use/Land Cover, 1987 - 1994

It is glaring from Tables 5.12 and 5.13 that the built-up land gained 15.719km^2 (26.158%) from the vegetal cover with an annual change of 2.25%. On the other hand, cultivated land lost 4.633km^2 (7.71%) to the vegetal cover. So, the total coverage of ground lost by vegetal cover during the 1987-1994 period was 11.086km^2. Other nature of changes that occurred during this period (i.e 1987-1994) are also depicted on the change maps (Figure 5.12 – 5.15).

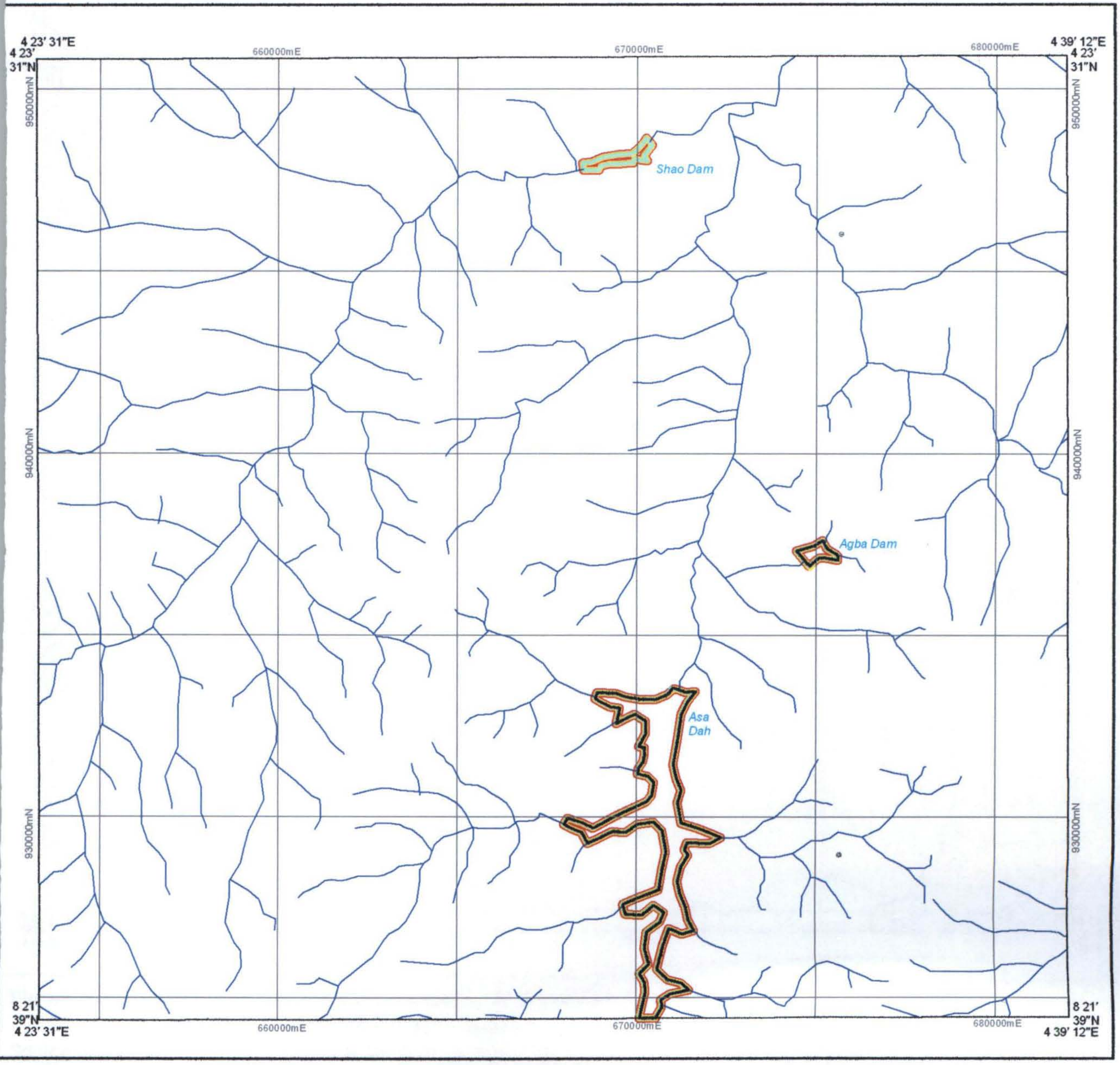
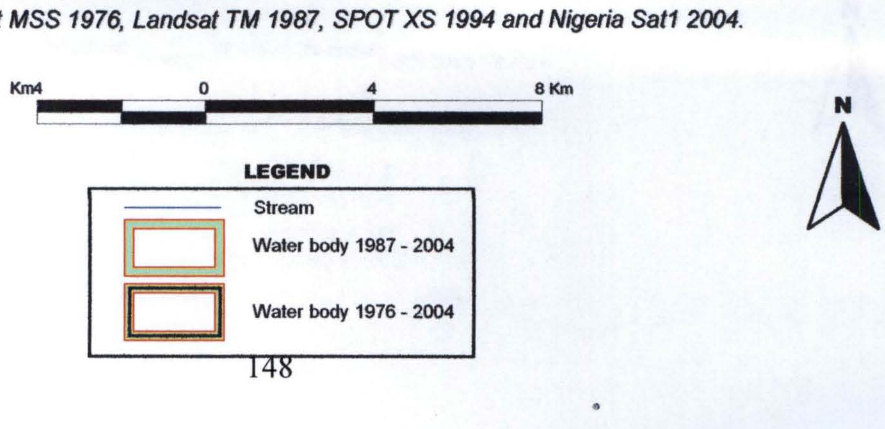


Figure 5.12: LANDUSE/LANDCOVER CHANGE IN WATER BODIES OVER ILORIN AND ENVIRONS (1976 -2004)

Source: Author's Analysis of Landsat MSS 1976, Landsat TM 1987, SPOT XS 1994 and Nigeria Sat1 2004.



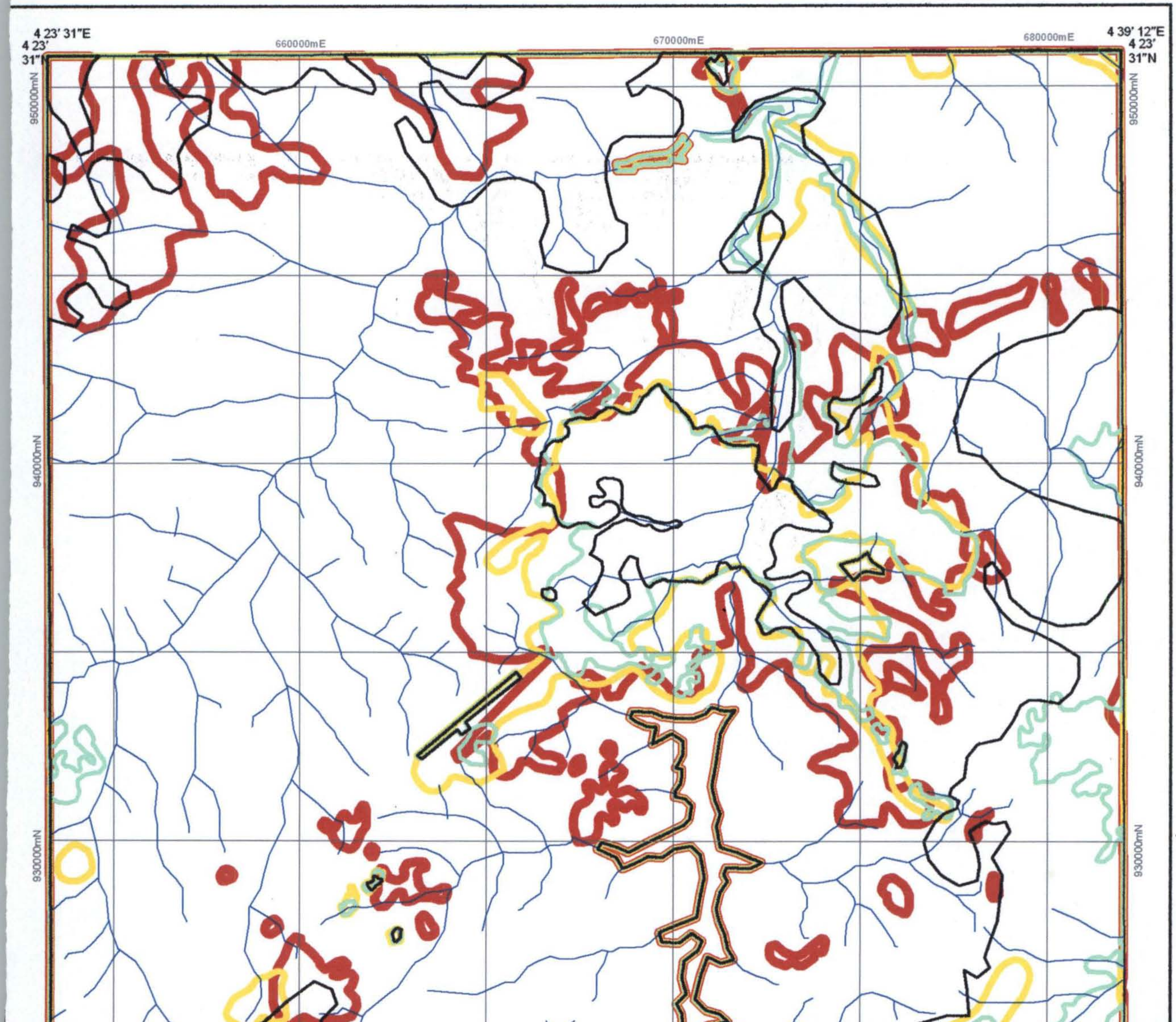
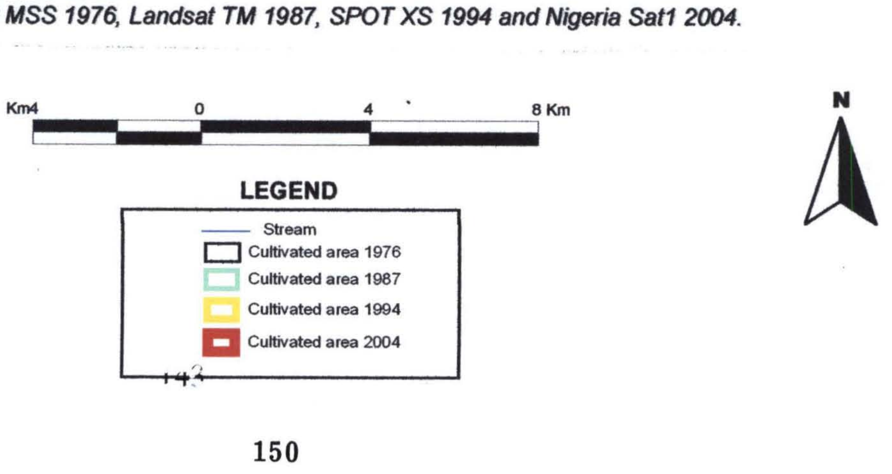


Figure 5.14: LANDUSE/LANDCOVER CHANGE IN CULTIVATED AREA OVER ILORIN AND ENVIRONS (1976 -2004)

Source: Author's Analysis of Landsat MSS 1976, Landsat TM 1987, SPOT XS 1994 and Nigeria Sat1 2004.



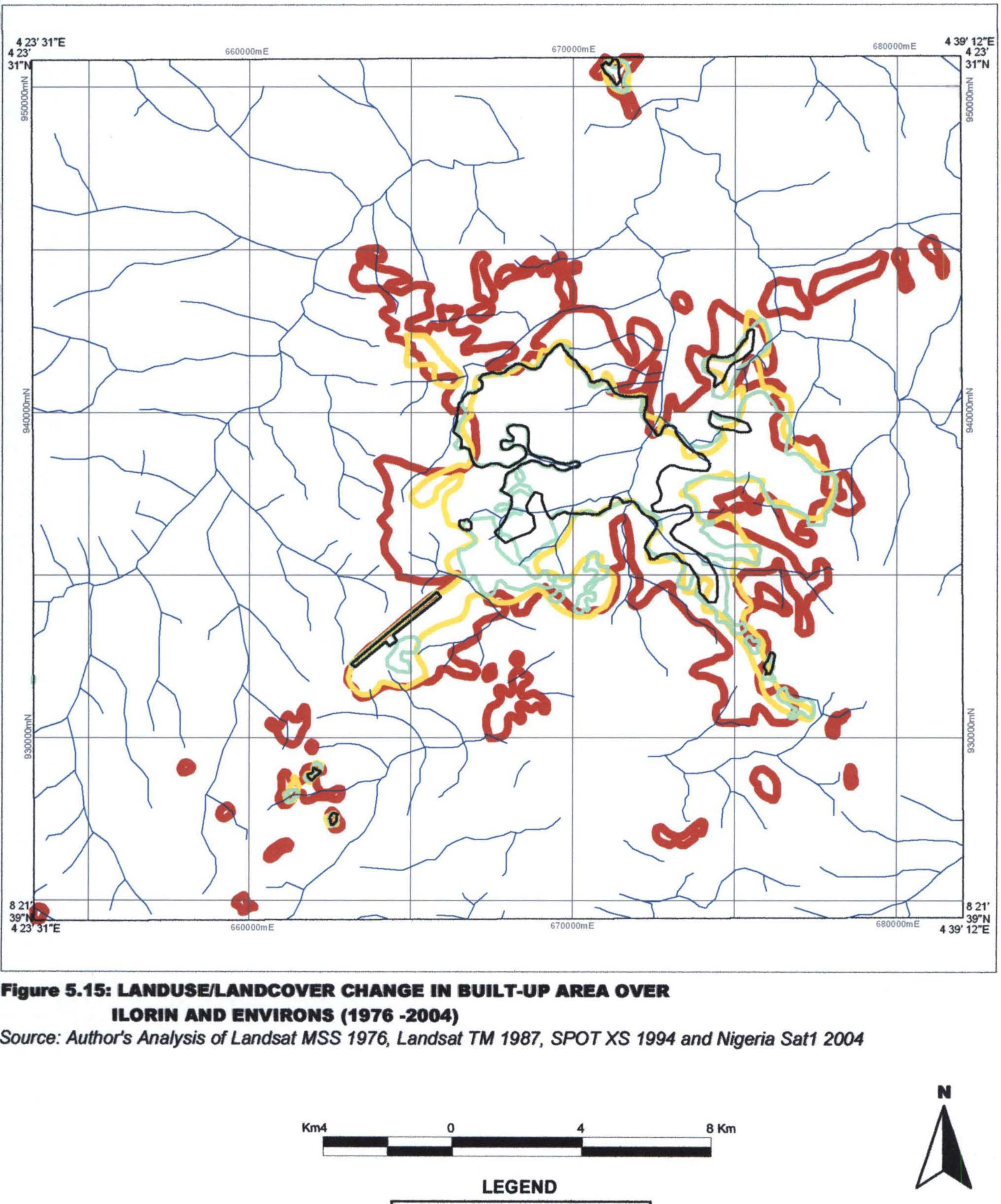
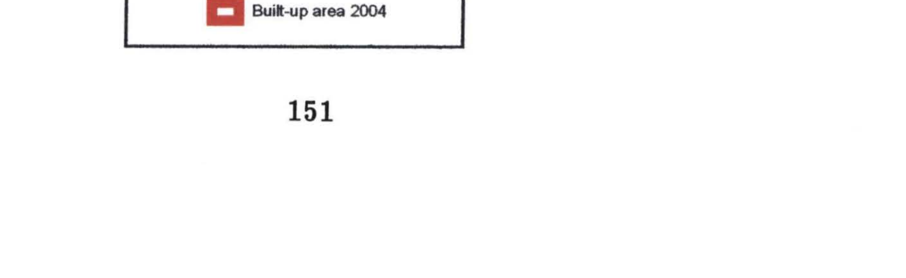


Figure 5.15: LANDUSE/LANDCOVER CHANGE IN BUILT-UP AREA OVER ILORIN AND ENVIRONS (1976 -2004)

Source: Author's Analysis of Landsat MSS 1976, Landsat TM 1987, SPOT XS 1994 and Nigeria Sat1 2004



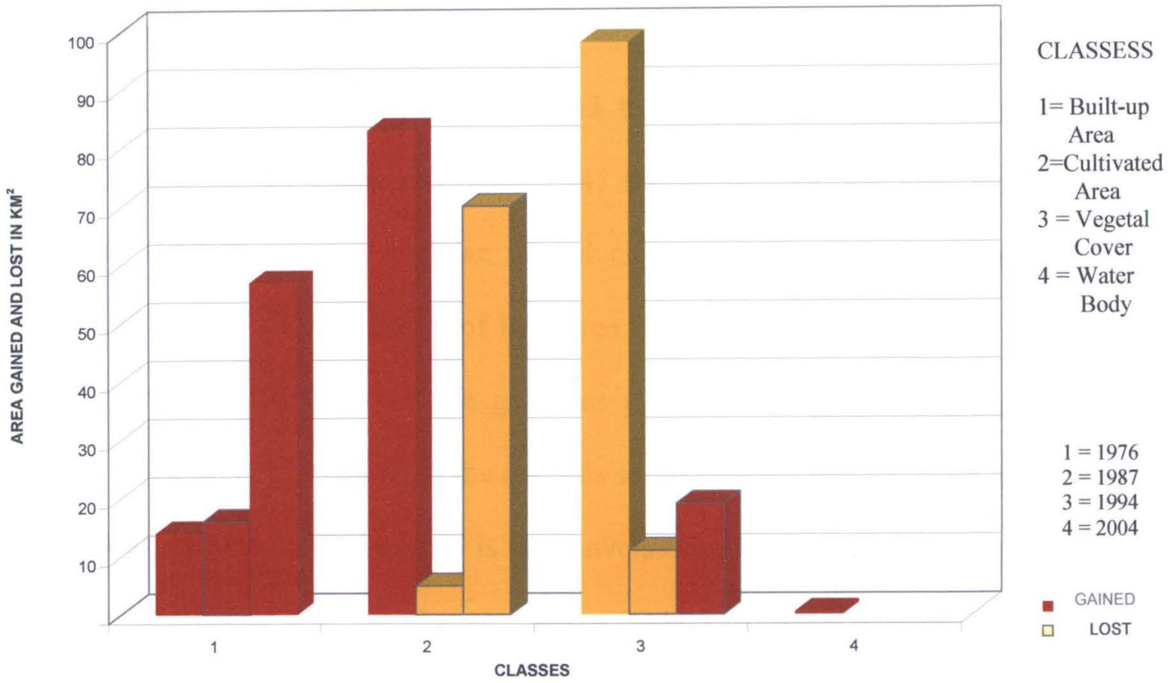


FIG. 5.16 LAND USE CHANGES (GAINED/LOST) FROM 1976 – 2004
Source: Author's Data Analysis, 2006.

Table 5.13: Land Use/Land Cover Change Statistics, 1987-1994

S/N	Land Use/Land Cover Class	Area (Km^2) 1987	1994	Increase(+)/ Decrease (-)	% Change	Annual Change
1.	Build-up Area	60.096	75.8159	+15.7199	26.158	2.25
2.	Cultivated Area	667.722	663.089	- 4.633	7.71	- 0.66
3.	Vegetal Cover	23.554	12.469	- 11.086	88.90	- 1.58
4.	Water Body	9.811	9.811	0.00	0.00	0.00

Source: Author's Data Analysis 2006.

lands have been taken over by buildings and other forms of urban development. Results of the oral interview held, with the traditional ward head of Balogun Gambari and his lieutenants (5/3/2006) during fieldwork specifically reveled among others, that having farmlands located in Sobi army barracks (north of Ilorin) posed problem for some of the Ilorin and Shao farmers because they felt that they could be harassed at will by barrack soldiers. Similar fear was expressed with respect to farmers from Tanke and Mosude villages during an interview session with the traditional head of Zango (8th of March, 2006). It was explained that some of the farmers that have their farmlands located right inside the main campus of the University of Ilorin to the northeast of the study area, fear losing them to the University Authorities anytime they wished to embark on physical expansion of the institution.

As for the "urban" farmers, it was gathered during these oral interviews that they were faced with the problem of transportation. Not all of them were mobile (had means of transportation) and so, such (less mobile) farmers always had to travel long distances sometimes with loads (either jerycan of water or farm produce), on their bicycles/motor cycles to and form the farm. However, some others patronized commercial buses/taxes but only on few occasions when affordable.

Through direct field observations in late February 2006, it was discovered in several parts of the immediate vicinity of Ilorin that many undeveloped and half-developed plots were used as farmlands. The farmers that worked those plots did not even know the plot owners. This practice was not unconnected with the remote location of their personal farm lands. Examples of areas where we found these developments include Ero-Omo, Ita Alamu, Olunlade and areas around Michel Imodu National Institute for Labour Studies (MINILS) along Ajesse-Ipo/Offa road and the Tanke area along university of Ilorin main Campus road to the south east of the study area. Others are around Oloje Estate and Ogidi settlement along Kaiama road to the north-west. It was established that the plot owners were not against the use of their plots for farming because of the fact that farmers keep them tidy not only through regular weeding during the raining season,, but also clearing the plots of unwanted cover during the dry season in preparation for the next rain. However, the use of the plots by the farmers are highly temporary as they could be asked to quit such plots at anytime the owners are ready to develop them. The affected farmers may thus, be described as "wonderers" since they have no "permanent" farmlands.

Additionally, oral interview with relevant functionaries of the Kwara State Ministry of Agriculture indicated that intensive cultivation/over cultivation in the study area, is already leading to loss of soil fertility. In fact, staff of the Department of Extension Services of the Ministry, explained that what farmers do in their attempt to remedy such situation is the excessive application of chemical fertilizers and insecticides, which are serious sources of land pollution. Another consequence confirmed in the interviews is the acknowledgement that over-cultivation has already uncovered the top soil at several locations in the study area (e.g Elekoyangan area after Oyun bridge along Jebba and Kwara Polytechnic road). The soils are now, therefore, exposed to some elements of weather like sunshine, wind and rainwater. This development has already initiated soil erosion in the affected areas (Table 5.15 and Figure 5.18). Other serious problems, as rated by the respondents and also shown in the Table, include land infertility (7%) and deforestation (14.8).

The scarcity and high cost of firewood in Ilorin as claimed by some respondents (Table 5.15) may not be unconnected with the effects of deforestation in the study area. In Sabon Gari ward, the representatives of hunters lamented during the interview session held with the traditional ward head that they hardly go on night hunting again. This, according to them, was because deforestation has dispersed the bush animals to areas largely beyond their reach. Similarly, our interview with the staff of the Kwara State Urban and Town Planning Board (in late February, 2006,) revealed that the growth of Ilorin has resulted in scarcity of accommodation and employment in the city. The interviewees explained that it was easier and cheaper to get decent accommodation in Ilorin in 1976, for instance, than in 2004. They reasoned that the rate at which buildings are being constructed is lower than the rate at which those in need of houses increase. To expressed it in another way, the expansion of the city and changes in land use have made it difficult for an average immigrant/inhabitant to afford decent accommodation and/or secure employment even after two years of stay in Ilorin. The fortunate ones who secure some accommodation have always paid high rents, because the landlords understand that many people are in need of houses. All the staff of ministries and parastatals interviewed shared a common view that many of the employees gained "misfit" employment (i.e under employed). On this basis, some immigrants are forced to return to villages and hardly or never to come back to Ilorin to settle. Also, as a result of these difficulties/problems, some inhabitants (of Ilorin) migrate to other towns/cities in the country, since to them, the home environment/condition is not friendly.

Despite these negative effects, a good number of the respondents agreed that changes in land use/cover and the growth of the study area over the years have had positive effects. For example, 620 (31%) of them said the rapid growth of Ilorin has brought about the availability of cheap labour in the city (Fig. 5.19 and Appendix 6). Some other respondents (580; 29.9%) saw the growth and changes as having boosted commercial activities in the study area. They held this view based on the understanding that there have always been more people to patronize the business men/women. As some of the migrants/ inhabitants got employed, the purchasing power of the "city-men", as they put it, improved.

Another interesting believe of some of the respondents (176; 9%) is that physical expansion, as experienced in Ilorin, is a direct reflection of the sound economic base of the people. Other positive effects are also contained in appendix 6.

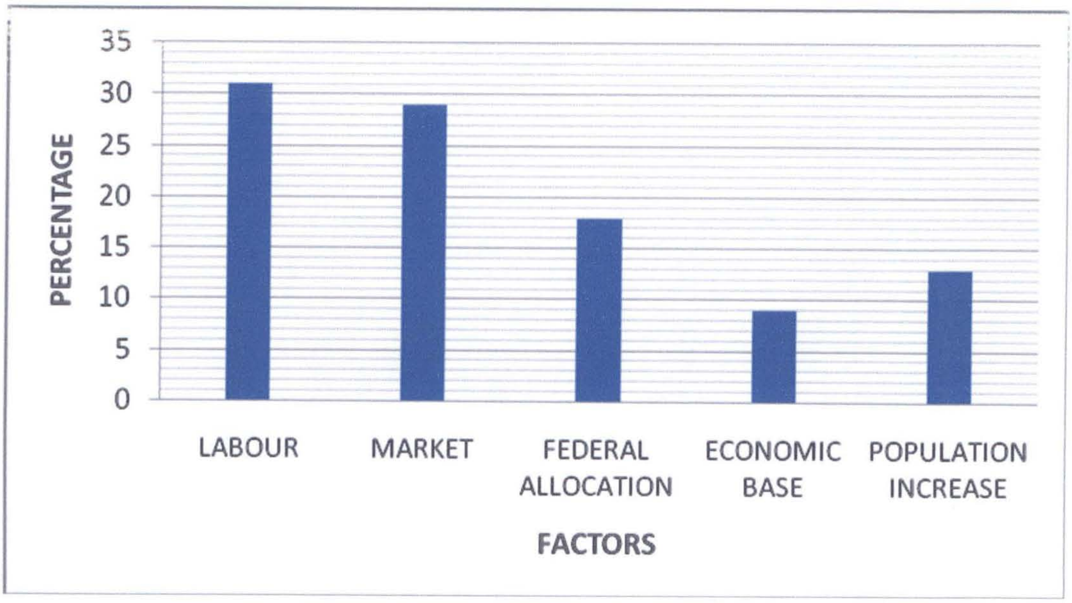


FIG. 5.19: POSITIVE CONSEQUENCES OF RAPID GROWTH
Source: Field work, 2006

The results of several direct and personal field observations indicated that relatively cheap city transportation fare and prices of local food stuffs amongst other factors cushion the unpleasant effects of urban growth. Some of the markets located within the city where, for example, food stuffs can be obtained cheaply include "Oja Oba", Baboko, Omada, Oloje and Panke. Food stuffs such as maize, yams guinea corn, gari, fruits etc are relatively cheap in these markets mainly because they are brought into the city from all parts of the country.

The consequences of the city growth and changes in land use/cover in the study area have been a mixed blessing. Thus, what some respondents have seen as advantages (of the growth) are perceived as disadvantages by some other respondents. It should however be noted that city growth should be seen as a process that cannot be halted. Hence, whatever effects that may come out of it have to be embraced. But necessary adjustments here and there may have to be made through adequate planning and development control to safeguard man's well being in the city. In line with this, most of the respondents recommended ways to curtail or control the rapid growth of Ilorin. Amongst these factors is the decentralization of government institutions/establishments (Table 5.16 and Appendix 8). That is, if some government institutions are located to other parts of Kwara State, some residents of Ilorin would definitely follow the relocated institutions to their new sites. This will go along way in reducing the pressure on land in Ilorin. It is (i.e relocation) also a strategy to develop the other parts of the state.

Table 5.16: Respondents Rating of Ways to Curtail Growth of Ilorin

Factors	No of Respondents	Percentage	Cumulative Percentage
Develop the country side	620	33.3	33.3
Encourage Farming in rural areas	433	23.3	56.6
Decentralize government institutions	572	30.7	87.3
City dwellers to pay more taxes	100	.5.4	92.7
Others	136	7.3	100
Total	1861	100	

Source: Field Work, 2006.

CHAPTER SIX

6.0 DISCUSSION OF FINDINGS, RESEARCH BENEFITS/IMPLICATIONS AND DIRECTION FOR FURTHER RESEARCH

6.1 Introduction

This chapter discusses in summary, the findings of the analysis carried out in the preceding chapter (i.e. chapter 5) of this thesis. It also lays emphasis on the research benefits and adverse effects of the findings with a view of providing methods of and/or solutions to land use and landscape planning (which are vital for human survival) as highlighted in this study. Lastly, as a way of conclusion, the chapter indicates the direction for further research.

6.2 Discussion of Findings

The fact that land use is dynamic is an ancient one and it changes in accordance with response to both natural processes (especially climatic) and human activities such as over-cultivation, animal grazing and increasing population. Some of the basic findings of this study is in line with this ancient and worldwide believe.

The study established that the city of Ilorin is sharply divided into two parts of old and new Ilorin by both River Asa and railway line. The growth pattern of Ilorin can therefore be described, according to the findings of this work as a twin city. This finding conforms with the description of Johnson (1972) of such cities as "mixed cities"; Mclee (1967) as "dual city" and Aderamo (1997) as "indigenous and exogenous". The population projection made by this study (Appendix 7), indicates that the indigenous part of Ilorin is more populated (much more crowded) than the new Ilorin. For instance, in 1987, the population of Balogun Alanamu, a ward in old Ilorin was 46,158 while that of Sabon Gari a ward in new Ilorin, for the same year 1987 stands at 25,873. This confirms the description of such traditional urban settlements in Africa by Johnson (1972) when he said that a population of local origin with high residential densities inhabits the indigenous portion predominantly.

This research used Figures 5.1, 5.2, 5.6 and 5.8 to trace the evolution of Ilorin right from the 18th century until 2004. This was done in order to fully appreciate the trend of the changes that occurred in land use and land cover of the study area over the years. By 1897, the fact that the Emir's palace, which was the administrative headquarters of Ilorin town was located at the centre of the town did not give Ilorin a concentric pattern of growth but radial. Also, at that time the traditional wards of Baloguns Ajikobi, Gambari, Fulani and Alanamu surrounded the palace.

The study reveals that by 1976, the radial pattern of growth was still maintained as the residential buildings and institutional developments were mainly along the major roads of Jebba, Offa, Kaiama and Lagos. This pattern of growth is at variance with the Burgess (1925)'s concentric zone model whose basic idea is that zones are arranged concentrically around the city centre.

By 1987, Ilorin had submerged several other settlements (villages) in its outskirt. The built-up area statistics generated from the 1987 TM image show that the built-up of the study area increased from 45.743km^2 in 1976 to 60.096 in 1987. During this time (1987), the cultivated area had the highest areal coverage of 667.722km^2. This high areal coverage is attributed to the fact that during this period, many of the inhabitants of Ilorin were farmers and the teeming population rushing to the city then needed to be fed, hence another urge for the farmers to struggle to increase their farm plots as the products were highly patronized. This large areal coverage by the cultivated area led to the gross reduction of the areal coverage of the vegetal cover. This means the cultivated area mostly gained all the losses experienced from the vegetal cover. For instance, between the period 1976 – 1987, vegetal cover lost 83.381km^2 of land to cultivated area (Table 5.12).

Generally, the historical evolution of Ilorin reveals that right from 1976 – 2004, the built up component of the study area never lost ground to any other class of land use. Rather, it (built-up area) steadily gained ground coverage through out the period of study. For instance, from the built-up area statistics generated from the 1976 Landsat MSS, 1987 Landsat TM, 1994 Spot XS and Nigeria Sat-1 of 2004 images, the built-up areal coverage on these images are respectively 45.743km^2, 60.096km^2, 63.815km^2 and 126.401km^2.

With the quest for more water supplies by the community of the study area among other factors, Sobi dam was built in 1984 and this changed the areal coverage of water body from 9.313km^2 in 1976 to 9.811km^2 in 1984.

In 1976, vegetation, which covered an area of 121.787km^2 (15.9%) drastically dropped to just 31.422km^2 (4.1%) in 2004. This shows the level at which deforestation has been taking place in the study area.

The growth of Ilorin has been further illustrated by examining the rate of change of urban land between 1976 and 2004. In 1976, the total built-up area was 45.743km^2 while the rate of change of urban land for the city between 1976 and 1987 was 2.9 percent per annum. In 2004, the total built-up area was 126.46099km^2 while the rate of change of urban land for the city between 1994 and 2004 was 6.7 percent per annum. The rate of growth of Ilorin increases between 1976 and 1987 and there was a further increase in the growth between 1987 and 1994. There was a great leap in the growth size of the city between 1994 and 2004. This (increase) has been explained by several factors, the most important are the government policies. For instance, the creation of more local government areas in Ilorin and the policy of the Town Planning Authority to give considerable open spaces between and round buildings especially in new Ilorin are factors of land use expansion. Increase in salaries was also singled out as an important factor that has contributed to the high rate of land absorption between 1994 and 2004.

Thus, the logistic curve model describing the course of diffusion process in the growth of Ilorin was derived as:

$$P = \frac{u}{1 + e^{a-bt}}$$

This finding differs from the findings of Aderamo (1997) on Ilorin, which conformed entirely with the three components of a diffusion process of primary, expansion and condensation/declining phases as ascribed to Brown and Cox (1972) and Casetti (1969). This study rather recorded a pattern of growth that could be described as a gradual increase all through the period of study (Fig. 5.10).

Using the Land Consumption Rate (LCR) formula, this study established that the administrative status of Ilorin very much influenced the land consumption rate of Ilorin. Thus, accounting for 0.00017 LCR in 1976, making it to rank second highest after year 2004. This finding is in contrast with Olorunfemi (1985)'s work on Ilorin, which observed a continuous progressive spatial expansion (LCR) of Ilorin.

The Land Absorption Coefficient (LAC) on the other hand, shows that the land absorbed by a unit increase in population between 1994 and 2004 is the highest as compared with the other periods of 1976 – 1984 and 1984 – 1994. Field survey established that this has been largely attributed to Government policies and rising purchasing power of the people during the period 1994 and 2004 amongst other factors (Table 5.6).

Section 5.7 of this work dwells on a time series analysis of the general level of all the land use/land cover classes of this study: built-up and cultivated areas as well as area of vegetal cover and water bodies between the years 1976 and 2004. The study shows that the rate of urban growth of Ilorin has been very moderate over the years. For instance, while the areal coverage of the built-up area was 45.743km^2 in 1976 (6.0%), it was 60.096km^2 (7.93%) in 1987. So, for a period of seventeen (17) years, the percentage increase in the built-up area of the city was just 1.9%. On the other hand, in 1994 the built-up area was 75.8159km^2 (9.9%) and 126.46099km^2 (16%) in 2004. This trend of growth is showing a percentage increase of 6.65 for a period of ten (10) years. Against this background, the rate of urban expansion of Ilorin can be said to be appreciating over the years. The last ten (10) years (1994 – 2004) is the most rapid period of growth. The year 1994 witnessed the highest areal coverage of cultivated land 663.087km^2 (87.1%) of the total areal coverage of 761.183km^2. This finding thus, helps to buttress the assertion of Adeniyi (1972) and Onokerhoraye (1982) that agriculture is one of the major indigenous occupations of the people of Ilorin.

Vegetal cover and water body components of the study area equally gained and lost land grounds, as the case may be. The area of vegetal cover suffered the highest loss among the other classes. It lost for instance, 98.232km^2 between 1976-1987. In all (i.e in respect of all classes.), the general total area gained was 199.642km^2 (26.23%) and the total area lost was 183.547km^2 (24.11%). The area, which was neither gained nor lost (maintained) was 377.994km^2 (49.66%) as portrayed in Figs. 5.16 and 6.1.

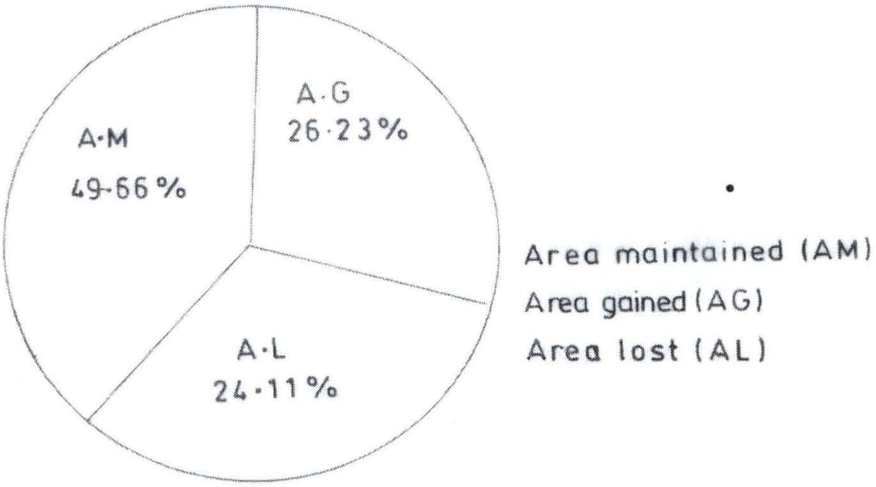


Fig. 6·1: Percentage Area Gained Lost and Maintained.
SOURCE: Authors Data Analysis 2006

Field survey has revealed several factors, which are responsible for the analyzed changes. These range from economic and government policies to geographical location/and relative peace amongst others.

Observable consequences of city growth and land use/land cover changes have also been discussed, which include loss of farm land and economic trees, pressure on land, soil erosion, deforestation, over cultivation and pollution. Others are farm land getting further away from the city, infertility of land, and scarcity of firewood and traces of unemployment.

By and large, the study demonstrated that remote sensing and GIS provide the potential (as data/tools) for more efficient monitoring and mapping land use and land cover changes over an expanse of land area. Otherwise, it would have been difficult or impossible in terms of cost for this study to have monitored and mapped an area of 761.183km within the time frame and resources used. This further proves that remote sensing and GIS are more appropriate tools for cost effective, less time consuming and less labour intensive and large scale time series study of features on earth's surface. This goes to buttress the findings of several authors like Heralick (1979); Jensen, (1983); Vengen, (1982); Olorunfemi, (1983 and 1987); Sada et al (1983); Abubakar, (1998); Jinadu, (2004) and Soneye (2006) who established the effectiveness of satellite remote sensing data as a tool for environmental study and planning.

Despite the immense advantages of remote sensing data, this study notes its limitation in the interpretation process. The resolutions of the images used for this work are low. So, categories of features such as routes were not clear. Consequently, information about the unclear classes had to be technically transferred from appropriate maps to complement the image information. Thus, the successful combined use of images and maps in this study demonstrates that the use of images for land use and land use change should not be thought as replacing and/or eliminating maps. Rather, in order to obtain fine detail/information, it is necessary to use images in conjunction with appropriate maps. As this provides for mutual support and complementarity amongst sources of land use data.

6.3 Research Benefits, Implications and Policy Requirements

There are several benefits/advantages of the research findings. In the first place, the findings revealed that the areal coverage of 761km^2 is far beyond the built-up area of the city of Ilorin. That is to say that the peripheral areas of the city are parts of the study area. This has made it possible to have the understanding of the effects of land cover changes that are occurring in the suburbs of the city of Ilorin. For instance, the result of over cultivation as discussed in section 5.4 was detected only because the study area is not limited to the built-up area. This consequently provides data for managing the peripheral areas of the city.

It is established that the built-up area never lost even an inch of ground to other categories. This empirical finding indicates that the city is rapidly growing year in and year out and therefore, necessitates an urgent need for development control. Field survey reveals that farmers are among the people that are most adversely affected by the growth and changes in land use/land cover of the study area. For instance, farmlands get further away from the city every year. Worst still, farmers also loss farmlands and economic trees most of the time without compensation. Moreso, erosion is threatening land use/land cover both within the city and the outskirt. Lands are also getting infertile.

Arising from this revelation, the state government should make loan facilities available to the farmers at a very low interest rate to cushion these problems.

Based on the findings of this study, vegetal cover lost a lot of hectares of land to the other categories. For instance, it lost 98.233km of land to other classes in 1976 – 1987 period (Table 5.11 and 5.12). This shows an evidence of deforestation, which if allowed to continue, can lead to a reduction in biological production, soil erosion and scarcity of wood among others. Moreover, as a result of growth, the land has been over cultivated. In view of this finding, it is recommended that the government of Kwara State should consider land conservation as one of the most fundamental principles of land use planning. In line with this, maximum potential use of land should be emphasized. In this context, a cultivated land can, for example, after a considerable period of restoration, be reverted to a vegetated land. Similarly, two or three activities can be carried out concurrently on an appropriate class of land use/land cover. For instance, Sobi dam (Fig. 5.5), which is more isolated from the built-up area than the other dams, can be used for domestic water supply, irrigation and for recreational activities all at the same time.

Buildings or houses surround Agba dam. There are also some settlements by Asa dam (Figs. 5.8 and 5.9). Some of such buildings are office complexes. Reconnaissance survey revealed that this attitude of constructing structures by the vicinity of dams is prompted by the urge to have easy access to water for fishing and farming on the flood plain of Asa River. Majority of those farmers/fishermen argued that since they were professionals, they could counter the adverse effects of flooding if and when it occurs at all. Other respondents informed us that the house construction near the dams were due to the fact that they could not afford plots else where in Ilorin.

With whatever scale one may weigh the argument of the respondents, it doesn't seem weighting enough reason to construct houses on a flood plain of the Asa river or any other river for that matter and worst still, on the down stream of a dam, such as Asa dam. In the first place, farming activities can pollute the river especially through the use of chemical fertilizers and insecticides. The inhabitants of the river channel using it as drainage system can also contaminate the river.

Of equal importance is the incidence of river flooding, which is not usually predicted in the study area. It is thus, the submission of this work that those houses should be immediately and appropriately relocated elsewhere. The cost of relocation may not be as much as that of flooding hazards that may consume them.

Inspite of population influx into Ilorin, it has been observed even from the satellite maps (Figs 5.3, 5.5, 5.7 and 5.8) that it is mostly the major roads such as Jebba, Offa, Kaiama, Ibadan, Abdulaziz Attah etc in the city that attract residential developmental projects and institutional buildings. The roads are always busy with human activities, which give rise to sound pollution and high pressure on land.

Since routes and social amenities such as electricity and pipe water can easily attract residential and institutional buildings, there is need to intensify the construction of feeder roads into the interior and/or suburb areas, which have been mainly left for farming and grazing. Such areas where urban expansion is desired include Oyun area on both sides of Jebba road which can go far beyond Kwara Polytechnic. Afon area on both sides of Offa road and Shao road immediately after Sobi barracks extending to Ibadan western bye – pass.

Some of the responses we recorded, revealed that land plots especially at the outskirt of the city, are lost to government and some influential individuals at times without compensation. A critical example is the destruction of commercial trees (cashew, mango, shear butter, locust bean trees). Non payment of compensation to land owners can, infact, be a very devastating experience, as the affected person losses the land together with what is on the land. That should not be the case, especially in a democracy.

There should be government policies to preserve farmlands. This is to address scarcity of food. Some of the Shao farmers that cultivate land parcels within army (Sobi) barracks for example, argued that they could not produce food to their optimum capacity. This is because they have no control over such land as soldiers can take over at any time the need arises.

There is also need to develop rural resources management policies for the study area with a view to protect natural resources such as forest, soil, water and edible plants. This is also tied to the fact that the survival of any urban centre depends upon the health and survival of the urban fringe. To put in another way, in recognition of some consequences of the growth of Ilorin (Section 5.8) such as pressure on land, soil erosion etc, it is here recommended that government should prepare comprehensive plans, which will outline the kinds of land use patterns to be encouraged or discouraged in specific sites or favoured locations for specific uses. If this is done, the city will look more organized and decent. No land use will be allowed to take the plot of another land use (such as preserving farmland for urbanization).

Because the city of Ilorin is expanding fast, (Figs 5.3, 5.5, 5.7, 5.9 and Table 5.1 - 5.4) the government should always seek for accurate information (through research) regarding existing uses of land. Such information assists in making sound decisions/policies regarding economic, demographic and environmental issues.

Going by the land use decree of 1978, government is said to be the custodian of all land. It is on this basis that government(s) acquires land at will sometime to the detriment of poor individuals. In other words, land is not most of the time judiciously acquired by government(s). A case in point is the forceful acquisition of Dumagi community land by the government of Kwara state for the white Zimbabwean farmers, which has been much to the detriment of the indigenous peasants. Thus, governments should always use only what is necessary in size, type and location. If land use policies are developed as here suggested, they should be supported/backed by planning legislation so that culprits can be punished accordingly.

6.4 Direction for Further Research

The basic aim of this research work is to monitor land use cover changes in Ilorin and environs, Nigeria. This, in conjunction with the spelt out objectives has been attempted. But as stated earlier (section 1.6.2), this work restricts itself only to the first class (level 1) in the classification scheme. This was simply due to the fact that the sub-categories under level II are too small to be identified on the low spatial resolution of the satellite images available for use in this study. Thus, the best that could be done was to identify generalized land use ad land cover categories, such as "urban land" or "agricultural land". In the light of the recommended policy options to safeguard and wisely manage the natural resources amongst others, further studies should be directed towards the monitoring and mapping of the sub-categories of level II in the study area.

Newer sensors give rise to improved image resolution. SPOT High Resolution Visible (HRV) can, for example, produce panchromatic imagery with 10m x 10m resolution. There is also Ikonos of 1 to 4 meter resolution and the quick-bird of 0.6 meter resolution. These higher resolution imageries could be acquired to enhance the ability to reasonably recognize and/or identify and map the homogenous individual elements under level II of [illegible]

REFERENCES

Abdulkadir, A. (1986), Land Evaluation for Irrigation, *Unpublished Ph.D Thesis, University of East Anglia..*

Abubakar,S.M (1998), Applicability of Multitemporal Digital NDAA-AVRR Satellite Data for Vegetation Change Detection in Semi-Arid Parts of Northern Nigeria *Unpublished Ph.D Thesis*, Bayero University, Kano, Nigeria, pp56-98.

Adeniyi, E. O (1976), The Kaiji Dam: An Exercise in Regional Development Planning, *Regional Studies* Vo.10 pp233-243.

Adeniyi, P.O. (1980), Land Use Change Analysis Using Sequential Aerial Photography and Computer Techniques. *Phogrammetric Engineering and Remote Sensing* 46 (II) USA pp. 1447-1464.

Adeniyi, P.O. (1985), Imaging Radar System. A paper presented at the Second UN/WMO/ESA/FAO/ *International Course on Remote Sensing Applications to Operational Agro-meteorology and Hydrology*, 16th April – 2nd May

Adedibu, A. A, (1980), Spatial Pattern of Housing Modernization in Traditional Residential Areas of Ilorin: *Nigerian Geographical Journal Vol.23,* Noş 1 and 2pp. 147-162.

Adedibu, A.A; Opeloyeru, G.O. and Ibrahim, M.A. (1998), Monitoring Urban Growth in Developing Cities: A Case Study of Ilorin in *Journal of the Nigerian Institute of Town Planners (NIIP) Vol. XI pp 70 and 84.*

Aderamo, A.J. (1997), The Structure and Growth of Traditional Settlements in Nigeria: The Case of Ilorin, in *Environmental Issues*. Vol.2 pp 42-56.

Ajayi, J. A (1981), "Estimation of Building Construction an Indication of Spatial Urban Growth Using Sequential Aerial Photographs", *Term Paper for GRY 372, Geo, Dept. University of Lagos.*

Aldrich, F.T (1981), "Land Use Data and Their Acquistion". In Lounsbury, J.L et al (eds) *Land Use: A Spatial Approach. Kendall – Hunt* USA pp 79-95.

Allan, J.A (1977), Remote Sensing in Land Use Studies, *Geography* 65; pp 35-43.

Allan, J. A. and Richards, T.S (1983), Remote Sensing for Identifying Low-Density Vegetation Cover in Semi Arid Coastal North West Egypt; Remote Sensing for Rangeland Monitoring and Management R/S Society, Reading pp 69-79.

Anderson, D.E and Anderson, P.N (1973), "Population Estimates by Human and Machines" *Photogrammetric Engineering,* Vol.39, pp 147-154.

Anderson, J. R, Hardly, E. E, Roach J. T. and Witmer, R. E (1976), A Land Use and Land Cover Classification System for use with Remote Sensor Data. *US. Geological Survey Professional Paper 96^th^*. US. Government Printing Office, Washington DC.

Armond, T.J and Steven, A.S. (1986), The Use of Remotely Sensed Data for The Monitoring of Forest Change in Tropical Area, *Presented at the Twentieth International Symposium on Remote Sensing of Environment,* Nairobi, Kenya, 4-10 Dec.

Avery, T.E and Berlin, G.L (1985), Interpretation of Aerial Photographs. Minneapolis: *Burgess, Latest Edition of Standard Test for Photo Interpretation* pp.251.

Ayeni, M.A.O (1976), Spatial and Sectoral Changes in the Structure of Manufacturing Activities in Lagos, 1965-1972, in *Nigeria Journal Qua Econ (2)* pp.27-46.

Ayeni, M. A (1978), Patterns, Processes and Problems of Urbanization, in Oguntoyinbo, J.S, Areola, O.O and Filani, M., *A Geography of Nigeria Development,* Heinemann Educational Books (Nigeria) Ltd

Barret, E.C and Curtis L.F. (1976), *Introduction to Environmental Remote Sensing,* Chapmen and Hall London New York pp. 303-306.

Barret, E.C and Curtis L.F. (1982), *Introduction to Environmental Remote Sensing, (2^nd^ Edition)* Chapman and Hall London New York pp. 309-349.

Berry, B.J.L and Garrison, W.L. (1958), Alternate Explanations of Urban Ranking Relationships. *Annals of the Association of American Geographers, 48, pp.83-91.*

Berry, B.J.L (1961), City Size Distribution and Economic Development. *Economic Development and Cultural Change,* 9, pp.573-588.

Berry, B.J.L (1964) Cities as Systems Within Systems of Cities: *Papers of Regional Science Association, 13,* pp.147-163.

Birnie R.V. and Gauld J.M (1982), A Major European Experiment on the Application on Synthetic Aperture Radar (SAR) for Resources Surveys and Agricultural Monitoring Applications in Scotland. *Soil Survey and Land Evaluation 2, U.K. pp. 20-23.*

Brooner, W. G. Haralick; R. M and Dinstein, 1 (1971), Spectral Parameters Affecting Automated Image Interpretation Using Bayesian Probability Techniques, *Proceedings of the 7^th^ International Symposium on Remote Sensing of Environment.* University of Michigan, Ann Arbor, pp 1929 – 49.

Brown, L.A and Cox, K.R (1972), Empirical Regularities in the Diffusion of Innovation. *Annals of the Association of American Geographers. 61,* pp.551-49.

Brown, R.K (1967), 'City Cybermetics', *Land Economic,* 45, pp.406

Bryne, G.F; Grapper, P.F and Mayo, K.K (1980), Monitoring of Land Cover Change by Principal Components Analysis of Multispectral Landsat Data. *Remote Sensing of Environment 10,* pp 175 – 184.

Burgess, E. W (1925), The Growth of the City; An Introduction to a Research Project in Park, R.E, Burgess E. W, and Makenzie D. (eds), *The City,* University Chicago Press pp.47.

Burley, T.M (1961), Land Use or Land Utilization? *Professional Geographer 13,* pp.18 – 20/

Campbell, J. B (1983), Mapping the Land: Aerial Imagery for Land Use Information, Resource Publications in Geography, *Association of American Geographers,* Washington, DC pp96.

Casetti, E (1969), Why Do Diffusion Process Conform to Logistic Trends? *Geographical Analysis, I,* pp.101-105 (7.3)

Castleman, K.R (1979), *Digital Image Processing.* Prentice Hall, New Jersey. Pp 30 – 44.

Chapin, F.S. Jr. (1976), *Urban Land Use Planning,* Illinois, University of Illinois Press pp 40-51

Clark, D (1982), *Urban Geography: An Introductory Guide,* Groom Helm, London and Canberra. Pp.40-45, 72-180.

Cliff, A. D and Ord, J. K (1973), *Spatial Autocorrelation,* Hutchinson, London.

Cliff, A. D and Robson, B.T (1976), *An Application of a Random Partitioning Model to the Urban Hierarchy of England and Wales, Pp 1801 – 1966.*

Colwell, R. N (1985), SPOT Simulation Imagery for Urban Monitoring. A comparison with Landsat MSS TM Imagery with High Altitude Colour *Photogrametric Engr. And Remote Sensing,* **518,** PP.1093 – 1101.

Courtney, F. M and Trudgill, S. T (9189), *The Soil. An Introduction to Soil Study,(2nd Edition)* Hodder and Stoughton, Great Britain. Pp 35.

Curran, P. (1988), *Principles of Remote Sensing.* Longman Group (FE) Ltd, Hong Kong. Pp1, 189, 194-221.

Curry, L. (1964), The Random Spatial Economy: An Exploration in Settlement Theory. *Annals of the Association of American Geographer.* **54,** PP 138 – 46.

Curry, L. (1967), Central Places in the Random Spatial Economy: *Journal of Regional Science 7, pp 217 038.*

Daniel, P. and Hopkinson, M (1986): *The Geography of Settlement. Conceptual Framework in Geography*. Longman Group (FE) Ltd. Hong Kong pp.86-97, 219 – 226, 235.

Dickinson, R. E (1974), *City Region and Regionalism,* Edward Arnold, London, pp.25.

Doxiadis and Associate (1976), *Master Plan and Programme for the Development of Ilorin,* International Consultant, Greece.

Emielu, S.A (1991) *Guide to Kwara,* Sam-Naak Nig. Ltd. Ilorin. Pp 5 – 10.

Eppler, W. G (1974). An Improved Version of the Table Look-up Algorithm for Pattern Recognition. *Proceedings of the 9th International Symposium on Remote Sensing of Environment.* University of Michigan, Ann Arbor, pp793-812

Fagbemi, A. (1986), Remote Sensing Options for Soils Survey in Developing Countries *ITC Journal, Netherlands. 1 pp. 3-8.*

Federal Republic of Nigeria (1962), *First National Development Plan* 1962 68 (Lagos, Federal Ministry of Information).

Federal Republic of Nigeria (FRN) (2007), *Official Gazette Nol.94* No 24 Lagos, Government Notice No 21, Federal Government Printer, Lagos, Nigeria Pp B190 – B191.

Fischer, W. A (1975), History of Remote Sensing: in Reeves R. G (ed) *Manual of Remote Sensing.* American Society of Photogrammetry. Falls Church, Virginia, Pp 27-50.

Forster, B. C (1993), Satellite Remote Sensing for Land Information in Developing Countries *Geocartor International A Multi- Displinary Journal of Remote Sensing, USA Vol. 8 pp. 5,9.*

Garner, B.J (1977), "Models of Urban Geography and Settlement Location ", in Chorley R.J and Haggett P (Eds.) *Models in Geography*, Methuen and Co. Ltd. London pp.303-354.

Green, P.H.W (1950), Urban Hinterland in England and Wales: "An Analysis of Bus Services" in *Geographical Journal,* **166.**

Haggett, P (1965), *Locational Analysis in Human Geography.* (First Edition), Edward Anold Ltd, London.

Haggett P (1966), *Locational Analysis in Human Geography,* Edward Arnold Ltd London

Haggett, P, Cliff A. D and Frey, A. (1977), *Locational Analysis in Human Geography,* (2nd Edition) Edward Arnold Ltd. London Vol. 1 Pp. 51, 121-139.

Haggett, P and Chorley, R. J (1977), "Models, Paradigms and the New Geography, in Chorley R.J and Haggett P. (Eds) *Models in Geography,* Methuen and Co. Ltd. London, Pp 19-26.

Hajic, E. J and Simoneth, D. S (1976), Comparison of Qualitative and Quantitative Image Analysis: in Lintz, J and Simonentt, D.S (eds) *Remote Sensing of Environment.* Addison-Wesley, Reading, Massachusetts, London, pp374-411.

Haralick, R. M (1979), Statistical and Structural Approaches to Texture, *Proceedings IEEE,* **67**, pp 786-804.

Harris, B (1967), *Quantitative Models of Urban Development.* University of Pennsylvania.

Harris, C.D and Ullman, E. (1945), The Nature of Cities *Annals of the American Academy of Political and Social Science* Vol.242 pp.7-17.

Harris, R (1987), *Satellite Remote Sensing: An Introduction. Routledge and Kengan Paul,* London Pp1, 124 – 125.

Holz, R.K, Huff, D.L; and Mayfield, R.C (1969), "Urban Spatial Structure Based on Remote Sensing Imagery" Proceedings, Sixth *International Sympossium on Remote Sensing of Environment,* University of Michigan, Institute of Science and Technology. Willow Run Laboratories, Ann Abor Pp.819-30.

Horton F. E and Marble, D.F (1969), "Remote Sensing: A New Tool for Urban Data Acquisition" in T.D. Ricket, (ed). *Urban and Regional Information Systems. Federal Activities and Specialized Programs.* Kent State University, Ohio. Pp.252 – 257.

Howarth, J.P and Wickware, G.M (1981), Procedure for Change Detection Using Landsat Digital Data. *International Journal of Remote Sensing.* Vol.2 pp 277.

Howarth, J.P and Boasson, E (1983), Landsat Digital Enhancements for Change Detection in Urban Environments. *Remote Sensing of Environment* Vol.13 pp 149 – 169.

Hoyt, H (1939), *The Structure and Growth of Residential Neighbourhood in American Cities.* Chicago University Press.

Hughes R. H (1982), Use of Landsat MSS Digital Data for Mapping Suspended Solids and Salinity in the Atcha Falaya Bay and Adjacent Water. *Unpublished Ph.D Thesis*, Louisiana State University.

Idris, S. (1988), "The Spatio-Temporal Changes of Urban Land Use in Zaria, a Study in Aerial Photo", *Unpublished MSc Thesis,* University of Ilorin

Ikhuoria, I.A (1993), Vegetation and Land Use Change in a Rainforest Ecosystem, in *Nigerian Journal of Remote Sensing* vol. 1, No.1 pp.73-77.

Iloeje, N. P (1980), *A New Geography of Nigeria.* Longman Nig. Ltd., Ikeja pp.35-58, 78-81

Isard, W (1956), *Location and Space-Economy: a General Theory Relating to Industrial Location, Market Areas, land Use, Trade and Urban Structure.* New York. (1.2.2, 2.2.2,2.7.3).

Jakubauskas, M. E; Lulla, K.P. and Mausel, P.W (1990), Assessment of Vegetation Change in a Fire Altered Forest Land Scape. *Photogrametric Engineering and Remote Sensing 56 (3)* pp371-377.

Jensen, J.R (1978), Digital Land Cover Mapping Using Layered Classification Logic and Physical Composition Attributes *The American Geographer Vol 1.5* Pp 121-132

Jensen, J. R (1981), "Urban Change Detection Mapping Using Landsat Data "*The American Cartographer*, **8,** 127 – 47.

Jensen, J.R (1983), Biophysical Remote Sensing. Annals of the Association of American Geographers, 73: pp 111 – 132.

Jensen J. R; Narumalani, S; Weatherbee, O and Mackey, H.E (1993), Measurement of Seasonal and Yearly Cattail and Waterlily Changes Using Spot Panchromatic Data. *Photogrammetric Engineering and Remote Sensing. Vol.59* Pp 519 – 525

Jensen, J. R (1996), *Introductory Digital Image Processing: A Remote Sensing Perspective* (2nd Edition), New jersey, U.S.A, Prentice Hall, pp257-278.

Jibril, M.S (1994), Monitoring Vegetation and Land Use Changes Around Gummi North West Nigerian Through Satellite Remote Sensing. Unpublished, *MSc. Thesis,* University of Lagos

Jimoh, H. I (1997), Effects of River Erosion on House: A Case Study of Asa River Catchments in Ilorin, Kwara State, Nigeria, in *Environmental Issues* Vol.2 pp 9- 32.

Jinadu, A. M (2004), Analysis of Urban Influence on Rural Stettlement Growth and Land Use/Land Cover Change in the Federal Capital Teritory of Nigeria Using Remote Sensing and GIS Data. *Unpublished Ph.D Thesis,* Federal University of Technology Minna, Nigeria. Pp.8-9, 64, 149-150.

Johnson, I. H (1972), *Urban Geography: An Introductiory Analysis,* Pergamon Press Oxford pp.121.

Jorg, A, (1986), Land Use Mapping and Monitoring by Remote Sensing, in Jorg and Rudiger (eds) Remote Sensing for Development, *Proceedings of the International Conferences in Berlin (West) Sep. Part* ***I,*** pp.57-63.

Kairu, E.N (1982), "An Introduction to Remote Sensing", *Geo. Journal* Vol.6 No.3 pp.241-251.

Kim, S.T. (1980), A Quantitative Evaluation of Landsat for Monitoring Suspended Sediments in Fluvial Channel, *Unpublished PhD Thesis, Louisiana State University, USA. pp. 129.*

Kinsley, D. B (1974), The Utilization of ERTS – 1 Generated Images in the Evaluation of Some Iranian Playas as Sites for Economic and Engineering Development *Contract 243*-AG-Washington D.C

Koopmans, B.N (1982), Some Comparative Aspects of SLAR and Air Photo Images for Geomorphic and Geologic Interpretation. *ITC Journal* **3**, *Netherlands* pp330-37.

Kressler, F. P and Seinnocher, K. T (1999), "Detecting Land Cover Changes from NOAA AVHRR Data by Using Spectral Mixture Analysis" *JAG* Vol.1 *Issue 1* **11.212**

Kuleli, T (2005), Change Detection and Assessment Using Multi Temporal Satellite Image for North-EastMediterranean Coast. *Htt:/www.gisdevelopment.net/application /nrm/mnm/tuncay-artpf.htm* accessed 3/3/2008.

Kwara State Govt. (1968), This is Ilorin, in *Kwara State* Obadaki Press Kaduna pp 1-3,13.

Kwara State Govt. (1977) *Kwara State LGA Series,* Ilorin (Ministry of Home Affairs, Information and Social Development).

Laliberte, A. S; Johnson, DF; Harris, NR; Casady, G.M (2000), Stream Change Analysis Using Remote Sensing and Geographic Information Systems (GIS). *File:IIc:/All Files/My Documents/msj4 – files/stream-paper htm* accessed on 6/22/01.

Lark, R. N (1995a), A Reappraisal of Unsupervised Classification; 1; Correspondence between Spectral and Conceptual Class. *International Journal of Remote Sensing* 16(8) pp 1425 – 1443.

Lark, R. N (1995b), A Reappraisal of Unsupervised Calassification, 11: Optimal Adjustment of the Map Legend and a Neighbouring Approach for Mapping Land Units. *International Journal of Remote Sensing 16(8)*. Pp 1445 -1460.

Lawson, and Stewart, (1965), *Land Use Information: a Critical Survey of U.S, Statistics Including, Possibilities for Greater Uniformity:* Baltiore, Md, The Johns Hopkins Press for Resources for the Future, Inc. pp.402.

Lee, C (1974), *Models in Planning: an Introduction to the Use of Quantitative Models in Planning,* Pergamon Press New York pp.135.

Li, X and Strahler, A. H (1985), Geometric – Optimal Modeling of a Conifer Forest Canopy. IEEE TRANSACTION ON Geo Sciences and Remote Sensing GE 23(5) pp.705 – 721.

Lillesand, T.M and Kiefer, R.W (1979), *Remote Sensing and Image Interpretation,* John Willey and Sons, New York. Pp 221 -236.

Lillesand, T.M and Kiefer, R.W (1987), *Remote Sensing and Image Interpretation,* John Wille, New York. Pp 627 - 695.

Lillesand, T.M and Kiefer, R.W (1994), *Remote Sensing and Image Interpretation,* John Willey, New York. Pp 612 - 691.

Lindgrem. D. T (1974), Urban Application of Remote Sensing: in John E.E, and Leslie WS (eds) *Remote Sensing Techniques for Environmental Analysis,* Hamilton Publishing Company, Santa Barbara, California pp.225.

Lintz, J and Simonnet, D.S (eds) (1976), *Remote Sensing of Environment,* Addison – Wesley, Reading, Massachusetts, London.

Lo, C.P and Welch, R (1977), Chinese Urban Population Estimates, *Annals of the Association of American Geographers,* Vol.67, No.2 June pp.246-253.

Lo, C.P (1976), *Geographical Application of Aerial Photograph* Crame Russak and Co Inc New York.

Lo, C.P (1984), Chinese Settlement Pattern Analysis Using Shuttle Imaging Radar-A Data, *Int. Journal of Remote Sensing* Vol.5, pp 595-67.

Lo, C. P (1986), *Applied Remote Sensing* Longman Inc. United State of America, New York. 218-279.

Louis, W (1983), "Urbanism As a Way of Life" *American Journal of Sociology,*Vol.44, No.2, July.

Lukermann, F (1966), Empirical Expressions of Nodality and Hierarchy in Circulation Manifold. *East Lake Geographers, 2,* pp 17-44.

Mabogunje, A. L (1962), *Yoruba Towns,* Ibadan, University of Ibadan Press

Mabogunje, A. L (1968), Toward an Urban Policy in Nigeria, *Nigeria Journal of Economic and Social Studies* **15**(1), 85-97.

Mabogunje, A. L (1971), *Urbanization in Nigeria,* African Publishing Corporation, New York.

Mabogunje, A. L (1986), *Urbanization in Nigeria*, African Publishing Corporation, New York

Madden, C. H (1958), Some Temporal Aspects of the Growth of Cities in the United States. *Economic Development and Cultural Change,* **6**, pp 134-69

Malcomber, S. A and Woodcook, C. E (1994), Mapping and Monitoring Conifer Mortality Using Remote Sensing in Lake Tahoe Basin. *Remote Sensing of Environment 50,* pp 255-266.

Martin, H, Gunter M, Keith, C.C (2002), *Remote Sensing and Urban Growth Modela Demands and Perspective;* Department of Geogrpahy, University. of California, Santa Barbara/Remote Sensing Research Group, Department of Geography, University. of Bonn, Germany; *h++p: //www.isrg. Unibonn.De/aufsaetze pdf/mherold 22234 regensb.pdf*

Martin, L. R.G and Howarth, P.J (1989), Change Detection Occuracy Assessment Using SPOT Multispectral Imagery of the Rural Urban Fringe. *Remote Sensing of Environment 3o* pp 55-66.

Mclee, R.G (1967), *The South-East Asian City,* London Bell, pp 204.

Moik, J. G (1980), *Digital Processing of Remotely Sensed Images.* National Aeronautics and Space Administration. Washington D.C. pp 39 -47.

Money, D. C (1980), *Climate, Soils, and Vegetation,* University Tutorial Press Ltd, Slough, pp 93-96.

Morrill, R L (1970), *The Spatial Organization of Society,* Duxbury Press London pp.165.

Muljosukojo, B. (1992), Comparison of Landsat (MSS) and Spot (XS) Data for Mapping and Monitoring Mangroove in Java, Indonesia, *The Indonesia Journal of Geography*, Vol.22, No.63. pp13-251.

Muhamood, I.A (1984), The Growth of Ilorin: A Geographical Analysis, *Unpublished Long Essay* Presented to the Department of Geography, University of Ilorin.

Murthy, H. G. S (1974), *Proceedings of UN/FAO Regional Seminar on Remote Sensing of Earth and Environment,* Cairo, Sept 4 – 15.

National Population Commission (NPC), Kwara State, Ilorin (2000)

National Remote Sensing Centre (NRSC) (1989), *Monitoring Change of the Urban – Rural Boundary from Landsat and SPOT HRV* Imagery, WP56 Farnborough, pp 53.

National Space Research Development Agency, (NASRDA) (2003), Nigeria Sat-1: A Medium Resolution Satellite for Earth Observation, *Federal Ministry of Science and Technology.*

Nigam, R. K (2002), Application of Remote Sensing and GIS for Land Use/ Land Cover Mapping and Change Detection in the Rural Urban Fringe Area of Enschede City· The Netherlands. *Fille/C My%20 Documents/Application %2of%20 Remote%20 Sensing%20 and %20Geographi.*

Nkambwe, M (1984), "Application of Multi-Data Aerial Photographs for the Study of Physical Urban Growth of Ile-Ife", *Nigerian Geographical Journal.* Vl.27, Nos 1 and 2 pp 7 – 13.

Nordbeck, S (1965), *The Law of Allometric Growth,* Discussion Paper No7, Michigan Inter University Community of Mathematical Geographers.

Ogrosky, C.E (1975), "Population Estimates from Satellite Imagery" *Photogrammestric Engineering and Remote Sensing* Vol.41, pp 707 – 12.

Ogunsanya, A.A (2002), "Maker and Breaker of Cities" *The Fifty-Ninth Inaugural Lecture,* University of llorin 27th June pp.15

Okpala,C.J (1979), A Critique of the Application of New Town Concept in Nigeria (the Case of Ajoda New Town), *Third World Planning Revolution* 2(1), 58-70.

Olofin, E .A (1990), Rehabilitating and Restoring Degraded Land; the Option for Nigeria, *Paper Presented at the Symposium Organized by the National Conservation Society of Nigeria,* Bayero University Branch, Kano, 10th February pp 1-21.

Oloru, A.J (1998), *A Guide to Ilorin,* Famost (NIG) Ltd 9 – 27

Olorunfemi, J. F (1979), Inter-Censal Population Estimation and Urban Land Use Changes in Nigeria *Ph.D Thesis,* University of Bristol.

Olorunfemi, J. F (1982), Application of Aerial Photography to Population Estimation in Nigeria, *Geojournal* 1 **6.3**, pp 225 - 30

Olorunfemi, J. F (1983), Monitoring Urban Land Use in Developing Countries – An Aerial Potographic Approach: *Environment International* **9,** pp 27 – 32.

Olorunfemi, J. F (1985), The Growth of Ilorin. A Documentary in Aerial Photography *Environmental International* Vol II pp.509 – 514.

Olorunfemi, J. F (1987), Identification of the Areal Extent of Settlements From Landsat' in *International Journal of Remote Sensing* Vol.8, No.12, pp.1839 – 1843.

Omojola, A. S and Soneye, A.S.O (1993), Application of Remote Sensing and GI Sub-System, Techniques for Land Use and Land Cover Mapping in the Middle Sokoto River, North Western Nigeria, *Nigerian Journal of Remote Sensing* Vol. 1 pp 52-75.

Omuta, G.E.D and Ikhuoria, I.A (1994), "Problem and Policy Implications of Urban Residential Land Use Characteristics in Nigeria", in *Albert, I.O et al (eds) Urban Management and Urban Violence in Africa Vol. 1 Proceedings International Symposium on Urban Mag and Urban Violence in Africa Ibadan.* No. 7-11 pp 227-236.

Oni, S.B (1980), Management of the Rapid Growth of Urbanization in Nigeria with Special Attention to the Conditions in Greater Ilorin Kwara State *Unpublished Ph.D Thesis University of Pihsburgh Pennsylvania pp 95-99.*

Onokerhoraye, A.G (1982), Public Services in Nigeria Urban Area (A Case Study of Ilorin), *Nigeria Institute of Social and Economic Research* (NISER), Ibadan University Press, Nigeria pp 34-56.

Oyebanji, J.O (not dated), Economic and Industrial Activities of Ilorin. In: Adedibu A.A (Coordinator), *The Ilorin Atlas,* Ilorin University Press pp 6-9.

Oyegun, R. O and Olaniran, O. J (not dated), The Physical Setting and Climate of Ilorin. In Adedibu A. A (coordinator) *The Ilorin Atlas,* Ilorin University Press pp 1-2.

Panikkar, S.V (2008), Forest Change Detection. *http://www.gisdevelopment net/application/environment/conservation/frcmoos.htm.* Accessed on 3/3/08

Patrick, S (1987), Gully Erosion in Gongola and Bauchi States, Nigeria. *Unpublished. Ph.D Thesis* University of London.

Patrick, S. and Abdulhamid (1989), The Impact of Jankara Dam on the Downstream Morphology and Agricultural Production, *Proceedings of Second Land Resources Workshop.* BUK. 1-11

Peterson, F (1969, An Urban Land Use Study of Lawrence, Kansas, Using K-B and Radar, in the Utility of Radar and Other Sensors in Thematic Land Use Mapping from Space Craft, *Inter Agency Report NASA 140, US Geological Survey,* Washington DC.

Philip, C. C (1997), Overview of Vegetation Changes Detection: A Satellite Remote Sensing Techniques ASE 389, *Remote Sensing from Space* pp.1.

Rao, K.M.L (1995), Remote Sensing for Land Use Planning *International Journal of Remote Sensing* Vol.16 No.1 pp53-60.

Rhind, D, and Hudson, R. (1980), *Land Use,* Methuen and Co, London and New York pp.68-69.

Rilwani, M. I. and Ufuah M. E (1999), Mapping the Land Use and Land Cover Resources of Edo North East for Effective Local Government Administration, *Journal of Nigerian Cartographic Association* pp. 61-67.

Robson, B. T (1973), Urban Growth: *An Approach.* Cambridge, London (4.2.3, 4.4)

Robson, B. T (1975), Urban Analysis: *A Study of City Structure with Special Reference to Sunderland, Cambridge,* Cambridge University Press (CUP), pp.97.

Rudd, R. D (1974) *Remote Sensing. A Better View.* Duxbury Press Massachuatts, London.

Rutchley, K and Velcheck, L (1994), Development of an Everglades Vegetation Map Using SPOT Images and GPS. *Photogrammetric Engineering and Remote Sensing* ***60(6):*** 767 – 775.

Sabin, F. F (1978), *Remote Sensing: Principles and Interpretation* W. W. Foreman and Co. San Francisco.

Sada, P. O; Adeniyi, P.O; Ihemadu, S.O and Olorunfemi, J.F (1983), "Technical Appraisal of Remote Sensing Technique for Census Surveys and Population Estimation, *A Report Prepared for the National Population Commission, Nigeria* pp 7-9.

Salami, A. T (1994), Urban Violence the State of Theory, Implications for Contemporary Urban Management in Africa. In Albert I. O. et al (eds). *Urban Management and Urban Violence in Africa Proceedings International Symposium on Urban Management and Urban Violence in Africa* Vol. I Nov.7-11 pp 73 – 86.

Short, N (1982), The Landsat Tutorial, Workbook National Aeronautics and Space Administration, Washington DC, *NASA Reference Publication 1087.*

Shryock, H.S and Siegel, J. S (1976), *The Methods and Materials of Demography,* Academic Press, New York, pp62

Simon, H.A (1955), On a Class of Skew Distribution Functions, *Biometrika,* **42**, Pp 425-440

Simpson, R. B (1969), *Geographic Evaluation of Radar Imagery of New England* Dartmouth College, Department of Goegraphy, Hanover.

Singh A. (1986), Change Detection in the Tropical Forest Environment of North Eastern India Using Landsat, in Edem and Parry (eds) *Remote Sensing and Tropical Land Management*, pp.237-253.

Singh, A (1989), Digital Change Detection Techniques Using Remotely Sensed Data. *International Journal of Remote Sensing.* Vol.10, pp 983 – 1003.

Skilling, H (1964). An Operational View; *American Scientist* Vol.52, pp 388A – 396A

Smith, P (1962), Calgary; A Study of Urban Patterns. *Economic Geography* **38**, pp.315-329.

Soneye, A.S.O (1992), "Application of Hydrid Satelite Remote Sensing and GIS to the Revision of Tropographical Maps". *A Graduate Seminar Paper Presented to the Department of Geography/Planning.* University of Lagos, Oct.20 pp 1-10.

Soneye, A.S.O (2006), GIS and Military Operations: What Opportunities for Nigeria? *Academy Journal of Defence Studies,* Vol.12 February, Pp 39-56.

Stewart, C. T, JR (1958), The Size and Spacing of Cities *Geographical Review,* **48**, pp 222-45. (4.3.1)

Stone, K. H (1974). Developing Geographical Remote Sensing. In John E.E and Leslie, W. S (Eds) *Remote Sensing Techniques for Environmental Analysis,* Hamilton Publishing Company, Santa Barbara, California pp 1-8

Strahler, A. H (1980). The Use of Prior Probability in Maximum Likelihood Classification of Remotely Sensed Data. *Remote Sensing of Environment, 10.* 135-63.

Toll, D.L.; Royal, J.A and Davis, J. B (1980), Urban Area Up-Date; Procedure Using Landsat Data. *Proceedings of the Fall Technical Meeting of the American Society of Photogrammetry held in Niagra Falls, Canada* (Fall Church Virginia American Society of Photogrammetry) PPRS-E 1-17.

Tomlins, G.F (1981), Canadian Experience in Wetland Monitoring by Satellite: In Smith, H (ed.) *Plants and the Daylight Spectrum.* Academic Press. London. Pp 102-113.

Udo, R. K (1978); *Geographical Regions of Nigeria.* Morrison and Gibb Ltd London Pp.100-108

Vass, P. A (1983), A Landsat Study of Vegetation and Seasonal Livestock Grazing in the Southern Sudan, Remote Sensing for Range Land Monitoring and Management, *Remote Sensing Society Reading,* pp 51-66.

Vengen, F (1982), L Observation De La Terre Parles' Satellites, *PUF, France, pp128.*

Vining, R (1955), A Description of Certain Spatial Aspects of an Economic System. *Economic Development and Cultural Change* **3**, pp 147-95

Vink A. P. A. (1982), Land and Ecological Mapping *ITC Journal 3*, pp.149-95.

Webber, M. M (1964), "The Urban Place and the Non-Place Urban Realm" in M. M. Webber et al *Exploration into Urban Structure,* University of Pennsylvania Press, Philadelphia, pp.79-153.

Webber, C.C (1994), "Per-zone Classification of Urban Land Cover for Urban Population Estimation". In Foody G.M. and Curran, P.J (eds) *Environmental Remote Sensing from Regional to Global Scales*, John Wiley and Sons, England pp.142-148.

Witenstein, M. M (1956), A Report on Application of Aerial Photograph to Urban Land Use Inventory, Analysis and Planning" *Photogramtric Engineering* **22**: pp656-663

Whynne-Hammond, C. (1979), *Elements of Human Geography*, Gorge Allen and Unwin Ltd. London pp.195.

Wolfe, W.L and Zissis, G.J (1978), *The Infrared Handbook.* Office of Naval Research, Department of the Navy, Washington, DC pp40-44.

Wu, W; Lambin, E. F: Courel, M.F (2005); Land Use and Land Cover Detection and Modeling for North Ningxia, China. *File:IIC: Documents% 20and%210 Settings/pc %My% 20 Documents/land%20 accessed on 1/26%.*

Yeates, M and Garner, B (1976), *The North American City,* Harper and Row Publishing New York.

Appendix 3: Annual Change Statistics

(1) **Annual Change for 1976 - 1987**

Difference between years 1976 and 1987 = 11 years

Built – up area = 60.09628 – 45.7434 = $\frac{14.3529}{11}$ = 1.30

Cultivated Area = 667.722584.3402 = $\frac{83.38}{11}$ = 7.58

Vegetal Cover = 23.554 – 121.7874 = $\frac{98.2}{11}$ =8.9

Water Bodies 9.8115 – 9.3133 = $\frac{0.4982}{11}$ = 0.05

(2) **Annual Change for 1987 – 1994**

The difference between years 1987 – 1994 = 7 years

Built-up area for 1994 = 75.815

Built-up area for 1987 = 60.096

.. 75.815 – 60.096 = 15.75 ÷ 7 = 2.25

Cultivated Area: 663.089 – 667.772 = 4.633 = -0.66

Vegetal Cover: 12.469 – 23.554 = -11.085 = -1.58

Water Bodies: 9.811 – 9.811 = $\frac{0.00}{7}$ = 000

(3) **Annual Change for 1994 - 2004**

The different between 1994 – 2004 = 10
Built-up Area = 126.46099 – 75.8159 = 50.6450 = 5.06

Cultivated Area = 593.489 – 663.087 = -69.598 = -6.96

Vegetal Cover = 31.422 – 12.467 = 18.953 = 1.80

Water Bodies: 9.811 – 9.811 = $\frac{0.00}{10}$ = 0.00

Appendix 4: Logistic Curve Statistics Work as Used in the Study

$$P = \frac{U}{1 + e^{a-bt}}$$

Where **U** is the Total Built-up Area of each year

e is the Mathematical Constant = 2.7183

a is the Rate of Change of the year = 2.9

b is the Slope of the Graph = 3.8

t is the Difference Between 1979 – 2004 = 28

$$\text{Slope} = \frac{Y^2 - Y^1}{X^2 - X^1} = \frac{6..7 - 2.9}{11-10}$$

$$\frac{3.8}{1} = 3.8$$

Where:

11 is the difference between 1976 and 1987

10 is the difference between 1994 and 2004

6.7 and 2.9 are respectively rates of change of the years 2004 and 1987.

1976 = U = 45.7434

$$P = \frac{U}{1 + ea\text{-}bt} = \frac{45.7434}{1+2.7183^{(2.9-3.8x28)}}$$

$$= \frac{45.7434}{1+2.7183^{(2.9-106.4)}}$$

$$= \frac{45.7434}{1+(2.7183)^{103-1.3.5}}$$

$$= \frac{45.7434}{1+ 1.12 \times 10^{-45}}$$

$$= \frac{45.7434}{1}$$

$$P = 45.7434\ (km^2)$$

1987 = U = 60.09628

$$P = \frac{U}{1+e^{a-bt}} = \frac{60.09628}{1+2.7183^{(2.9-3.8x28)}}$$

$$= \frac{60.09628}{1+(2.7183)^{2.9-106.4}}$$

$$= \frac{60.09628}{1+(2.7183)^{2.9-103.5}}$$

$$= \frac{60.09628}{1+ 1.12 \times 10^{-45}}$$

$$= \frac{60.09628}{1}$$

$$P = 60.09628$$

1994 = U = 75.8159

$$P = \frac{U}{1+e^{a-bt}} = \frac{75.8159}{1 + (2.7183)^{2.9-3.8x28}}$$

$$= \frac{75.8159}{1+(2.7183)^{2.9-106.4}}$$

$$= \frac{75.8159}{1+(2.7183)^{2.9-103.5}}$$

$$= \frac{75.8159}{1+ 1.12 \times 10^{-45}}$$

$$= \frac{75.8159}{1}$$

$$P = 75.8159$$

2004 = U = 126.46099

$$P = \frac{U}{1+ e^{a-bt}} = \frac{126.46099}{1 + (2.7183)^{2.9-3.8x28}}$$

$$= \frac{126.46099}{1+(2.7183)2.9^{-106.4}}$$

$$= \frac{126.46099}{1+(2.7183)^{2.9-103.5}}$$

$$= \frac{126..46099}{1+ 1.12 \times 10^{-45}}$$

$$= \frac{126.46099}{1}$$

$$P = 126.46099$$

APPENDIX 6: SPSS 9.0 SUMMARY STATISTIC OUTPUT

Education

		Frequency	Percent	Valid Percent	Cummulative Percent
Valid	Pri. Education.	386	19.3	19.3	19.3
	Sec. Education.	349	17.4	17.4	36.7
	Tertiary Education.	1001	50.0	50.0	86.7
	Non Formal Education.	269	13.4	13.4	100
	Total	2005		100	

Occupation

		Frequency	Percent	Valid Percent	Cummulative Percent
Valid	Farming	67	3.3	3.3	3.5
	Trading	514	25.6	27.1	30.6
	Artisans	237	11.8	12.5	43.1
	Civil servants	601	30.0	31.7	74.8
	Private business employee	309	15.4	16.3	91.1
	Unemployed	166	8.3	8.8	100
	Total	1894		100	
	Missing system	111	5.5		
	Total	2005			

Name of Ward:

		Frequency	Percent	Valid Percent	Cummulative Percent
Valid	Balogun Gambari	248	12.4	12.4	12.4
	Magajin Ojunekun	240	12.0	12.0	24.4
	Magajin Oloje	162	8.1	8.1	32.5
	Adewole	304	15.2	15.2	47.7
	Zango	492	24.5	24.5	72.2
	Sabon Gari	460	22.9	22.9	95.1
	Magajin Baderi	99	4.9	4.9	100
	Total	2005	100	100	

Household Size:

		Frequency	Percent	Valid Percent	Cummulative Percent
Valid	1 – 5 Persons	1024	51.1	51.1	51.1
	6 – 10 Persons	649	32.4	32.4	83.5
	11 – 15 "	232	11.6	11.6	95.1
	16 – 20 "	48	2.4	2.4	97.5
	21 and above	52	2.5	2.5	100
	Total	2005	100		

Years of Residence in this Ward:

		Frequency	Percent	Valid Percent	Cummulative Percent
Valid	1 – 5 Years	88	4.4	4.4	4.4
	6 – 10 "	325	16.2	16.2	20.6
	11 – 15 "	249	12.4	12.4	330
	16 – 20 "	571	28.5	28.5	61.5
	21 and above	772	38.5	38.5	100
	Total	2005	100	100	

In which part of Ilorin is this ward located?

		Frequency	Percent	Valid Percent	Cummulative Percent
Valid	Eastern (New Ilorin)	746	37.2	37.2	37.2
	Western-(Old Ilorin)	1259	62.8	62.8	100
	Total	2005	100		

Reasons for living in this ward

		Frequency	Percent	Valid Percent	Cummulative Percent
Valid	Availability of labour	323	16.1	61.3	61.3
	Vast land for farming/grazing	51	2.5	2.6	18.9
	Security purposes	60	3.0	3.0	21.9

Proximate to place of work/school	488	24.3	24.6	46.5
Cheap rent/housing	273	13.6	13.8	60.3
Business/employment opportunities	340	17.0	17.2	77.5
Availability of infrastructure facilities	96	4.8	4.8	82.3
Cultural factors	350	17.5	17.7	100
Total	1981		100	
Missing system	24			
Total	2005	100		

Do you experience Population growth in this ward?

		Frequency	Percent	Valid Percent	Cummulative Percent
Valid	Yes	1980	98.8	99.8	99.8
	No	3	0.001	0.002	100
	Total	1983		100	
Missing System		22			
	Total	2005	100		

Do you agree that this ward is growing in size?

		Frequency	Percent	Valid Percent	Cummulative Percent
Valid	Yes	2001	99.8	99.8	99.8
	No	4	0.2	0.2	100
	Total	2005	100	100	

Factors of growth in size of this ward

		Frequency	Percent	Valid Percent	Cummulative Percent
Valid	Being an Administrative Centre at Various Periods	413	20.6	20.6	20.6
	Oil Boom	311	15.5	15.5	36.1

Population Growth due to in-migration	253	12.61	12.6	48.7
Establishment of industries	209	10.4	1.2	59.1
Increase in Salaries	303	15.1	15.1	74.2
Good geographical location of Ilorin	205	10.2	10.2	84.4
Peace in Ilorin (i.e low crime rate)	109	7.4	7.4	91.3
Agriculture – Production of more crops (cash and food)	162	8.1	8.2	100
Total	2005	100		

Low rate of growth

		Frequency	Percent	Valid Percent	Cummulative Percent
Valid	Unemployment	509	25.4	25.8	43.3
	Effects of SAP	346	17.3	17.5	25.8
	Urban-Urban migration	272	13.6	13.8	57.1
	No cash crops	428	21.3	21.7	78.8
	No much federal establishments	200	10.0	10,1	88.9
	Others	219	10.9	11.1	100
	Total	1974		100	
	Missing System	31	1.5		
	Total	2005	100		

Period of lowest/highest rate of growth

		Frequency	Percent	Valid Percent	Cummulative Percent
Valid	1976-1987	204	10.2	10.2	33.2
	1984-1994	461	23.0	23.0	23.0
	1994-2004	1340	66.8	66.8	100
	Total	2005	100	100	

Factors of highest rate of spatial growth

		Frequency	Percent	Valid Percent	Cummulative Percent
Valid	Nigeria independence	98	4.9	4.9	4.9
	Production of more crops (food/cash)	641	32	32	36.9
	Rising purchasing power of people	624	31.1	31.1	68.0
	Creation of Kwara State in 1967	200	10	10	78.0
	Establishment of industries	100	4.9	5.0	83.0
	Total	1663			
	Missing System	342	17.1	17.1	100.1
	Total	2005	100	100	

Positive consequences of rapid growth

		Frequency	Percent	Valid Percent	Cummulative Percent
Valid	Availability of labour	620	30.9	31.1	31.1
	Availability of market	580	28.9	29.1	60.2
	A yard stick for Federal allocation	362	18.1	18.2	78.4
	Physical expansion is a function of sound economic base	176	8.8	8.8	87.2
	Population increase is a resource in it self	253	12.6	12.7	100
	Total	1991		100	
	Missing system	14	0.007		
	Total	2005			

Major adverse effects of growth of this ward

		Frequency	Percent	Valid Percent	Cummulative Percent
Valid	Farmlands are getting further away from the city	338	16.9	16.9	16.9
	Country side farmers loss farm plots to physical development	297	14.8	14.8	31.7
	Soil erosion	200	10.0	10.0	41.6
	Deforestation	281	14.0	14.0	55.7

Pollution	105	5.2	5.2	60.9
Pressure on Land	92	4.6	4.6	65.5
Infertility of Land	140	7.0	7.0	72.5
Scarcity of firewood	59	2.9	2.9	75.4
Lack of: Accommodation;	147	7.3	7.3	82.7
Employment	130	6.5	6.5	89.2
Infrastructure	60	3.0	3.0	92.2
Exorbitant rent	49	2.4	2.4	94.6
General high cost of living	70	3.5	3.5	98.1
Insecurity due to crime and social vices	37	1.8	1.9	100
Total	2005	99.9	100	

Ways to curtail growth in size

		Frequency	Percent	Valid Percent	Cummulative Percent
Valid	Develop villages	620	30.9	30.9	30.9
	Encourage farming in rural area	433	21.6	21.6	52.5
	Decentralize Govt. institutions/ Establishments	572	28.5	28.5	81.0
	City dwellers to pay more taxes	100	5.0	5.0	86.0
	Others	136	6.8	6.9	82.8
	Total	1861	92.8	-	-
	Missing system	144	7.2	7.2	100
	Total	2005	100	100	-

Appendix 7A: Population Projection Analysis for years 1976, 1987, 1994 and 2004

Pt = Po(1 + rp)t (Shryock et al, 1976)

Where

T is the difference in years

Therefore, the population of Magajin Gari Ward

In 1976 (as an example)

$= 8,224\ (1 + 2.8\%)^{13}$

$= 8,224\ (1 + 2.028\%)^{13}$

$= 8,224\ (1.02.8)^{13}$

= 8,224 x 14

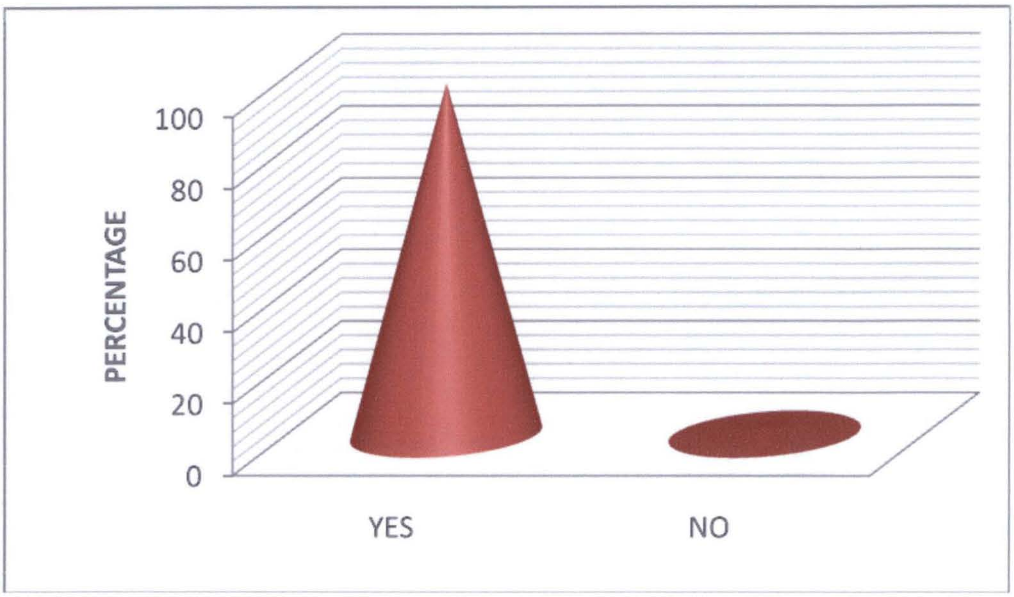
= 11514

Appendix 7B: Results of Population Projection analysis

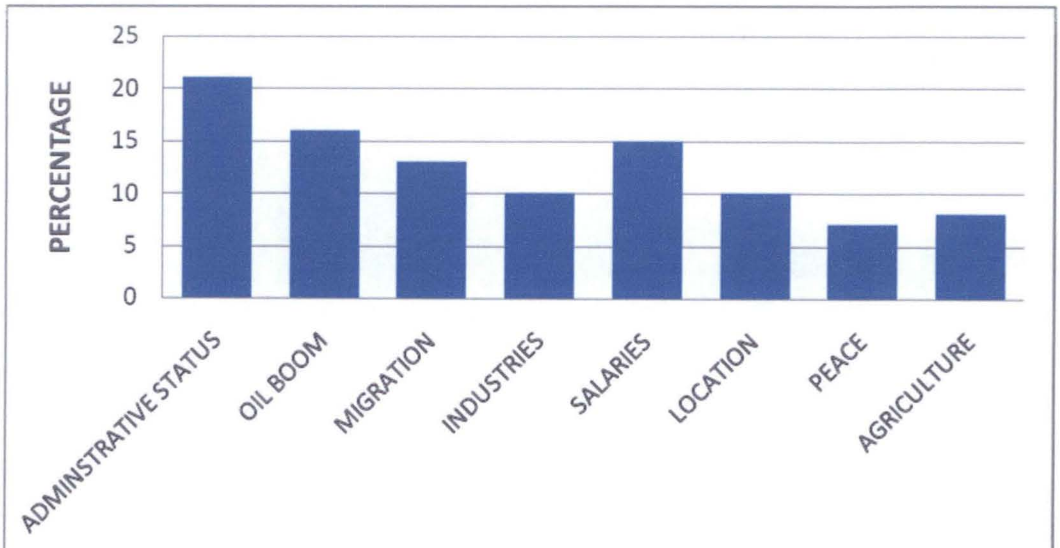
S/NO	WARD	CENSUS 1963	Projected Population			
			1976	1987	1994	2004
1.	Magajin Gari	8,224	11,514	16,110	19,332	25,132
2.	Magajin Baderi	2,190	3,066	4,292	5,150	6,695
3.	Balogun Gambari	9,405	13,.167	18,434	22,121	28,757
4.	Zango	15,239	21,335	29,869	35,843	46,596
5.	Magajin Ibagun	10,070	14,098	17,737	23,684	30,789
6.	Balogun Ajikobi	18,097	25,336	35,470	42,564	55,333
7.	Ubandawaki	20,514	28,720	40,194	48,233	62,703
8.	Adewole	11,938	16,713	23,398	28,078	36,501
9.	Balogun Ajikobi	23,557	32,970	46,158	55,389	71,994
10.	Magajin Oju Ekun	8,417	11,784	16,498	19,798	25,737
11.	Magajin Zarumi	4,721	6,609	9,253	11,104	14,435
12.	Magajin Ogidi	7,084	9,918	13,885	16,662	21,661
13.	Magajin Oloje	4,867	6,814	9,530	11,436	14,867
14.	Balogun Fulani	9,088	12,723	17,812	21,374	27,786
15.	Oke-Ogun	10,070	14,098	19,737	23,684	30,789
16.	Magajin Okaka	8,156	11,418	15,985	19,182	24,937
17.	Magajin Are	2,495	3,493	4,890	5,868	7,628
18.	Sabon Gari	13,201	18,481	25,873	31,048	40,3262
Total		**187,333**	**262,266**	**367,172**	**440,606**	**572,788**

Source: Computed by the Author, 2006.

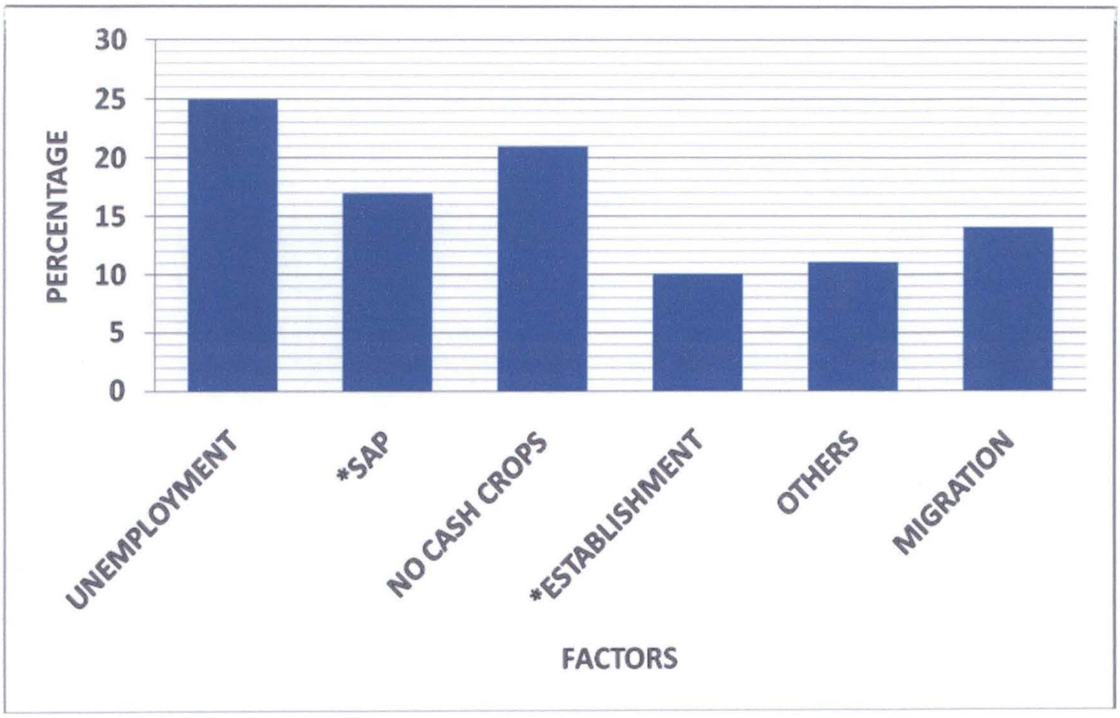
APPENDIX 8: PORTRAY OUTPUT GRAPHS FOR THE PERCEPTION OF RESPONDENTS ON THE CHANGE IN GROWTH OF ILORIN



APPENDIX 8A: RESPONDENBTS' PERCEPTION OF POPULATION GROWTH

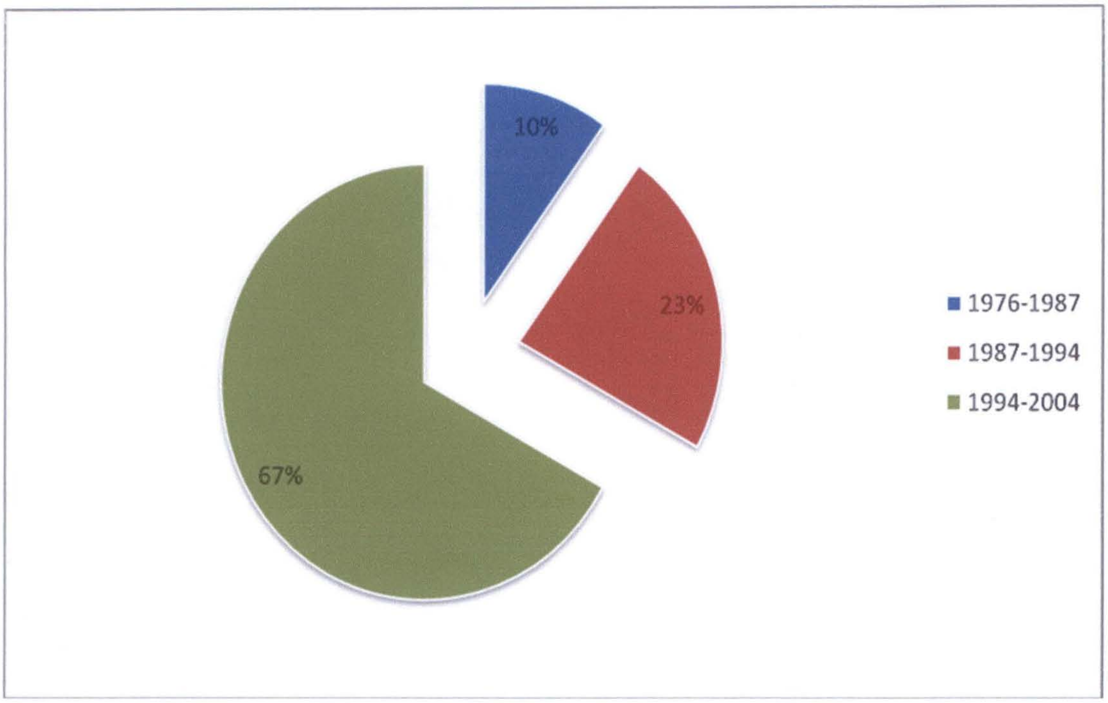


APPENDIX 8B: FACTORS OF GROWTH IN SIZE OF ILORIN METROPOLIS

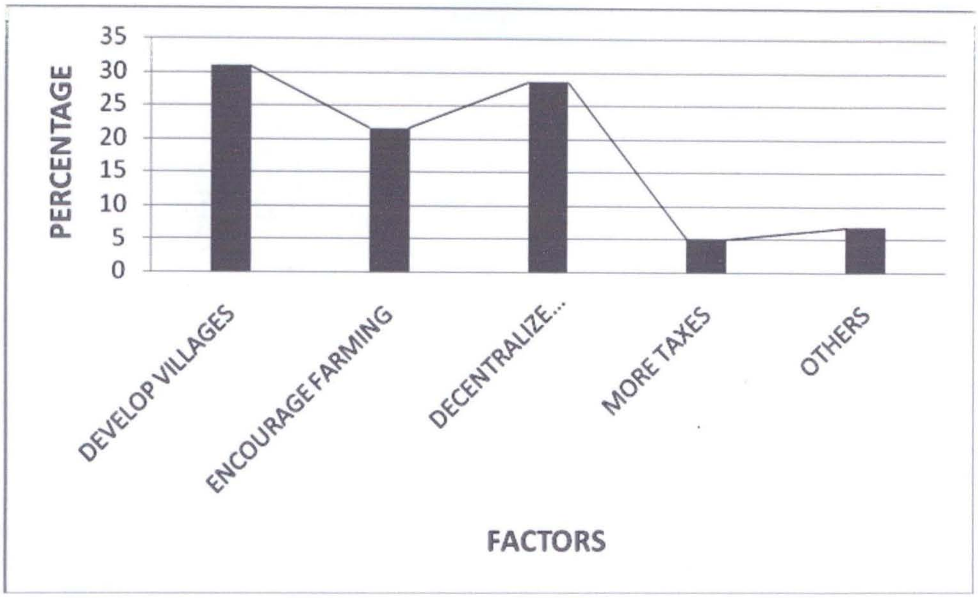


APPENDIX 8C: FACTORS OF LOW RATE OF GROWTH

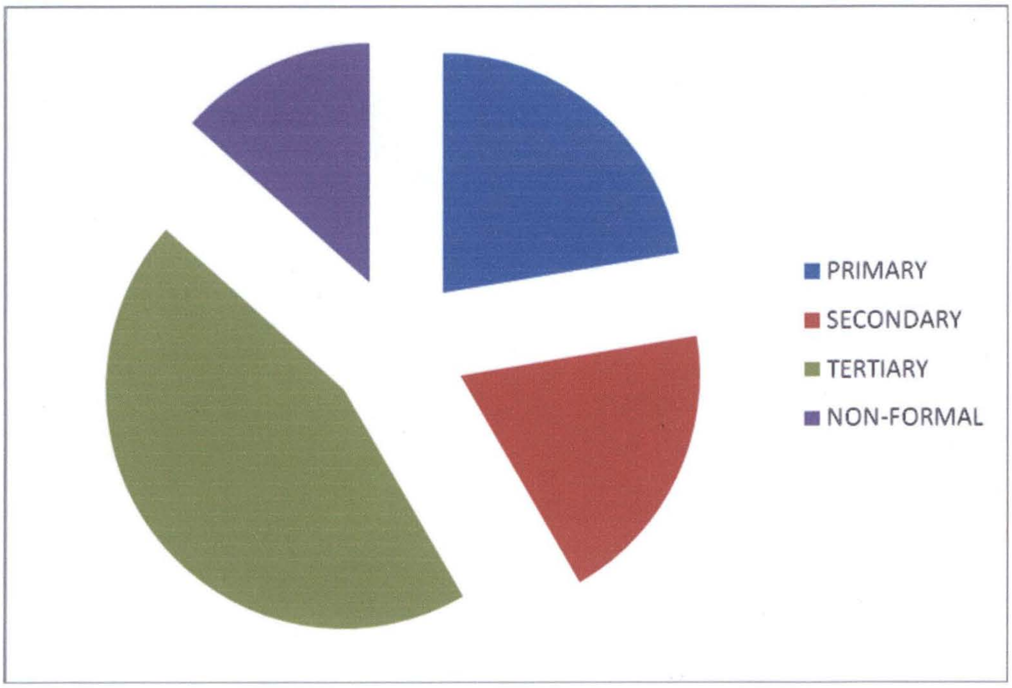
*Structural Adjustment Programme (SAP) *Establishment of Industries



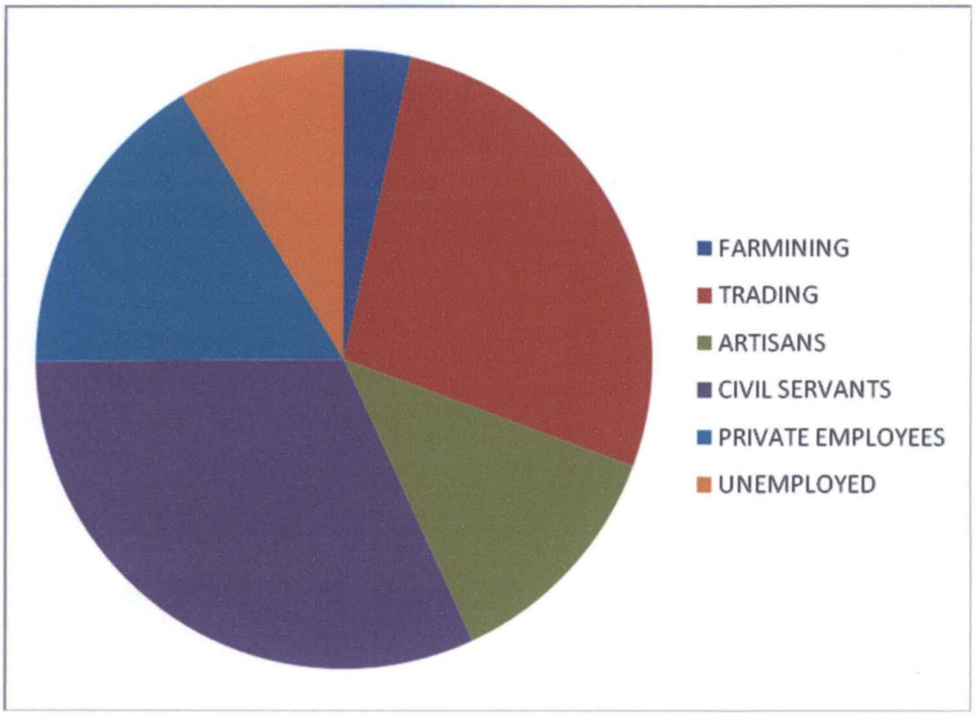
APPENDIX 8D: PERIOD OF LOWEST/HIGHEST RATE OF GROWTH



APPENDIX 8E: WAYS TO CURTAIL GROWTH IN SIZE OF ILORIN



APPENDIX 8F: EDUCATIONAL ATTAINMENT OF RESPONDENTS



APPENDIX 8G: OCCUPATION OF RESPONDENTS

classification scheme. In other words, efforts should be made to make judicious use of these remotely sensed images and GIS to gather and handle up-to-date information on land use and land cover and the nature and rates of changes in land use/cover for the purpose of policy making and implementation, especially with regard to physical planning and development of the urban environment. The motivation for this could among others, be the efficient exploitation of the land, protection of natural resources and/or the preservation of human amenity.

It has been established under section 5.5 that population increase is a major driving force behind land use and land cover changes in the study area. But, the limited need for indepth population data in this research, has made the available population data provided here, far inadequate to understand the dynamic nature of the population growth of Ilorin. It is through continuous trend analysis and reliable data on population increase that a stable relationship between man and land could be maintained. For instance, even a minor increase in population, leading to demands in land, which cannot be met, could lead to a process of degradation and destruction.

In this context, it is pertinent to note that further research must effectively project and monitor population changes and assess the consequences on a continual basis, so as to address environmental problems facing the study area.