# URBAN-INDUCED LANDUSE / LANDCOVER CHANGES IN ZARIA KADUNA STATE, NIGERIA

***BY***


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## DECLARATION

I hereby declare that this thesis titled "**Urban–Induced Landuse / Landcover Changes in Zaria, Kaduna State, Nigeria"** was written by me and is a product of my research effort. It has not been presented in any previous application for any degree or diploma. All quotations are indicated and the sources of information are acknowledged by means of references.

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## CERTIFICATION

This thesis titled**, "Urban–Induced Landuse/Landcover Changes in Zaria, Kaduna State, Nigeria**" by **Augustine Amedu OKEWU** meets the regulations that govern the award of Degree in Masters of Science (GIS and Remote Sensing) of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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# DEDICATION

This research work is dedicated to GOD Almighty, and to my kid brother Mr. Simon Abu Okewu (Late)

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# ABSTRACT

This study aimed at analysing urban-induced landuse and landcover changes in Zaria between 1990 and 2014, using Geographic Information Systems and Remote Sensing techniques. Landsat Thematic Mapper (TM) of 1990, Landsat Enhanced Thematic Mapper Plus (ETM+) of 1999, Landsat Enhanced Thematic Mapper Plus (ETM+) of 2006 and Landsat Enhanced Thematic Mapper Plus (ETM+) of 2014 were used. Supervised classification was employed using maximum likelihood classifier to classify the images into LULC classes. Also overlay analysis was used to determine the changes within the period. The result from the analysis showed that built-up areas witnessed consistent increase over time and this was basically because of increased population and consequent conversion of other land uses into residential areas. Also, the extent of urbanization throughout the study period witnessed the highest level between 1999 and 2006. Finding on landuse/landcover changes that were affected most during the study period reveals that agricultural land lost about 31.3km2 while vegetative land lost about 36.75km2, whereas built-up increased from 40.37km2 in 1990 to 55.8 km2 in 2014 which signifies an increase of about 15.43km2 and a progressive encroachment of built-up areas into other land uses. The rate of urban-induced landuse/landcover change showed an annual rate of change to be 5.67% for the study period. Finally, it was observed that landuse landcover had changed significantly over the period of study (1990s-2014). This could be explained by the rapid population growth in Zaria; an increase in the diversity of functional activities; growing demand for lands for residential housing and other land-based activities. The study has indicated that urbanisation and its functional activities were gradually taking over the negligible lands. It is therefore recommended that regular landuse change studies should be carried out more frequently by researchers and other stakeholders to detect urban induced landuse/cover changes in the study area so as to ensure a more sustainable urban development.

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# CHAPTER ONE

# INTRODUCTION

## 1.1 BACKGROUND TO THE STUDY

Urbanization is a process through which the productive agricultural land, forests, surface water bodies and ground water prospects are being irretrievably lost (Tali and Murthy, 2012). Rapid urbanization results in a tremendous growth of population and buildings in cities, as well as an increasing replacement of natural landscapes by impervious surface areas (Owen, Carlson and Gillies, 1998). Human dependence on the physical environment for his basic needs has generated actions and inaction in various areas and at various times, often translating into land conversion, alteration and modification, much of which degrade and severely damage the abiotic and biotic components of the environment. For instance, since humans have controlled fire and domesticated plants and animals, they have cleared forests to wring higher value from land (Mittermeier, Mittermeier, Gil, Pilgrim, and Fonseca, 2003).

Urban development is a significant global phenomenon and continues to be a great concern for the decades ahead. The outcomes of these processes are manifested in the diversity of urban environments that characterize the contemporary world. Urbanization has caused many impacts on natural resources associated with the reduction and conversion of green space. The land use/land cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space and has become a central component in current strategies for managing natural resources and monitoring environmental changes (Pacione, 2009).

Urbanization as a process of landuse and landcover changes has been a universal and important socio-economic phenomenon taking place all around the world. This process, with no sign of slowing down, could be the most powerful and visible anthropogenic force that has brought about fundamental changes in land cover and landscape pattern around the globe. In the developing world, urban growth is continuing to be one of the crucial issues of global change in the 21$^{st}$ century affecting the physical dimension of cities (Mohan, 2010).In addition, Lindgren (1974) noted that urban areas represent a complex association of population concentrations, intensive economic activities, and diverse lifestyles. They are a microcosm of human activity, and frequently experience rapid changes that need to be monitored and understood. Today changes made on cities are more extensive and take place more rapidly than ever before. Not only the city centres but also the urban fringes are under pressure because of their environmental significance such as forestry areas and water resources.

According to United Nations, in 2011 3.6 billion of the world's population (52%) were urban dwellers. Universally, the level of urbanization is expected to rise to 67% by 2050. In the less developed regions the urban population is expected to rise from 47% in 2011 to 64% by 2050. In Africa alone urban population is expected to triple from 414 million in 2011 to 1.2 billion in 2050 (UN-HABITAT, 2011). Africa held a particular situation, despite its place of the least urbanized region in the world (39.1%), it had the highest urban growth of the world: 3.3% per year between 2000 and 2005 (UN-HABITAT, 2009). The built-up area of developing-country cities is expected to increase from 200,000 km$^2$ in 2000 to more than 600,000 km$^2$ by 2030 (Angel *et al*., 2005). This implies that urban population in developing countries is on the increase with increasing ubiquitous city expansion encroaching into their hinterlands.

In most countries of the world urbanization is recognized as a crucial phenomenon of economic growth and social change as it offers opportunities for employment, specialization, production of goods and services. This has initiated a larger number of people to migrate from rural to urban areas. As a result, cities are growing faster than ever (in physical dimension), being a huge centre for residence, industry, trade and investment, communications, infrastructure, social services etc (UN-HABITAT, 2011).

Landuse and landcover changes refer to the set of biophysical transformation of land surface and water bodies driven by an interconnected complex of human and natural processes such as building construction and unplanned disaster (flood) which in turn take charge of the inhabitant's lands. The human induced changes to the structure, composition or function of large natural bio-geophysical and ecological system which entail changes in the complex array of forcing and feedback that characterize the internal dynamics of the earth system (Steffen *et al.*, 2004).

The most striking feature of the global urban environment is landuse change. Urban-induced landuse landcover change is a global phenomenon in which non built-up area is converted into a built up area over a period of time through a process referred to as urbanization (Verma and Kumar, 2013). The extent and rate of global landuse/landcover changes whether greenhouse gas-induced warming, deforestation, desertification, or loss in biodiversity, are driven largely by the rapid growth of the Earth's human population (Grimmond, 2007). A good example of the urbanization of the world is the increase in the number of megacities of 10 million or more people which were only four in 1975; 18 in 2000 (Torrey, 2013) and were estimated to be 22 by 2015 (United Nations, 2013). A greater percentage of the future growth, however, will not be in these megacities, but in the small to medium-size cities around the world (National Research Council, 2003).

The proportion of urban population in Nigeria has risen from 15% in 1960 to 43.3% in 2000 and is projected to rise to 60% by 2015 (Halidu, 2009). Total area taken up by urbanization in Nigeria during the same period increased by 131% (from 2,083 sq.km in 1976 to 5,444 sq.km in 2000) with an average rate of urbanization estimated at 3.7% per year

(National Population Commission, 2004). Urbanization in Nigeria is driven by high population growth rate; concentration of development activities in urban centres; rapid growth of formal education; and rural-urban wage differentials (Halidu, 2009). Rapid urban population growth results to an increasing demand for urban land, particularly for housing and also for various other urban uses (Thuo, 2013).

Grimmond (2007) noted that, given the large and ever-increasing fraction of the world's population living in cities, and the disproportionate share of resources used by these urban residents, cities and their inhabitants are key drivers of global landuse change. Urbanization leads to conversion of agricultural lands, forests, wetlands, bare surfaces, water bodies, rocky areas and other ecological sensitive areas to other urban uses in order to accommodate newer developments such as construction of residential houses, factories, markets, dams, roads, etc. (Hardoy, Mitlin, and Satterthwaite, 2001). Landuse and landcover changes caused by urbanization are not without their associated socio-economic problems (Pirez, 2002) and severe environmental consequences (Hardoy *et al*., 2001). These problems are global, continental and national levels.

Zaria has continually experienced increase in population, due to presences of many educational institutions, and also being a historical and cultural centre. This increase in population has consequently brought about human influence leading to high rate of land use change. The 1952 census recorded 56,000 for the population of Zaria which included Tudun-Wada, outside the north gate of the city, and Sabon-Gari across the Kubani River to the north. By 1963 Census, the population had risen to about 110,000 and the built-up area covered some 33.67square kilometre (Mortimore, 1970). However, during the 1991 national census, Zaria recorded a population of 489,858 with 2.86 growth rate per annum (NPC, 1991). By 2006 the region recorded a population of 695,109 with 3.2 growth rate per annum (Federal Republic of Nigeria, 2007). These figures show that the population of Zaria has rapidly grown, owing to the range of functional activities, such as agricultural, economical, educational, administrative, health, military and industrial functions which have spread and diversified over the area under study with the serious effects on the land use pattern of the environment.

Geospatial technologies had been applied to investigate the effects of urbanization on landuse/landcover variables and to quantify urban growth in different parts of the world. Remote Sensing and Geographical Information Systems (GIS) as modern technologies are increasingly used due to their cost effectiveness and technological soundness to develop useful sources of information and to support decision making in connection with a wide array of urban applications (Lo and Yang 2002). Satellite images are potentially useful source of land cover information (Saleh, 2006).

Remote sensing data and geographic information systems (GIS) provide efficient methods for analysing urban growth and landuse change, planning and modelling. Understanding the driving forces of urban growth development in the past, managing the current situation with modern GIS tools, and modelling the future, plans can be developed for multiple uses of natural resources and nature conservation. The knowledge about urban growth, landuse and landcover changes has become increasingly important as all nations plan to overcome the problems of haphazard, uncontrolled development, and deteriorating environmental quality (Anderson, Hardy and Witmer, 1976). All these pose a formidable challenge in many developing countries. Hence there is a need for quantitative and qualitative information on the environmental consequences of expansion of cities in Nigeria.

## 1.2 STATEMENT OF THE RESEACH PROBLEM

The United States Geological Survey (1999) identified that urbanization is creating societal problems worldwide. Urban landuse and landcover changes are causing great environmental problems leading to loss of lives and property. Apart from air and water pollution, there are other severe environmental problems, such as deforestation resulting from road projects, subsistence activities, logging, mining, and dam construction which are causing serious problems to the environment in Nigeria (Moffat and Linden, 1995).

A review on the urban growth impacts on the landuse and landcover across the world shows that urbanization generally, and sprawl in particular, contribute to loss of farmlands and open spaces (Berry and Plaut, 1978; Fischel, 1982; Nelson and Dueker, 1990). Urban growth, in developed countries like the United States, is predicted to consume 7 million acres of farmland, 7 million acres of environmentally sensitive land, and 5 million acres of other lands during the period 2000–2025 (Burchell *et al.*, 2005).

Early accounts of Northern Nigeria, including Zaria area, suggests that there is a high level of agricultural intensification with a dynamic mosaic of croplands in the gently undulating terrain of the area. There is no doubt however, that in recent times, human activities have profoundly changed the environment in the Zaria area (Jaiyeoba, 2010). Zaria has witnessed a remarkable expansion, growth and developmental activities such as building, road construction, deforestation and many other anthropogenic activities over time just like many areas in Nigeria.

Under a condition of rapidly increasing population and economic growth, other activities such as housing for various uses (residential, educational, health, commercial, and recreation) and industries tend to compete with agriculture for land except where official land use policies that privilege agriculture over other uses exist and are strictly followed. This is because they pay higher rents. This has given rise to the emergence of informal land market with more speculative land holdings, and agricultural lands tend to be more easily converted into other uses (Ariyo, 1991). It is therefore necessary for a study such as this to be carried out to avoid the associated problems of a growing and expanding regions like many others in the world.

Coskun *et al.,* (2008) also analysed land use change and urbanization in the Kucukcekmece water basin (Istanbul, Turkey) using Remote Sensing and GIS from 1992 to 2006. Landsat-5 TM (1992), SPOT-XS and Pan (1993), IRS-1C 2000 and IRS-LISS (2006) data were used. The study revealed that rapid, uncontrolled urbanization led to the pollution of streams and the terrestrial environment.

In Africa for instance, Nyakaana, Sengendo and Lwasa (2004) reported that the resultant effects of urban development, on landuse/cover in Kampala, Uganda from 1980 to 2002 revealed a decrease in agricultural land from 62% to 45% of total land area mainly to housing and industrial establishments as well as low land forests changes from 7.6% to 0.4% of the total land area.

Adeboyejo and Abolade (2006) carried out a study on spatial changes of Ogbomoso area in Ibadan. The results showed that expansion of the city has destroyed fertile agricultural land, and the residential land-use spread to and beyond distant location relative to the city core.

Similarly, Oyinloye (2010) conducted a study on the spatial growth of Akure, Ondo State, Nigeria using satellite imageries of three time periods. The result shows that there has been a rapid conversion of agricultural areas to urban (non-agricultural) land uses. The encroachment of built-up area into the cultivation area due to the demand for shelter and cultivation replacing the vegetation due to farming activities. The implications of the urban expansion in the area include loss of open space, deforestation and colonization of adjacent farmlands, overcrowding, poor quality of housing, traffic congestion and poor standard of living.

Abbas and Arigbede (2011) carried out a study on sustainable land management in Zaria using Remote Sensing and GIS techniques. The result revealed that built-up areas increased from 10.16km$^2$ in 1985 to 179.34km$^2$ in 2005, water body decreased from 95.68km$^2$ in 1985 to 32.17km$^2$ in 2005 while cultivation decreased from in 198.69km$^2$ 1995 to 176.01km$^2$ in 2005. This indicates that Zaria is fast becoming more unplanned due to increase in population and the consequent human influence leading to high rate of land use-land cover change which has led to elimination of the crop, forest and scrub lands mostly towards the eastern and southern outer limits of the city. Also growth of built-up areas mainly towards the east- west route in a linear pattern.

Uhwache, Sawa and Jaiyeoba (2015) carried out a study on landuse dynamics in Zaria between 1973 and 2009. The findings indicated that Zaria is experiencing rapid expansion leading to a large chunk of the scrubland, farmlands and even part of the flood plains giving way to residential buildings with built-up areas increasing from 44.27km$^2$ in 1973 to 130.25 km$^2$ in 2009, while fadama lands decreased from 146.35km$^2$ in 1973 to 571.29 km$^2$ in 2009, plantation/forest decreased from 89.24 km$^2$ in 1973 to 63.36 km$^2$ in 2009, scrubland decreased from 1,765.72 km$^2$ in 1973 to 1,350.39km$^2$ in 2009 and water bodies from 38.16km$^2$ in 1973 to 4.20km$^2$ in 2009.

Odeh (2013) assessed the impact of urban growth on agricultural lands in Zaria and its environs using Remote Sensing and GIS techniques between 1970 and 2009. The study revealed that urban growth has encroached on agriculture lands and agriculture in turn moved into shrub lands, wet lands and former plantation lands. The findings showed an increase in built up areas from 14.51km$^2$ in 1973 to 37.13km$^2$ in 2009.

In most of the studies carried out in Zaria, for instance Abbas and Arigbede (2011) and Uhwache *et al.*, (2015) was generally on landuse landcover change while Odeh (2013) was on effect of urban growth on only agricultural land. Moreover, the study covered from 1970 to 2009. None of this research attempted to study urban-induced landuse landcover changes in Zaria with emphasis on the effect of urban growth on various aspects of the landuse and landcover of the environment such as water body, floodplain, and vegetation cover using GIS and Remote Sensing techniques covering a temporal scope that extends to 2014.

From the foregoing, this research work proposes the following research questions;

1. What is the extent of urbanization in the study area between 1990 and 2014?
2. What is the extent of landuse/landcover changes that have taken place between 1990 and 2014?
3. What are the magnitude and rate of urban-induced landuse/landcover changes in Zaria between 1990 and 2014?

## 1.3 AIM AND OBJECTIVES

The aim of the study is to analyse the urban-induced landuse and landcover changes in Zaria between 1990 and 2014. The aim is achieved through the following objectives which includes to;

i. determine the extent of urbanization in the study area between 1990 and 2014
ii. determine the extent of landuse/landcover changes have taken place in the study area between 1990 and 2014.

iii. determine the magnitude of urban-induced landuse/landcover changes in the study area between 1990 and 2014.

iv. determine the rate of urban-induced landuse/landcover changes in the study area between 1990 and 2014.

## 1.4 SCOPE OF THE STUDY

The spatial extent of this study covers Zaria comprising of Sabon-Gari and Zaria local government areas. The content focused on urban induced landuse/landcover changes, the extent of urban growth in the study area, the pattern of urban growth and the classification of these patterns, as well as examining the implications of urban encroachment on other aspects of the environment such as water body, flood plain (fadama), scattered cultivation and shrub lands were considered. The temporal scope of the study covers a time frame of 24 years between 1990 and 2014. This is due to the availability of satellite data of the period under investigation.

## 1.5 SIGNIFICANCE OF THE STUDY

Urban induced changes in the environment are creating regional adverse environmental problems such that, within the next 50 to 100 years may see the loss of plant and animal species and environmental quality (Tilman and Lehman, 2001). Nigeria is witnessing serious landuse/landcover changes due to urbanization with its attendant consequences. Current and up-to-date information in terms of the rate, nature and spatial distribution of these changes will be very useful for better urban environmental planning and development. Unfortunately, such information is not readily available for decision makers to make informed decisions.

This research will aid government agencies in strategic planning. By understanding the changes and estimating the nature of future changes that will take place, the government will be able to plan for future urban growth so as to avert negative environmental consequences due to unplanned urbanization

Accurate and timely information on urban-induced LULC changes, its spatial distribution and changed process are critical for planning, utilization and formulation of policies and programmes for making any micro and macro development (Oluseyi, 2006). The use of GIS and Remote Sensing techniques in this study, it will enable a reliable and accurate mechanism for the collection and analysis of complex environmental data than the old traditional method.

# CHAPTER TWO

# CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

## 2.1 INTRODUCTION

The purpose of this chapter is to present the conceptual framework, including literature review to give an indepth understanding of urban-induced landuse landcover changes. This framework will form the basis for the analysis in this study.

## 2.2 CONCEPTUAL FRAMEWORK

### 2.2.1 Concept of Urbanization

Urbanization is an increasing proportion of a population living in settlements defined as urban centers. This usually results from the net movement of people from rural to urban areas or natural increase; the excess of births over deaths (Isma'il, Salisu, Yusuf and Muhammed, 2013). However, the definition of what qualifies as urban center differs from one country to another depending on the criteria used. Whatever criteria used to define urban centers, Satterthwaite (2005) noted that many aspects of urban changed during the period 1950-2000 were unprecedented.

Urbanization is a universal concept, signifying changes in man's interests, activities and values, and appearing to have been related to increasing functional specialization in human societies. It has characteristics and processes of manifestations which differ from place to place given environmental, socio-cultural and political conditions peculiar to a particular geographical location. Thus, urban growth is a quantitative measure frequently associated with progress (Yichun *et al.*, 2007).

Urbanization, which refers to the expansion in the proportion of a population living in urban areas, is one of the major social transformations sweeping the globe. It represents the movement of people from rural areas to urban areas with population growth equating to urban migration (Ajiboye, 2011). It is generally believed that urbanization has both direct and indirect impacts on land use transformation. According to Ejaro and Abdullahi (2013), Urban sprawl is one of the most noticeable effects of urbanization on land use. Though, sprawl can alter a region's unique rural character by creating miles of undifferentiated new developments that bring habitat loss along with traffic congestion. Rimal (2001) opined that urbanization is an inevitable process due to economic development and rapid population growth. Urbanization is a process of increase of modernization system which modifies the socioeconomic activities and revolutionizes the land use practice according to time frame (Ejaro and Abdullahi, 2013).

Developing countries are experiencing a rapid rate of urbanization. This is manifested more in Africa where the average annual growth rates were estimated as 4.7% and 4.6% between the period 1960 and 1980, and 1980 and 2000 respectively. The growth rate of urban population is more pronounced in Nigeria than most other countries in the African continent. The number of urban cities in Nigeria has risen drastically in the last one hundred years. The resultant effect has been the formation of more urban centres which are densely populated (projectfaculty.com, 2014).

Urbanization has become an environmental problem of global importance. Although the absolute amount of urbanized land is still a few percent of the earth's land surface, the impacts of urbanization on biodiversity, ecosystem fluxes, and environmental quality are profound and pervasive (Breuste *et al.*, 1998; Pickett *et al*., 2001). Urban growth affects the ecology of cities in a number of ways, such as eliminating and fragmenting native habitats, modifying local climate conditions, and generating anthropogenic pollutants. It is widely recognized that the spatial pattern of a landscape affects ecological processes (Turner, 1989; Wu and Loucks, 1995).

Urbanization is now a common feature of all third world countries. In Africa, Asia, and Latin America, the unprecedented population growth that characterized much of the 20th century has evolved into unparalleled urban growth (Brockerhoff, 2000). The rapid urbanization particularly in developing countries require a scientific understanding of complex urban growth patterns and processes. This knowledge is highly crucial to sustainable land management and urban development planning. Over the past half century, a great rural-to-urban population movement has occurred and the process of urbanization is set to continue well into the 21st century. Major demographic evidence has indicated that, already, the Asia-Pacific region is well advanced in the transition from predominantly rural to predominantly urban societies. Although population growth rates have slowed down in many countries for the past decade, 62 percent of the world's population will live in urban areas by the year 2020, while the Asia-Pacific Region will contain about 49 per cent of that urban population and will have contained a level of urbanization of 55 percent. An additional 1.2 billion people will be living in the urban centres of the Asia- Pacific region by 2020 (Ichimura, 2003).

Africa has the lowest level of urbanization and the fastest urban growth. Currently, a little more than one third of Africans are urban dwellers. The proportion, by 2030, will be a little more than half. The urban growth rate for Africa as a whole currently is around 4.4 percent. East Africa is growing at 5.6 percent per annum and West Africa at 5.1 percent, with individual countries growing at even higher rates. Projections shows that the growth rate for Africa as a whole will stay above four percent through 2005 and above three percent until 2020-2025 (Brennan, 1999). The problem of such rapid rates of urban growth is that it makes exceedingly difficult efforts to provide needed services.

One of the major problems arising from urbanization is thus landcover changes such as vegetation degradation. It is a decline in the quantity and quality of the grasses, herbs and woody species found in an ecosystem (Douglas, 1994). Conacher and Sala (1998) defined

Vegetation degradation as the temporary or permanent reduction in the density, structure, species composition or productivity of vegetation cover. Vegetation condition is the key aspect of degradation in grasslands, wood/forest lands and croplands. Thus, over exploitation and management practices may result in vegetation degradation and tend to enhance land degradation risk. Pressure on the natural vegetation has arisen from changing agricultural practice, fire and livestock grazing, and the feed-back with the loss of bio-diversity.

Anthropogenic processes of vegetative degradation are caused both directly by humans and indirectly by their animals. Humans introduce arable farming into rangelands to satisfy the increasing needs for food and other products. Vegetation is often set on fire for the purpose of clearing vegetated land rapidly or to eliminate economically useless plants (Parry, 1996). As long as burning was light and the interval between fires ranged from six to seven years, vegetation could regenerate. However, increased frequency of fires has become a major cause of widespread destruction of native vegetation and accompanying land degradation. Moreover, a several-fold increase in erosion and runoff followed when bulldozers were used to remove vegetation instead of manual clearing (Lewis and Berry, 1988). Damage due to fuel-wood extraction is also substantial. However, Dregne and Chou (1993) maintain that overgrazing by livestock stands as the principal factor of vegetation destruction in rangelands. In view of the pivotal place of livestock in the economy of territories susceptible to desertification, wide-scale degradation of rangelands is a matter of serious concern.

In developing countries, about 40% of the energy for cooking is derived from non-commercial sources; fuel wood, dung, and crop residues. That percentage increases beyond 80% in small towns and hamlets (Lele, Mitra and Kaul, 1994). Fuel wood remains the predomdinant source of energy for cooking. In order to lessen dependence on woody perennials, it is essential to improve the efficiency of cooking with fuel wood and to search for alternative sources of energy. Biogas and solar energy offer attractive alternatives for energy in the tropics (Lele *et al.*, 1994).

### 2.2.2 Urban Centres / Growth

The urbanization level for any nation is the growth of the national population living in urban centre. So it is influenced by how the national government defines an 'urban centre'. For instance, most of India's rural population lives in villages with between 500 and 5,000 inhabitants and if these were classified as 'urban' (as they would be by some national urban definitions), India would suddenly have a predominantly urban population rather than a predominantly rural population. Each nation uses its own criteria for defining urban centre (or for distinguishing them from other settlements). In virtually all nations, official definitions ensure that urban centre include all settlements with 20,000 or more inhabitants. Urban centre is a cluster of contiguous with an aggregation population of 20,000 people or more persons within an area of urban character (United Nations, 2010). However, governments differ in the size of smaller settlements they include as urban centre – some that include all settlements with a few hundred inhabitants as urban; some that only include settlements with 20,000 or more inhabitants. This limits the accuracy of international comparisons, because in most nations, a large part of the populations lives in settlements that fall into this range.

Urban growth indicates a transformation of the vacant land or natural environment to construction of urban fabrics including residential, industrial and infrastructure development. It mostly happens in the fringe urban areas (Shenghe and Sylvia, 2002). This process can be regarded as the spatial representation of the economic structural shift of labour away from agricultural to industrial-based activities. Crucial to this shift are the output gains associated with resource transfers from the low-productivity agricultural sector to the high productivity industrial sector (Kam, 1994).

Urban growth is the physical expansion of an urban centre as well as increases in its population. Whenever there is physical growth in an area, it means that something have changed to give way to others. When a town expands, green areas and farmlands would have to give way for new buildings and other land use types. Urban growth also refers to increase in a town's populations, which by implication, means there will be internal changes in the town, which will eventually have their different effects on the environment and the available social infrastructures (Kenk *et al.,* 1983).

Urban growth has become common phenomenon around almost all Chinese big cities despite the government policies and effort to either control or maximise it (ADB, 2006). All of this expansion and growth have mainly come at the cost of agricultural lands. Millions of farm households have been either evicted or resettled and farmlands surrounding urban areas have been converted to urban uses such as residentials, commercial, industrial, public open spaces and infrastructure.

#### 2.2.2.1 The Factors of Urban Growth

Several factors are responsible for urban growth. Increasing urban employment opportunities is a factor that leads to urban growth. People tend to migrate from rural to urban centres in search of better job opportunities. Adindu and Ogbonna, (1998) are of the view that urban growth is as a result of rural unemployment, increased rural poverty, deteriorating living condition, declining soil fertility and unchecked rural urban migration. All these are responsible for people's movement out of rural land to urban centre. Urban infrastructural development such as water, electricity, health, education, increases urban growth. Oyesiku (1995) remarked that growth depends on the natural increase on the part of the total population that is already in urban but it is affected more by difference in the natural level between rural and urban areas. Two major factors responsible for urban growth; these are natural increase and rural- urban and urban-urban migration. People respond to urban socio-economic opportunities by undertaking rural-urban and urban-urban migration.

According to Adedibu, Opeloyeru and Ibrahim (1998), it was established that there are two major forces shaping the pattern of development of any city in the world. One is centrifugal nature while the other is centripetal force. Moreover, it was added that factors that constitute the later force dominate the development of most of the developing world cities while centrifugal force is often associated with cities in the developed world. Salami (1997) also remarked that among factors responsible for growth in Nigeria includes urbanization, associated population increase, nature of urban uses, landscape configuration, and location of development scheme, government policy and pattern of route development. Route development serves as a major force in reorganizing landuse (Nkanbwe, 1984), it is the pivot for economic growth, population expansion and overall progress of any region. Improved transport technology and services bring food and raw materials to feed growing urban population and industries. However, land being used for agricultural production around a rapidly growing urban centre will most likely be converted to non-agricultural uses. Therefore, an urban centre where these factors are in operation will expirience physical expansion as residential houses, factories, warehouses, offices, schools, healthcare centres, roads and streets and social centres will be built to accommodate people and their work places and to provide easy movement, living and working areas.

With respect to the concept of environment, this has been viewed from diverse perspectives, and defined in various ways. The variety of definitions and conceptions of environment is closely linked to the fact that the study of environment is multi-disciplinary, and thus each discipline tended to develop and adopt definition(s) in line with its interest. This multiplicity of definitions, concepts and usage of the term in various disciplines was clearly captured by the study that the multiplicity of the usage and concept of the term environment have resulted in a variety of adjectival forms which include social environment, moral environment, physical environment, home environment, psychological environment, behavioural environment and geographical environment (Porteous, 1977).

For instance, Bain, a sociologist, defined environment as all the external and non-personal conditions and influences that affect the welfare of a people in a given area (Bain, 1973). Hagget, a geographer, on the other hand, defined environment as the sum total of all conditions that surround man at any point on the earth's surface (Efobi, 1994), while the Federal Environmental Protection Agency in Nigeria (FEPA) stated that the environment includes water, air, land, plants, animals, and human beings living therein, and the inter-relationships that exist among them (FEPA, 1989). However, a more comprehensive and all-embracing definition was offered by Keller who defined the environment as: total set of circumstances that surrounds an individual or a community, these circumstances are made up of physical conditions such as air, water, and climate and landforms; the social and cultural aspects such as ethics, economics, aesthetics and such circumstances which affects the behaviour of an individual or a community (Efobi, 1994).

From these definitions, it is clear that environment consist of all the physical, non-physical, external, living and non-living conditions surrounding an organism or groups of organisms that determine the existence, development and survival of organism(s) at a particular time (Daramola and Ibem, 2010). It encompasses constantly interacting sets of physical (natural and man-made) elements and non-physical, living and non-living (e.g. social, cultural, religious, political, economic) systems which determine the characteristic, features, growth and sustainability of both the component elements of the environment and the environment itself (Johnson, 1992; Muoghalu, 2004).

Sustainability in this context relates to the ability of the environment to meet the basic requirements for the sustenance of the living and non- living components of the ecological, economic and socio-cultural systems in a manner that does not limit the possibility of meeting the present and future needs of the various components and aspects of the environment. It can also be viewed as the carrying capacity of the supporting ecosystems (Marcuse, 1998).

Evidences suggested that the prevailing global environmental degradation poses serious threat to sustenance of carrying capacity of the ecosystem (Marcuse, 1998; Peters, 2000); hence environmental sustainability have taken priority position in housing, infrastructure provision, planning, land use and urban development among others (Salama and Alshawaikhat, 2005; Aribigbola, 2008). Although, Marcuse (1998) was of the view that sustainability should not be considered as goal for housing or urban programmes on the account that many of bad housing or urban programmes are sustainable. However, recent development indicated that environmental sustainability is interwoven with urban development and housing programmes (Peters, 2000; Aribigbola, 2008).

According to the Bruntland Report, sustainable development is the development that meets the present without compromising the ability of future generations to meet their own needs and development (WCED, 1987). This suggest that the principal goal of sustainable development is meeting present human needs in such a way that will not jeopardize the potential of posterity to meet their needs. Viewed from a holistic perspective, Wiedenhoeft (1981) and Padisson (2001) noted that sustainable development entails the attainment of equilibrium among three contending sub-systems (economic, social-cultural, and environmental).

Urban areas as centres of arts, culture, education, entertainment, technological innovations, providers of specializes services and "economic engines" (Udeh, 1992; Okeke, 2002; Kadir, 2006; Kjellstrom and Mercado, 2008) are products of urbanization which come with far reaching economic, socio-spatial and health implications (Acho, 1998; Marmot, 2006). Adedeji (2005) noted that sustainable development as applied to urban areas is the ability of the urban areas and their regions to continue to function at levels of desired quality of life by communities without limiting the options available to the present and future generations and resulting to adverse impacts within and outside their boundaries. However, Peters (2000) noted that the ecological and sociological "footprint" of cities has spread over ever-wider area and that fewer places on the planet earth are unaffected by this phenomenon. Changes in the ecology of urban environment occasioned by increasing population, overcrowded habitations and uncontrolled exploitation of natural resources may account for this wide ecological footprint of urban areas which is not peculiar to developing countries (Stoel, 1999; Hales, 2000). Hales (2000) however, observed that the pace and scale of growth have outstripped the capacity to maintain acceptable standards of public health, environmental safety and sustainable economic growth in urban areas in less developed nations in Africa, Asia and Latin America.

Generally, environmental problems are mostly due to developmental processes and are of local, regional and global effects. These effects are viewed as consequences of human activities, and are most often harmful on human beings, livelihoods, animal and plant lives presently or transferred to posterity (Simond, 1994; Acho, 1998; Danish International Development Agency, 2000; Kjellstrom and Mercado, 2008). This has far reaching implications on sustainable development, most especially in the face of declining economic fortunes. Therefore, urban environmental issues will continue to dominant sustainable development agenda in developing nations in particular and the world in general in the next few decades.

Undoubtedly, urbanization is a process that continuously initiates changes in land use. According to Gove, Edwards and Conquest (2001), the impervious surfaces which abound in many urban centres degrade the quality of stream water runoff, collect pollutants either dissolved in runoff or associated with sediment, such as nutrients, heavy metals, sediment, oil and grease, pesticides, fertilizers and fecal coliform bacteria. These pollutants are moved and discharged into water bodies by runoff.

Besides, urban growth in sub-Saharan Africa is mainly taking place in an unplanned manner, creating sprawling low-density development and uneconomic use of environmental resources. Most urban areas in Africa are faced with deteriorating environmental conditions and a weak public sector unable to provide adequate services (Stren and White, 1989; Nordberg and Winblad, 1994; Yankson and Gough, 1999).

Conversions of agricultural land and forest, as well as reclaiming of wetlands, for urban uses and infrastructure, are associated with widespread removal of vegetation to support urban ecosystem. They may also exert additional pressure on nearby areas that may be even more ecologically sensitive. Areas that are ecologically rich often foster higher agricultural yields, and sustain greater urbanization. The sprawling urban centres and enormous tracts of agricultural lands that typify the modern age are both a direct and indirect threats to surrounding ecosystems. They are a direct threat through habitat conversion, and an indirect threat through the effects human populations typically have on their environment: habitat fragmentation, resource depletion, waste generation, and freshwater consumption (Ricketts and Imhoff, 2003). The concentration of people around urban centres is impacting not only on the biodiversity of urban and peri-urban area (Romero and Ordenes, 2004) but also in other medium-sized cities (Azocar *et al.,* 2003).

## 2.3 LITERATURE REVIEW

### 2.3.1 Application of Remote Sensing/GIS in Landuse/Landcover Changes

Many researchers have stressed the importance of Remote Sensing and GIS in urban studies. Almeida (2005) carried out an assessment of urban sprawl in Richmond-Virginia USA. The study mapped the growth distribution using analytical capabilities in GIS. The urban or built-up land for each year; 1992 and 2001 was calculated which showed an increase in the amount of urbanization over the given time period. It was observed that in 1992 that there was approximately 559 square kilometers of urban or built-up land within the study area. In 2001 that number increased by 25% to 746 square kilometers of urban or built-up land indicating a large increase in the extent to which urban sprawl occurred between 1992 and 2001.

In Kaduna, Ndubula (2000) undertook an assessment of the landuse/landcover characteristics using multi-temporal air photos to monitor urban Kakuri in Kaduna metropolis. The techniques involved analogue photo interpretation of uncontrolled photo mosaic of the delineated built up areas. Temporal series of rasterised maps showing Kakuri urban growth of 1970s, 80s and 90s information layers were digitized, geo-referenced and overlayed. This study improved the use of multi-date air photos of three decades and conversion of analogue layers of uncontrolled photomosaics into vector layers by using manual digitizer and GIS to manipulate various themes to produce overlay maps of urban growth being monitored over a period of three decades. Also information from different sources could be harmonized during map composition on overlay by geo-referencing data from these different sources to a common base topographic map of the study area.

Oluborede, Soumah and Dieng (2004) carried out a study on development of administrative maps and monitoring of Urban growth of some cities in Osun State using Nigeria Sat-1 data of 2003, Landsat TM, 1991and Spot-XS; 1986 with auxiliary data such as topo maps and administrative maps were used. The results showed that Ilesa, had a horizontal spatial growth of 141.33% between 1968 and 1986 and 36.84% between 1986 and 2003. Ile-Ife had a spatial growth of 398.85% between 1966 and 1986 and 8.72% between 1986 and 2003. While Osogbo recorded a spatial growth of 422.22% between 1966 and 1986 and 11.49% between 1986 and 2003.

Oyinloye, Agbo and Aliyu (2004) applied Nigeria Sat-1 data for landuse/landcover mapping of Ilesa and environs within Osun state in Nigeria. Their methodology included image enhancement through global contrast stretching, selection and extraction of sub scene covering the study area. Contrast enhancement of FCC of the sub scene and georeferencing of the sub scene for improved metrical qualities using GCPs from GPS. NDVI computation was used for vegetation analysis. Thesupervised digital image classification of thematic features was used formapping of landuse/landcover classes. Their results showed that between 1991 and 2003, built-up has increased from 79.17 to 139.76km2, while theAgro forestry/secondary re-growth vegetation class decreased drasticallyfrom 1452.70 to 297.40km2. Furthermore, Annual crop/Shrub/Fallow landsincreased from 726.00 to 1014.84km2. Bare surfaces however, decreasedfrom 499.78 to 297.40km2 within the same period.

Zubair (2006) carried a research on change detection in landuse/land cover of Ilorin, Kwara state using remote sensing data and GIS. Ilorin the capital of Kwara state witnessed a remarkable expansion, or growth and developmental activities; which had resulted increased in land consumption, a modification and alterations in the status of her land-use/land-cover over time without any detailed and comprehensive attempt to detect the land consumption rate. The study deployed the use of landsat satellite images of Kwara state for three years such as 1972, 1086 and 2001. The result shows a reduction in spatial expansion between period of 1986 and 2001, as compared to a period between 1972 and 1986. The study concluded that there is likely going to be crowdness brought by compactness in Ilorin come 2015.

In a study carried out by Ifatimehin and Ufuah (2006) on analysis of urban expansion and loss of vegetation cover in Lokoja, using GIS techniques combined with field checks and survey to map land use and land cover changes and to measure the rate of urban expansion and loss of vegetation, noted that there was a rapid conversion of vegetation cover to other land uses in the town between 1987 and 2005. Their major findings were that, there has been rapid conversion of vegetation cover to other land uses, thus the built-up area has increased in all directions most especially in the southern part of the town and the cultivated land has increased more than any other land uses. In their study, some 3380 hectares of vegetation cover was reported lost between 1987 and 2005, of which 2355 hectares are recoverable and 1025 hectares are not. The rapid loss of the natural vegetation was related to the increasing population of Lokoja while the increase in cultivated land was related to urban poverty.

Ifatimehin, Musa and Adeyemi (2011) on managing land use transformation and land surface temperature change in Anyigba Town, Kogi State, Nigeria. This study used Remote sensing and GIS techniques to identify, mark and measure the extent of the various land uses from the Landsat TM image of 1995 and Landsat ETM+ image of 2006. The study revealed tremendous transformations in the various land use in Anyigba town between 1995 and 2006. The built-up area experienced the highest changes from 7.49 percent in 1995 to 29.84 percent in 2006 while vegetation cover suffered the greatest reduction from 31.50 percent in 1995 to 7.16 percent in 2005. A major factor that accounted for the sharp increase in built-up areas is the elevation of the town to a university town, the Kogi State University within the period. As a result of that, both private individuals and government went into development of properties particularly residential, commercial and academic structures.

In another instance, Ishaya, Ifatimehin and Okafor (2008) carried out a study on urban expansion and loss of vegetation cover in Kaduna town, deployed the use of GIS and Remote sensing techniques with survey to identify the various land use and their transformations over time, recorded significant increase in the built-up area between 1990 and 2000. Such expansions were mostly at the fringe of the town area and are mainly due to population growth and development in its formal and informal sector of the economy. The expansion of the town has been in all directions, but more especially to the south. Important aspect in the town land use change is the large increase of bare land, from 16 percent in 1990 to 29.4 percent in 2000 while the built up areas has increased from 39.1 percent to 53.8 percent. Some 297.5 hectares of vegetation cover was reported lost annually due to various processes of urban transformation and it is noted that the town has been expanding at the rate of 167.8 hectares annually since 1990. This implies that within the study area, the vegetation covers will be completely lost in few years from now.

In studies carried out in Zaria, Abbas and Arigbede (2011) carried out a study which focused on changes in land use-land cover between 1985 and 2005 with a view to providing database for future planning. Landsat, spot and digital globe imageries for 1985, 1995 and 2005 respectively were used for the analysis and deployed the ArcGIS onscreen digitization of land use types and overlay of various years. The result showd that built-up areas increased from 2.3%in 1985 to 36.4% in 2005, water body decreased from 22.5% in 1985 to 6.5% in 2005 while cultivation decreased from 44% in 1995 to 40% in 2005 sending a bad signal of imminent food crisis if not checked. The process has led to elimination of the crop, forest and scrub land mostly towards the eastern and southern outer limits of the city. The growth of built-up areas is mainly towards the east- west route in a linear pattern.

Olusegun (2013) carried out a study on urban expansion in Ado Ekiti, Nigeria, using GIS and Remote sensing techniques. The results showed the expansion that has resulted over the years. It was discovered that Ado-Ekiti had an area of 2.5 square kilometres in 1956, which increased to 6.9 square kilometres in 1996, and 36.7 square kilometres in 2006. The study suggested that if nothing is done to stem the uncontrolled expansion, the area may increase to 134.7 square kilometres in 2030. Appropriate mechanisms are recommended to be put in place to stem urban expansion, and to direct and reprioritize land use.

Ade and Afolabi (2013) monitored urban sprawl in the FCT, Nigeria using Remote sensing and GIS techniques. The research was set out to measure the changes in landmass or landuse/landcover and population increase in the study area. Multi-temporal Satellite images of 1987, 1999 and 2007 (Landsat TM, Landsat ETM and Nigeriasat-1) were acquired and used in analyzing the physical expansion of the city overtime. Using supervised classification algorithm, the images were classified into built up, rock-outcrop, vegetation and water bodies and used to carry out change detection or time series analysis. In addition, coordinates of locations in the area were obtained using a GPS while figures from National Population Commission were used. Change detection analysis was carried out on the imageries to obtain the physical expansion of the area. The study found that the builtup area increased from 8% in 1987 to 22% in 2007, rock-outcrop decreased from 74% to 37%, vegetation decreased from 40% to 17%, while the area occupied by water body has remained constant overtime. They recommended constant monitoring of the urban growth to be sustained by anthropogenic activities.

Also, Odeh (2013) assessed the impact of urban growth on agricultural lands in Zaria and its environs. The study was carried out through the use of remote sensing and GIS techniques with survey to determine the spatial expansion of built up areas in Zaria between 1970-2009. Four satellite images were used which include LandSat Multi-Spectral

Spectometer (MSS) image of 1973, LandSat Thematic Mapper (TM) images of 1990, LandSat Enhance Thematic Mapper (ETM) images of 1999, NigeriaSat-1 image of 2009, where Supervised Classification using the maximum likelihood classifier and change detection in Ilwis were used in the analysis. The study revealed that urban growth has encroached on agriculture lands and agriculture in turn moved into shrub lands, wet lands and former plantation lands. The findings showed that between 1973 and 1990, there was 13.81% decrease in cultivated land use land cover, and 24.52% increase in built-up land use land cover. Between 1990 and 1999, cultivated land increased to 29.09% and built-up areas to 38.71% and then in 1999 and 2009, agricultural land increased by 2.63% while built-up increased with 25.86%. This shows that urban growth in the study area is on the increase, so also is agricultural land because of the movement of farming into shrubland, wetland, forest plantations and bare surface.

Uhwache, Sawa and Jaiyeoba (2015) carried out a study on landuse dynamics in Zaria between 1973 and 2009. The study employed the use of GIS and Remote sensing techniques such as supervised image classification, NDVI and change detection. The findings indicated that Zaria is experiencing rapid expansion leading to a large chunk of the scrubland, farmlands and even part of the flood plains giving way to residential buildings with built-up areas increasing from 44.27km$^2$ in 1973 to 130.25 km$^2$ in 2009, while fadama lands decreased from 146.35km$^2$ in 1973 to 571.29 km$^2$ in 2009, plantation/forest decreased from 89.24 km$^2$ in 1973 to 63.36 km$^2$ in 2009, scrubland decreased from 1,765.72 km$^2$ in 1973 to 1,350.39km$^2$ in 2009 and water bodies from 38.16km$^2$ in 1973 to 4.20km$^2$ in 2009.

Odjugo, Enaruvbe and Isibor (2015) examined the spatio-temporal pattern of urban growth in Benin City, Nigeria for a period of 26 years (1987-2013) using remote sensing data and geographic information systems techniques. The study also examine the factors driving the observed pattern of growth in the city. The results show that Benin City is growing more towards the north, east and south along the major transportation routes. The land use pattern in Benin City is compact and radial from the city centre while the growth pattern makes Benin City a monocentric city. The settlement expanded from 220 km2 in 1987 to 359 km2 in 2013 with a mean annual growth rate of 1.5%. The growth of Benin City was observed to be influenced by the siting of public institutions such as schools, hospitals, government offices and industries. While the study demonstrates the importance of using geospatial technology in the acquisition of data for urban planning and management, the results highlight the influence of infrastructure development on urban growth pattern.

The empirical studies reviewed here on RS/GIS application in urbanization and landuse/landcover studies laid emphasis generally on the factors of urban growth in Zaria as well as their implication for environmental quality, and landuse/landcover dynamics. They are silent on urban-induced landuse landcover change. The present study aimd to bridge this knowledge gap by using the techniques of remote sensing and geographic information system to effect of urban growth on various aspects of the landuse/landcover of the environment.

# CHAPTER THREE

# STUDY AREA AND METHODOLOGY

## 3.1 INTRODUCTION

This chapter deals with the physiography of the study area on one hand which encompasses location, topography, drainage, soils, landuse, vegetation and population. It deals with the methodology of the study on the other hand.

## 3.2 THE STUDY AREA

### 3.2.1 Location and Extent

The study area is located between Latitudes 11°01'30"N and 11°12'00"N and Longitudes 7°36'00"E and 7°46'30"E (See Figure 3.1). The total area covered is about 2638.20Km$^2$ with an altitude of about 762 metres above sea level (Ogunleye, 2006). Zaria lies in the Northern part of Kaduna state. It is a historical, ancient and traditional centre of the north with its administrative capital situated at BirninZazzau (Zaria City). It remains a strategic political centre of the north with authority vested solely in hands of the Emir of Zazzau (Mortimore, 1970).

Essentially, Zaria metropolis comprises two Local Government Area (LGA), namely, Zaria and Sabon-Gari LGAs. The study area is bounded to the south by Igabi LGA, to the north by Kudan LGA, to the east Soba LGA and to the west Giwa LGA.Zaria is 156km south-west of Kano, 84km north-east of Kaduna. Zaria is about 698km north of the Atlantic Ocean. Zaria is the second largest city in Kaduna covering a total landmass of about 61km$^2$ making it a nodal point in terms of road and rail transport because of location factors (Jatau, 1999).

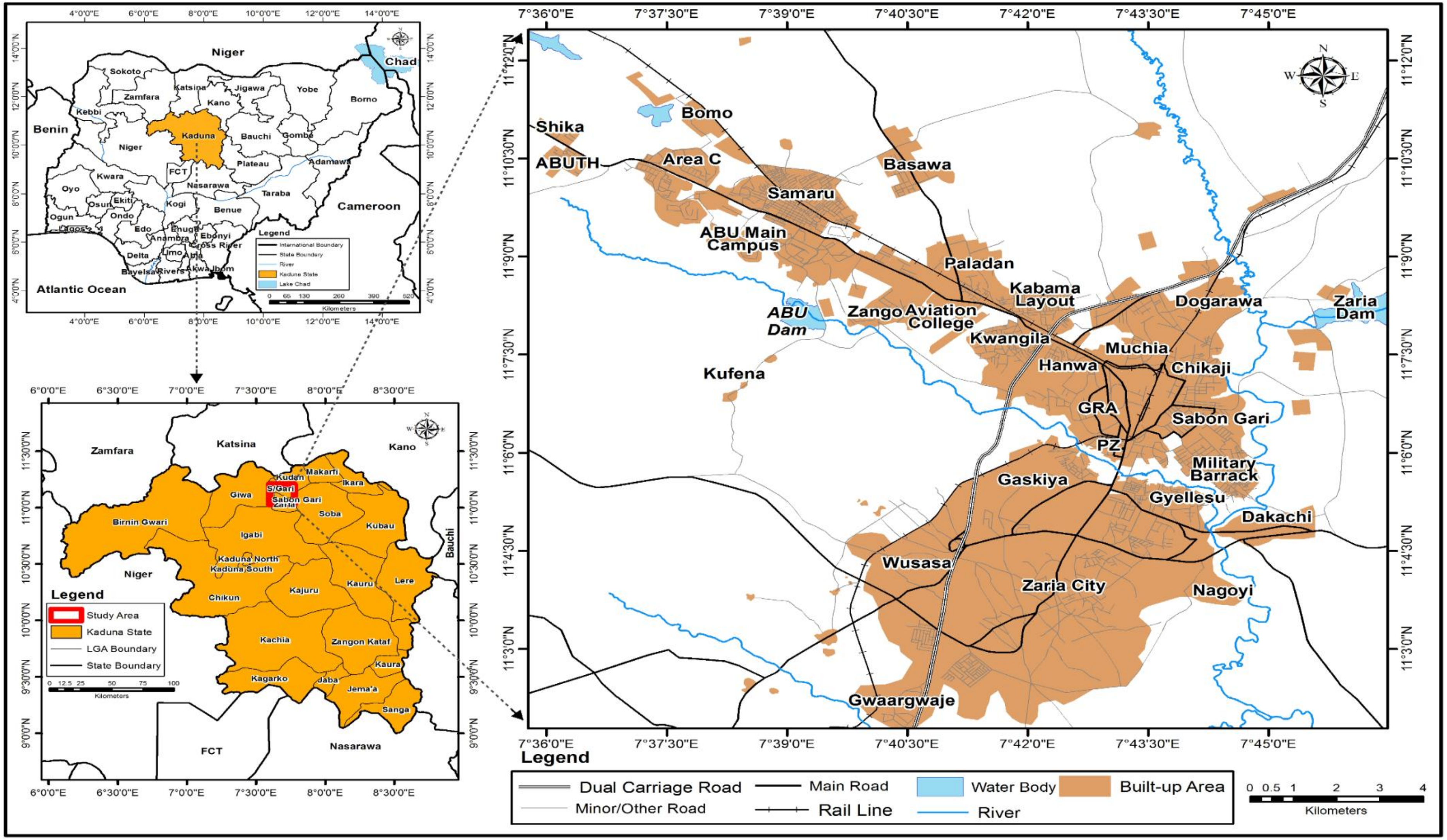


**Figure 3.1: Zaria (Study Area)**
**Source: Modified From the Administrative Map of Kaduna State.**

### 3.2.2 Brief History

The history of Hausa states dates back to Bayajida from Daura. But over the years, evolution of settlement has caused a serious spread of the Hausa people to cover areas or states like Katsina, Kano, Sokoto, Zamfara, Kaduna, Kwara and Zaria inclusive. By the beginning of the 15$^{th}$ century permanent settlement had been established in Zaria, and this has led to the expansion of its kingdom during the reign of MuhammaduYan Hazo (1671-1684) (Mortimore, 1970).

Old Zaria city is 83 kilometers to the north Kaduna, and is the second largest city in Kaduna state. It covers a total area of about 6,000 hectares and totally it has some of the amount of agricultural and craft activities (Urquart, 1976).

### 3.2.3 Population and Settlement

Zaria comprises of six (6) traditional districts, Birni Da Kewaye (Zaria town and its environs), Dutsen Abba, Gyallesu, Tudun Wada, TukurTukur, and Wuchiri. They all lie within the farmlands of the monotonous plains which make up most of the area occupied by the Hausa speaking farmers and craftsmen of Zaria (Urquhart, 1977). Zaria is a cosmopolitan city with tribal nationalities from all parts of Nigeria and other West African countries co-existing harmoniously in the midst of the warm receptive traditional values and norms of the people of Zazzau. The main Ethnic groups are Hausa and Fulani and they are predominantly Muslims.

The pattern of human settlement is tied to the historical, political and socioeconomic forces the area has been subjected to from the precolonial to post-colonial period. Prior to the advent of the British occupation, the basic unit of human settlement was the extended family compound. This pattern of settlement dominated the Hausawa cultural groups to the north (i.e. Giwa, Igabi, Zaria, SabonGari, Kudan, Makarfi and parts of lkara LGAs). The impact of the historical and cultural developments on settlement pattern and the nature of the rural economy (agrarian), created the dominance of the urban centre (Mortimore, 1970).

In recent times, the rate of population has been astronomical due to high birth rate and immigration. The population of Zaria, as put together by the population and housing census of 2006, is 1, 364,942 people. But for the purpose of this study, the major local government areas that concerns it are Zaria and Sabon-gari local government areas with a population of 196,090 and 142,247 respectively (NPC, 2006). Islam and Christianity are the dominant religions practiced here.

### 3.2.4 Land Use

Two types of lands are found in the study area; Gona or upland fields which support crops such as maize, millet, sorghum and groundnut during the wet season, and Fadama or lowland fields which support crops such as sugarcane, onion, tomatoes, pepper, spinach and other garden vegetables throughout the year. There is a relative buffering by the addition of organic manure and fertilizer application. Sand mining is also conspicuous with their left overs as holes, pit, gullies etc. used as material for moulding bricks and building of mud houses for both residential and animal shelter and in road construction. Minor fishing activities usually take place especially during the dry season both on commercial and consumption scales. Along the gentle rolling plains are human settlements. Settlement pattern in the river basins is highly concentrated in some areas and randomly scattered in other areas (Yusuf, 2010).

### 3.2.5 Climate

Owing to its interior location of about 698km north of the Atlantic Ocean, Zaria experiences a Tropical Continental Climate characterized by distinct wet and dry seasons subject to the movement of the Inter Tropical Discontinuity (ITD) associated with Tropical Continental and Tropical Maritime air masses. The former airmass originates from the Sahara desert and therefore dry, bringing dusty and hazy conditions known as ‘harmattan’ to the region in the dry season while the latter air mass originates from the Atlantic Ocean and hence moist and rain-bearing (Kowal and Knabe, 1972).

The region experiences convectional rainfall type with single maximum and a long-term average of about 1100mm per annum. Of great importance is the seasonal character of the rainfall. About 90% of the rains fall between April and October with the heaviest recorded in July and August. Monthly total can vary as well as the annual (Adejuwon, Adejuwon and Balogun, 1989). However, the mean annual rainfall of Zaria is 800mm (Ojo, 1982).

Onset of the rainy season is highly variable and unpredictable; although long-term average appears to be first week of May (Owonubi and Olorunju, 1985). Variability in the cessation date of the rainy season has also been observed. Akintola (1986), for example, reported that the expected mean cessation date of the rainy season is October 8$^{th}$ with an upper limit of October 23$^{rd}$. The North East Trade wind (Tropical Continental Air mass) characterized by hazy to dusty conditions lowers temperatures to as low as 10$^{0}$C at night. In the afternoons, up to 42$^{0}$C is sometimes recorded.

### 3.2.6 Geology

The Zaria area is a dissected portion of the Zaria-Kano plains, an extensive peneplain developed on crystalline metamorphic rocks of the Nigerian Basement complex (Wright and

McCurry, 1970). Russ (1957), described the Basement complex as composing of older high grade metamorphosed gneiss interspersed by belts of younger metasediment of mainly quartzite and schist oriented in the north – south direction. In the south-eastern corner, younger granites and bathyliths are evident. Deep chemical weathering and fluvial erosion, influenced by the bioclimatic nature of the environment, have produced the characteristic high undulating plains with subdued interfluves (Mortimore, 1970). According to Ike (1988), the older granite outcropping of Zaria is exposures of a syntectonic to late tectonic granite batholiths which intruded a crystalline gneissic basement during the Pan-African Oregeny. In some places, the interfluves are capped by high grade lateritic ironstone especially in the Northwest. Egbeifo (1978), in his work on Kubanni Basin in general listed the different basement rocks found in the area viz:

i. Coarse perphyritic – biotite granite which is distinctly foliated and aligned.
ii. Medium – coarse grained biotite granite gneiss.
iii. Aplite granite, pegmatites and quartz veins intrude most of the bodies; and
iv. Weathered basement. This is about 14% of the basin's total area and formed a storage aquifer.

The surface of the older granite basement is overlain by a deposit of older laterite, young laterite, older alluvium and younger alluvium; the last two being quaternary deposits. The thickness of this zone varies from place to place, especially along stream valleys. There are frequently older granites exposed on the surface. They exist either in the form of domed hills (inselbergs), or as low outcrops (whaleback), (Wright and McCurry, 1970).

### 3.2.7 Relief

In general, over much of Zaria area, relative relief (the height range between interfluves crests and the valley bottom) is less than 20m. Similarly, the average slope (average inclination of the landscape from the horizontal) really exceeds 6degree (a slope value which is still quite satisfactory for a wide range of land use) and is very rarely more than 10degree.Average slope is predominantly 3 degree. Taking the relative relief and the average slope together, we can characterize the terrain as gently rolling to undulating, studded with residual hills of various shapes and sizes.

The plain area is stunted by a large number of mostly small residual hills, either as isolated features or grouped together, including:

(i) **low ridges** on quartz and pegmatite veins, rising less than 10m above the surrounding terrain

(ii) **low whalebacks** on migmatite, granite-gneiss and granite; the inhabitants of the area use these as drying, grinding and pounding surfaces and often build their granaries on them, safe from the fierce.

(iii) **Inselbergs -** more commonly occurs, perhaps, on granites and migmatites. Occurring often as impressive, steep-sided domes, they are also found as elongated and assymetrical features. They may be relatively free of boulders, but more commonly carry boulders of various sizes on their tops and on fairly gentle side slopes.

(v) **Broken rocky hills -** these rise abruptly (many as much as 200m) from the gently-sloping plains surrounding them which also differ by carrying weathered and transported regolith of various depths.

The valleys are shallow but wide, stretching several tens of kilometres into the headwater areas with gentle sloping valley sides; imperceptibly grading into flat moist to marshy alluviated bottomlands or floodplains, called "fadamas" in Hausa. Although stream valley incisions and dissections of the high plains are evident in several areas, especially in the Zaria, they are due to more anthropogenic influences and climatic factors than regional geologic instability (Abdulraheem, 2011).

### 3.2.8 Drainage

The drainage system of Zaria area focuses on the River Galma, a major tributary to River Kaduna. It flows north-ward while Kubanni River flows eastward. The confluence of Galma and Kubanni is about 1.2km at the North-Eastern direction. Galma and Kubanni rivers carry water throughout the year (Thorp, 1970). Stream flow in the area strongly reflects the climatic environment and, in particular, the seasonal and torrential nature of the rainfall. Thus, three main types of stream flow pattern have been recognized in the area:

i. Perennial flows: low dry season discharges; flash floods superimposed on high rainy season discharges. This flow pattern occurs on the largest stream;
ii. Seasonal flow: zero dry season flow; flash floods superimposed on rainy season flow which may be high or low depending on catchment area;
iii. Flash flow only that is, there is flowing water in the stream channel only during rainy season and for a short while after runoff producing storm.

### 3.2.9 Soils

Zaria soils falls within the ferruginous tropical soils. The soils are deeply weathered with fine particles up to 50m deep (Jackson, 1958). A typical soil profile of the study area shows that the lower part of the underlying soil shows the presence of mineral materials from the weathered gneisses and still has some pieces of quartz and mica. The upper layer is a mixture of some materials together with blown (wind-blown) particles. The profile also indicates and accumulation of clay between a depth of 36cm and 119cm (Jaieyeoba, 1986).

According to him, below the horizon of clay accumulation, there exists another horizon which is of iron deposit. This is signified by the red or brown coloration; lower down is also found hard iron concentration. Though the soils of Zaria belong to the ferruginous group, those at the fadama (flood plains) belong to the hydromorphic type of soil which has high water retention capacity (Wright and McCurry, 1970).

### 3.2.10 Vegetation

Zaria lie within Northern Guinea Savanna which has been modified by continues cultivation, grass burning and grazing activities. Within the radius of about 12km around Zaria almost all available lands are used for agricultural and another radius 19km to 24km is a belt, in which these patches of wood land appear with short grasses. Agricultural activities have resulted in the evolution of the thorny shrubs interspersed with short annual grasses. The dominant species of shrubs isoberlina doka, which has an average of about 0.8m other less common shrubs are *Butryo_spesum spp, piliostigma spp, vitex spp, terminalia spp, Dachrostacys spp* etc (Oluyori, 1999).

In the immediate vicinity of settlement, and over otherwise intensively farmed areas, is man-made parkland or tree savannah. The community is a peculiar non-natural vegetation type, which is the mark of many settlements in northern Nigeria. It consists of remarkably uniform immature trees of economic value that are scattered throughout a mosaic of cultivated fields and short-term fallows covered with mostly annual grasses. Such grasses may include *Rhynchelytrumrepens, Panicumkerstingii, Setariapallide-fusca, Aristida sp.* and*Hackelochloagranularia*.

The trees are largely indigenous and represent either the few surviving species of once-dense tree savannah woodland, which formally covered the whole area, or trees deliberately planted by man. Prominent among such trees are *Ceibapentandra*, *Tamarindusindica, Adansoniadigitata*and *Mangiferaindica*. Others are *Vitexdoniana, Vitaleriaparadoxa, Borassusaethiopum, Afzeliaafricana, Acacia albida, Khayasenegalenesis,* *Parkiabigloboza, Daniellaoliveri, Ficussycomorus, Pterocarpuserinaceus* (Abdulraheem, (2011).

## 3.3 METHODOLOGY

### 3.3.1 Reconnaissance Survey

A reconnaissance survey was carried out in order to get the researcher acquainted with the study area and acquire relevant information. Also relevant community leaders in the study area were consulted, with a view to intimating them on the objectives of the study and to seek for their permission and cooperation.

### 3.3.2 Types and Sources of Data

The major data set used for this study and their sources include;

1. Topographic Maps (Zaria Sheet 105, 1:100,000) was obtained from The Department of Geography Ahmadu Bello University Zaria, which was used for mapping out the study area and obtaining the geographical coordinates.

2. Satellite images used to generate the LULC data for the study area.

   (i) Landsat Thematic Mapper (TM) 27th November 1990 with spatial resolution of 30m was obtained from the National Centre for Remote Sensing, Jos (Figure 3.4).

   (ii) Landsat Enhanced Thematic Mapper Plus (ETM+) 19th October 1999 with spatial resolution of 30m was obtained from the National Centre for Remote Sensing, Jos (Figure 3.5).

   (iii) Landsat Enhanced Thematic Mapper Plus (ETM+) October 2006 with spatial resolution of 30m was obtained from the National Centre for Remote Sensing, Jos (Figure 3.6).

(iv) Landsat Enhanced Thematic Mapper Plus (ETM+) August 2014 with spatial resolution of 30m was obtained from Global Land Cover Facility Website (Figure 3.7).

3. Ground Control Points (GCPs) which was obtained through fieldwork using Global Positioning System (GPS). This was used for image Co-registration and verification of image interpretations.

4. Both published and unpublished relevant literature was used for this work, which include; theses, articles published and unpublished journals. These literatures were obtained from internet, Geography Department Library, Ahmadu Bello University, Zaria.

### 3.3.3 Processing of Satellite Imageries

The satellite imageries for the study were imported into the GIS environment for image processing and classification.

3.3.3.1 Pre-Processing Stage

The pre-processing stage involved image rectification in which distortions that have occurred during data acquisition from satellite were corrected. However, this has already been carried out at the ground receiving station during satellite image acquisition. However, the data sets were geo-referenced and subsetting was done.

(a) Image registration (Geo-referencing)

Even though all the images had already been geo-referenced from the ground receiving station, coordinates of some known point were used to verify the positional accuracy of the images. The map projection of the images (Universal Transverse Mercator (UTM) WGS ’84 Zone 32 North) was retained.

(b) Subsetting

The image subsetting is a procedure that requires an image and a polygon layer as an input feature class. The input polygon layer is the Zaria and Sabongari LGA combined. Within the image extent, a new smaller sized image is created that follows the polygon boundary as a subset of the entire image.

(c) Image Classification

For the purpose of this study, supervised classification was employed based on the classes shown in table 3.1. Supervised classification is much more accurate for mapping of classes. The maximum likelihood class algorithm was used, maximum Likelihood Classifier assumes that a pixel has certain probability of belonging to a particular class. These probabilities are equal for all classes and the input data in each band follows the Gaussian (normal) distribution function (Lillesand and Kiefer, 2004).

Based on prior knowledge of the study area and a brief reconnaissance survey a classification scheme was developed after Anderson *et al*., (1976). The classification gave a rather broad grouping where the land use land cover is identified (See Table 3.1).

**Table 3.1 Classification Scheme**

| **Code** | **Landuse/Land Cover Categories** | **Descriptions** |
|---|---|---|
| 1 | Built-up | All residential, institutional, commercial, and industrial areas, villages and settlements |
| 2 | Bare surface | All non-vegetated lands, open spaces, rock outcrops |
| 3 | agricultural land | All agricultural land under cultivation |
| 4 | Water body | River, permanent open water, lakes, ponds, canals, and reservoirs |
| 5 | Vegetation | All land areas covered non-agricultural vegetation including natural and man-made forest and riparian vegetation |
| 6 | Fadama | All marsh land covers. |

**Source:** Modified from Anderson (1976)

### 3.3.4 Methodology Flow

The research was designed to collect and analyse information on the land use and landcover as well as the pattern and extent of urban growth in the study area and its effects on the other classes of the landuse and landcover. Figure 3.3 summarizes this approach.

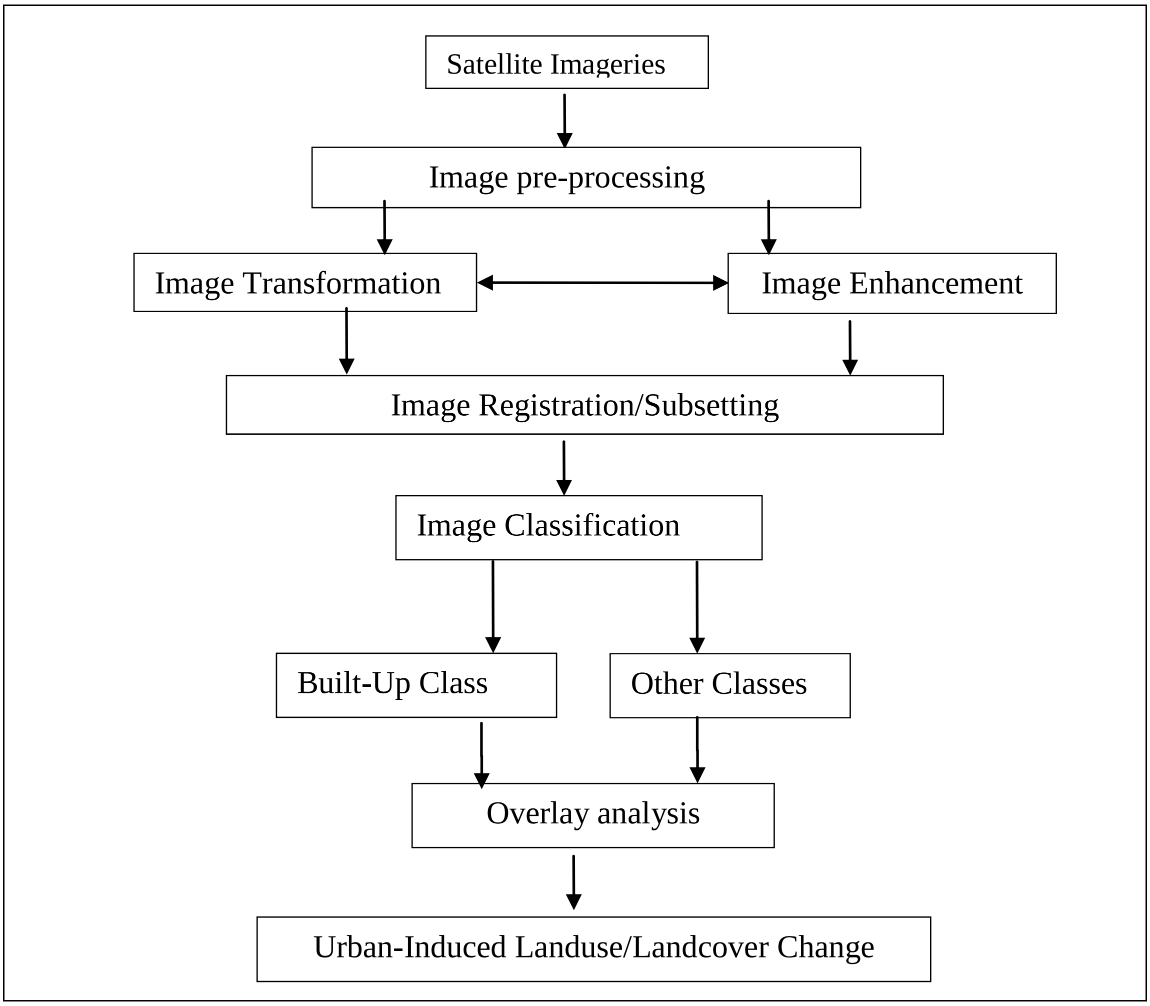


**Figure: 3.2. Methodology Flow chart**

## 3.4 DATA ANALYSIS

The extent of urbanization in the study area in 1990, 1999, 2006 and 2014 was achieved using satellite imageries. Having classified all imageries, built-up areas of the region was extracted and overlay analysis carried out to determine the growth between 1990-1999, 1999-2006, and 2006-2014.

The extent of landuse/landcover changes that have taken place in the area between 1990 and 2014 was achieved using same technique as the previous, In this case, the changes in all the other classes with the exception of built-up were extracted and overlay analysis was carried out. The classified image of the begin year was overlaid on that of the end year. For example, the image of 1990 was overlaid on 1999, 1999 on 2006 and 2006 on 2014 to determine the growth.

The magnitude of urban-induced landuse/landcover changes in the study area between 1990-1999, 1999-2006, and 2006-2014 was achieved by carrying out an overlay analysis of the built-up areas on each class of environmental variables for the study period to determine the urban induced landuse/landcover changes. The ArcGIS software was used in determining the magnitude of environmental change due to urbanization within the study area. The magnitude of urban induced change was then calculated by subtracting the area coverage of the base year from the reference year thus:

Magnitude = Reference Year - Base year (e.g. 1999-1990)

While the rate of urban-induced landuse/landcover changes in the study area was determined following these steps:

**Step 1**

Percentage change was calculated by dividing magnitude change by the base year (the initial year) and multiplied by 100 thus:

$$\text{Percentage change} = \frac{\text{Magnitude of change}}{\text{Base Year}} \times 100$$

**Step 2**

The Annual rate of change is calculated by dividing the percentage change by the number of study period 1990 – 1999 (9years), 1999-2006 (7years), 2006-2014 (8years) thus:

Annual rate of change = Percentage Change / Period

# CHAPTER FOUR

# RESULTS AND DISCUSSION

## 4.1 INTRODUCTION

This chapter deals mainly with presentation and discussion of results obtained from the analysis. The results and discussion are presented under the following sub-themes: the extent of urbanization in the study area, extent of landuse/landcover change, magnitude of urban-induced landuse/landcover change, rate and trend of urban-induced landuse/landcover changes in the study area.

## 4.2 THE EXTENT AND DIRECTION OF URBAN GROWTH IN THE STUDY AREA

### 4.2.1 THE EXTENT OF URBAN GROWTH IN THE STUDY AREA

This section presents the result from the analysis of extents of urbanization in the study. The extent of urbanization was obtained by selecting the built-up area layer from each of the classified images. Table 4.1 shows the quantitative extents of the urban growth.

**Table 4.1: The Extent Urban Growth in the Study Area**

| | | | Growth rate/Year | | | |
|---|---|---|---|---|---|---|
| **Period** | **Year** | **(km²)** | **(km²)** | **%Km²/Year** | | **%** |
| **1990-1999** | 1990 | 40.37 | 16.78 | 41.57 | 4.49 | 4.62 |
| **(9Years)** | 1999 | 57.15 | | | | |
| **1999-2006** | 1999 | 57.15 | 27.35 | 47.86 | 3.91 | 6.84 |
| **(7Years)** | 2006 | 84.50 | | | | |
| **2006-2014** | 2006 | 84.50 | 11.67 | 13.81 | 1.46 | 1.73 |
| **(8Years)** | 2014 | 96.17 | | | | |
| **1990-2014 (24Years)** | **1990** | **40.37** | **55.8** | **138.22** | **2.33** | **5.76** |
| | **2014** | **96.17** | | | | |

**Source: Author's Analysis, 2015**

Table 4.1 shows a progressive increase in urban extent throughout the study period. Between the year 1990 and 1999 urban area grew by 41.57% while the period between 1999 and 2006 witnessed an urban growth of 47.86%. The overall period of study (1990-2014) witnessed an urban growth of 138.2%. This finding agrees with Abbas *et al.*, (2011) and Odeh (2013) who reported that Zaria is experiencing rapid expansion as a result increase in built up areas. However, the period 2006-2014 witnessed the lowest urban increase (13.82%). This could be attributed to the riot incidence that occurred in Zaria within this period which might have necessitated the movement of people out of Zaria.

### 4.2.2 THE DIRECTION OF URBAN GROWTH IN THE STUDY AREA

Figures 4.1, 4.2, 4.3 and 4.4 show the direction of urban growth in the study area between the study period 1990, 1999, 2006 and 2014 respectively.

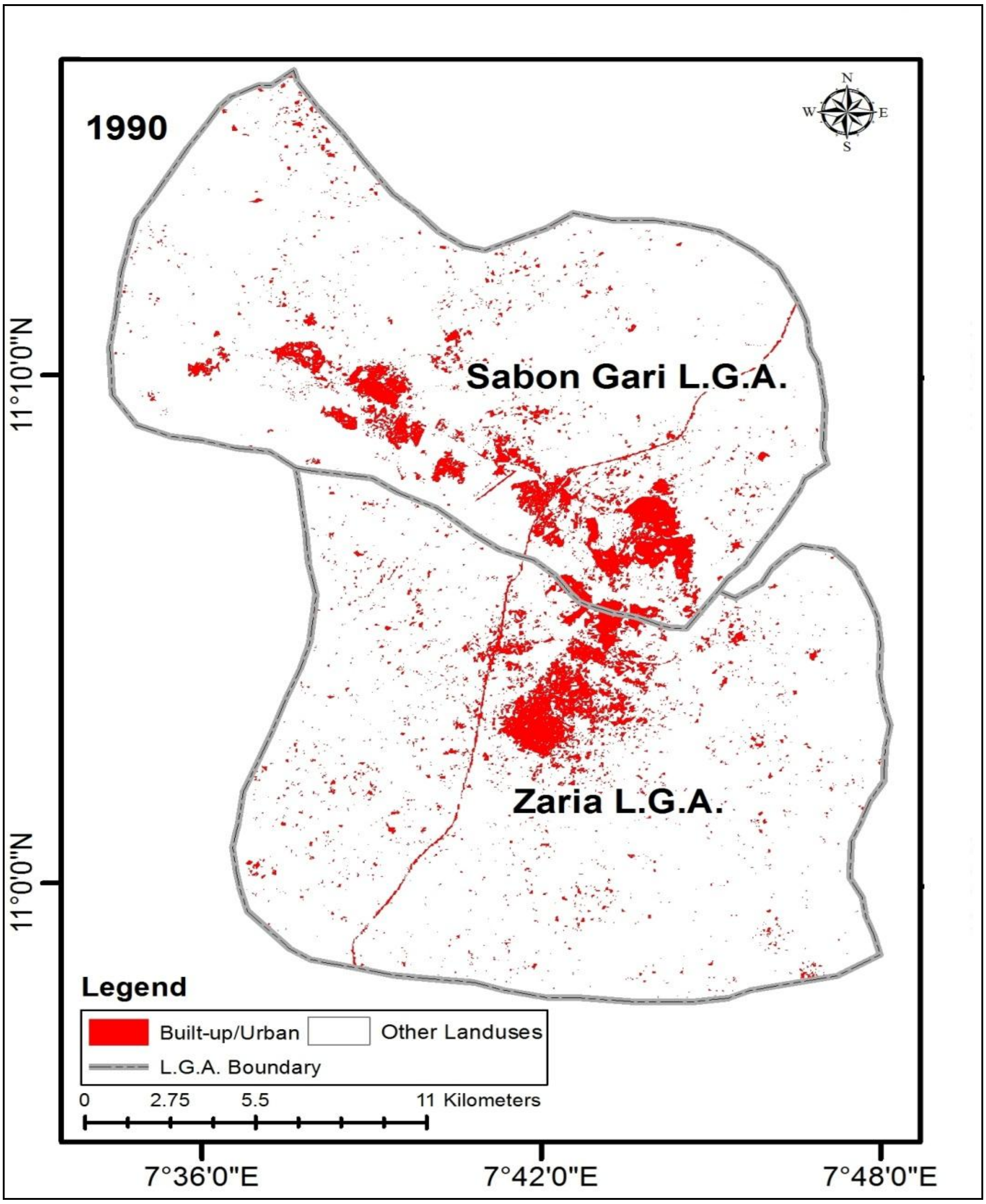


**Figure 4.1: The extent of urban growth in the study area in 1990**
**Source: Author's Analysis, 2015**

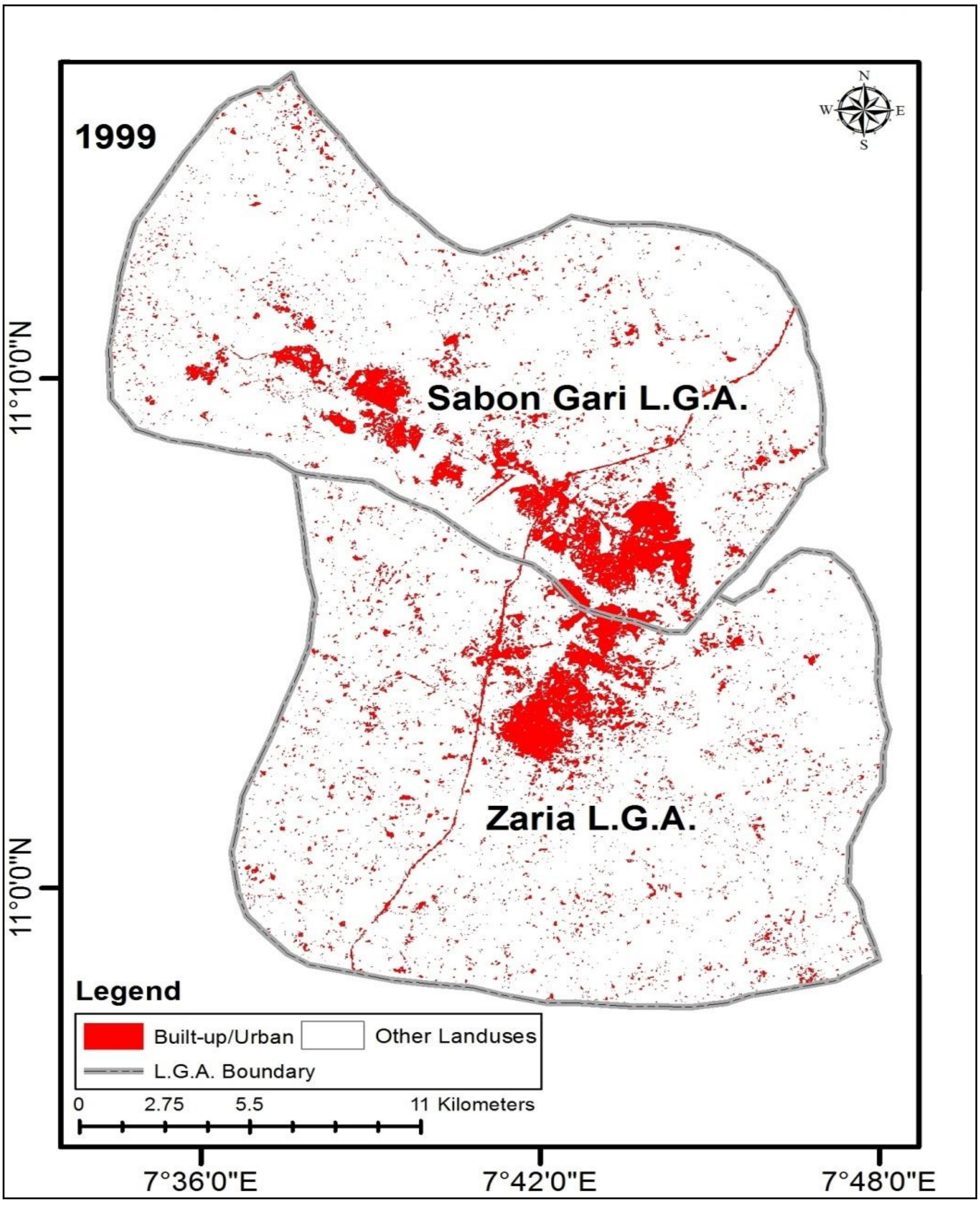


**Figure 4.2: The extent of urban growth in the study area in 1999**

**Source: Author's Analysis, 2015**

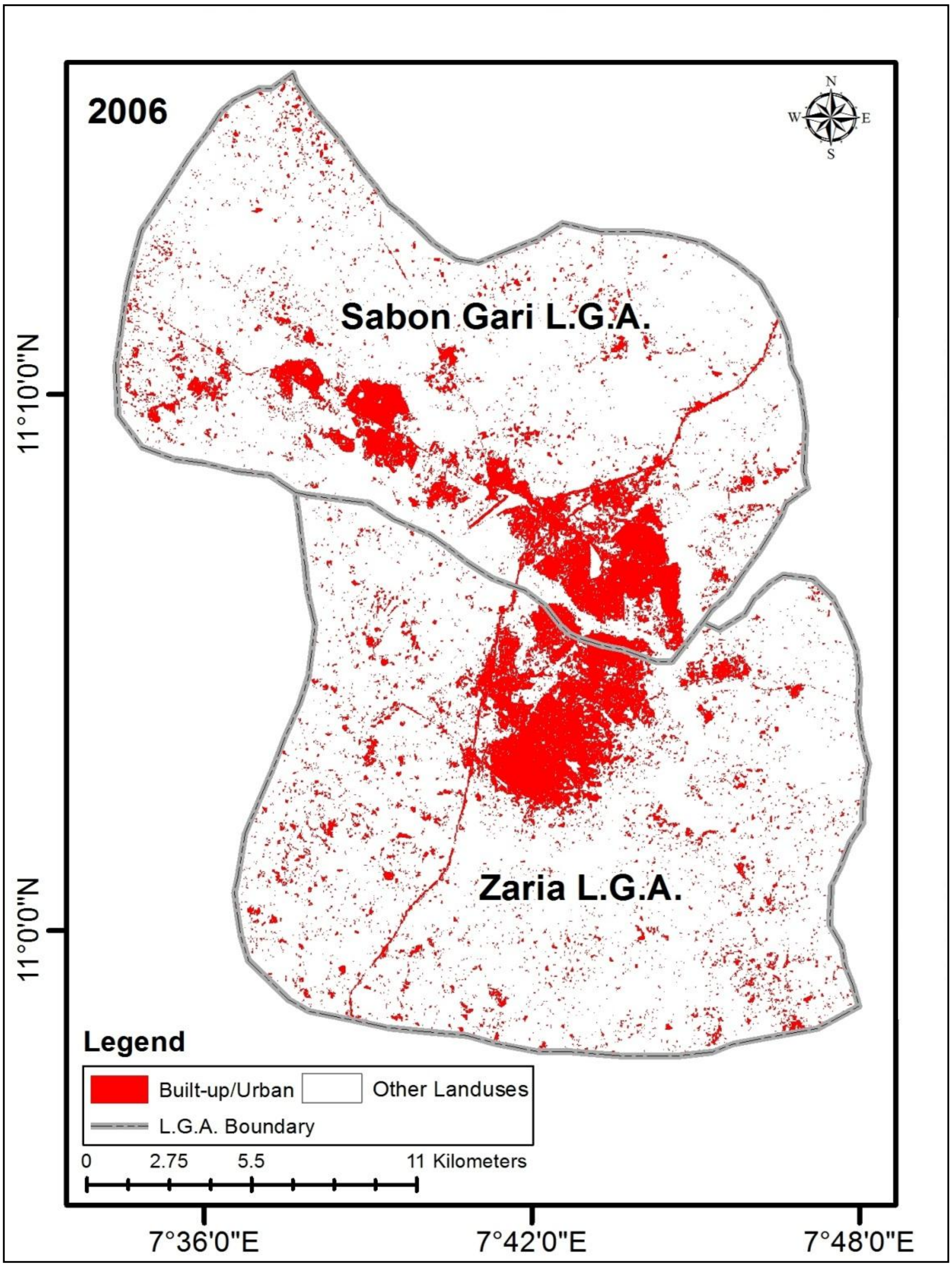


**Figure 4.3: The extent of urban growth in the study area in 2006**
**Source: Author's Analysis, 2015 urban area**

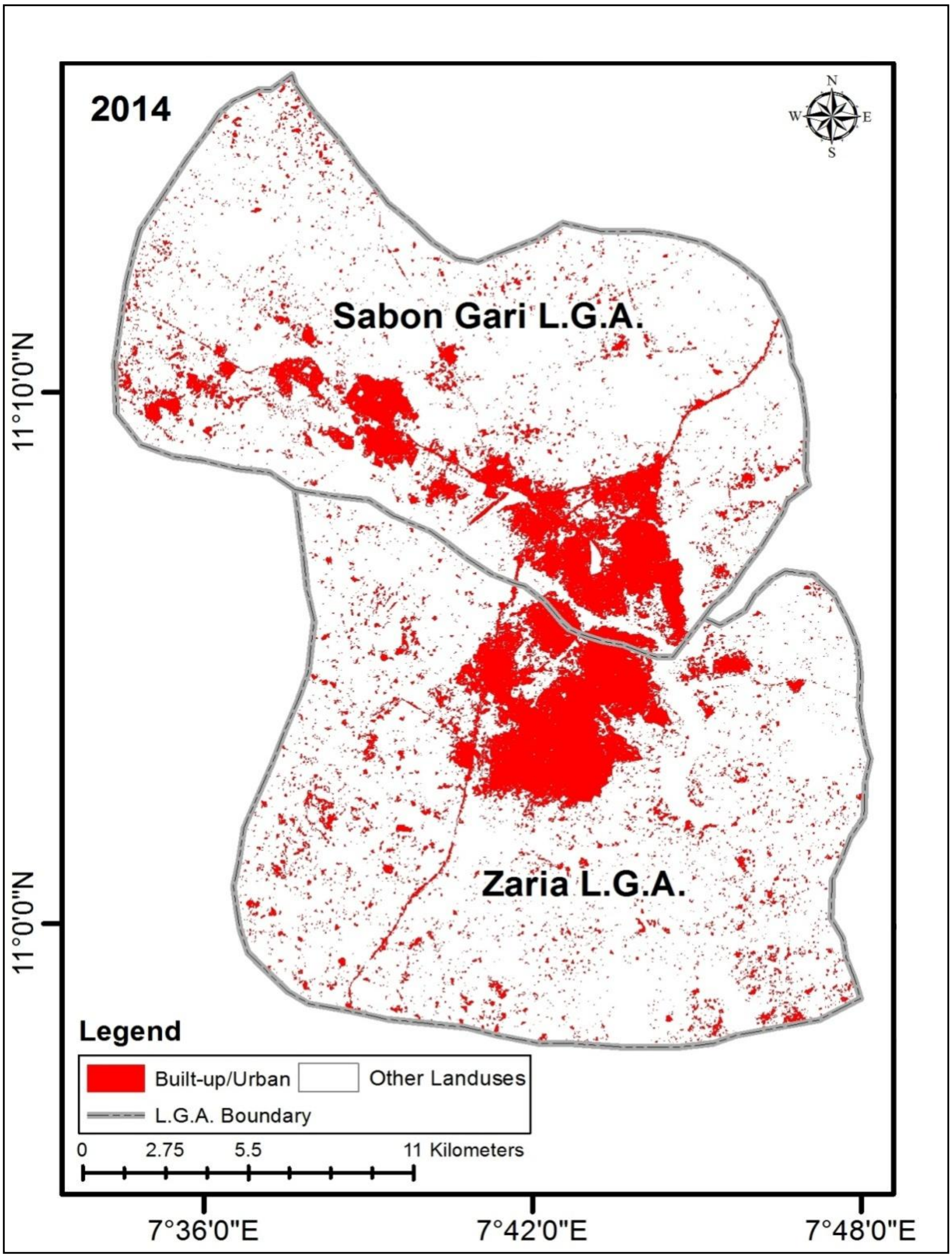


**Figure 4.4: The extent of urban growth in the study area in 2014**
**Source: Author's Analysis, 2015**

The direction of growth over the period of 1990-2014 with respect to extent of urban area and land use of the study area, showed remarkable rises in the built-up. For instance, between 1990 and 1999 the urban growth was towards the north-east direction along the Army depot barrack. This could be attributed due to the feeling of the people being more secured staying towards the barrack given the security concern especially among the non-indigenes. The period between 1999 and 2006 had the urban growth change direction from north-east to the north-west direction. The change in direction of growth could be as a result of the presence of the army barrack which limited physical development in that direction.

However, in the period between 2006 and 2014 the extent of urban growth in the area still maintains the north-west direction although the physical development tends to be more concentrated. Continuous growth in this direction may result to the merging of Sabon-Gari and Zaria city settlement.

### 4.3 STATIC LANDUSE AND LANDCOVER

Tables 4.2, 4.3, figures 4.5, 4.6, 4.7 and 4.8 shows the respective quantitative and spatial extent of landuse/landcover change in the study area.

Table 4.2 shows the status of landuse/landcover distribution for 1990, 1999, 2006 and 2014 obtained by classifying the image of each year into defined landuse/landcover.

**Table 4.2: Landuse / Landcover Distribution of Zaria**

| LANDUSE/ LANDCOVER | 1990 | | 1999 | | 2006 | | 2014 | |
|---|---|---|---|---|---|---|---|---|
| | ($km^2$) | (%) | ($km^2$) | (%) | ($km^2$) | (%) | ($km^2$) | (%) |
| **Built-up** | 40.37 | 7.1 | 57.15 | 10.15 | 84.5 | 15.00 | 96.17 | 17.07 |
| **Agricultural Land** | 376.46 | 66.84 | 365.27 | 64.85 | 351.85 | 62.47 | 345.17 | 61.28 |
| **Vegetation Land** | 78.86 | 14.00 | 67.49 | 11.98 | 51.96 | 9.22 | 42.11 | 7.48 |
| **Bare Surface** | 64.85 | 11.51 | 68.69 | 12.20 | 70.41 | 12.50 | 76.26 | 13.54 |
| **Water Body** | 2.72 | 0.48 | 4.66 | 0.83 | 4.54 | 0.81 | 3.55 | 0.63 |
| **Total** | **563.26** | **100.00** | **563.26** | **100.00** | **563.26** | **100.00** | **563.26** | **100.00** |

**Source: Author's Analysis, 2015**

Table 4.2 clearly shows the static landuse and landcover distribution over the study period. Built up had the highest proportion covering almost 17% of the entire area in 2014. In 1990 agricultural and vegetation lands had the highest proportion covering about 66.84% and 14% respectively. Bare surface had its highest proportion in 2014 of about 13.54% and water body with about 0.83% in 1999. The pictorial representation is shown in Figure 4.5, 4.6, 4.7 and 4.8.

**Table 4.3: Landuse and Landcover Changes of Zaria**

| LULC | 1990 | 1999 | 2006 | 2014 | EXTENT OF CHANGE 1990-1999 | | 1999-2006 | | 2006-2014 | | 1990-2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | km² | km² | km² | km² | km² | % | km² | % | km² | % | km² | % |
| **Built-up** | 40.37 | 57.15 | 84.5 | 96.17 | 16.78 | 41.57 | 27.34 | 68.26 | 11.67 | 13.82 | 55.8 | 138.2 |
| **Agricultural Land** | 376.46 | 365.26 | 351.85 | 345.17 | -11.2 | -2.98 | -13.41 | -5.5 | -6.69 | -1.9 | -31.3 | -8.31 |
| **Vegetation** | 78.86 | 67.49 | 51.96 | 42.11 | -11.36 | -14.41 | -15.53 | -37.61 | -9.85 | -18.96 | -36.75 | -46.6 |
| **Bare Surface** | 64.85 | 68.69 | 70.41 | 76.27 | 3.84 | 5.92 | 1.72 | 11.03 | 5.86 | 8.32 | 11.42 | 17.6 |
| **Water Body** | 2.72 | 4.66 | 4.54 | 3.55 | 1.94 | 71.22 | -0.12 | -23.9 | -0.99 | -21.88 | 0.83 | 30.29 |
| **Total** | **563.26** | **563.26** | **563.26** | **563.26** | | | | | | | | |

Positive (+) indicates an increase in area coverage
Negative (-) indicates a decrease in area coverage
**Source: Author's Analysis, 2015**

Table 4.3 shows that the period between 1999 and 2006 witnessed the highest amount of change in built-up/urban area of (68.26%). This could be attributed to the transition to democratic rule in Nigeria which took place in 1999, which ushered in development and consequent increase in built-up area. Agricultural land had the highest decrease (-5.50%) between 1999 and 2006. This could be linked to the increase in built-up area which led to the conversion of agricultural land to built-up areas. Vegetation had its highest decrease (-37.61%) in the period of between 1999 and 2006, the reason for this might not be different from that of agricultural lands. Bare surfaces also had the highest increase of (11.03%) between 1999 and 2006, while water body increase by (71.22%) in the period 1990-1999 and experienced a decrease of (-21.88%) between 2006 and 2014. Critical example of conversion of agricultural lands to built up area is seen around Zango, Kabama area, Hanwa, Line Zomo and Zaria city, as shown in plate i, ii, iii, iv, v and vi respectively.

The result shows that as urban growth in the study area increases, with rapid decrease in agricultural lands and natural vegetation. Previous researchers Mabogunje, (1975), Ajibade, (1999), Fasal, (2000), Zubair, (2006), and Ndabula, (2006) asserted that increased urbanization result in loss of agricultural lands, the present findings reveal that urban expansion takes over agricultural lands and natural vegetation.

**Plate I: Urban Encroachment around Kubanni – Galma River**
**Source: Field Survey (2015).**

**Plate II: Urban Encroachment along River Kubanni – Unguwan Maje**
**Source: Field Survey (2015).**

The expansion of urban settlement into the floodplains is evident around the confluence of the two major rivers (Galma and Kubanni) in Zaria as shown in Plate I and II.

**Plate III: Urban Encroachment around Unguwan Maje**
**Source: Field Survey (2015).**

**Plate IV: Residential Buildings under Construction Now in Graceland Area**
**Source: Field Survey (2015).**

As shown in Plate III and IV, the Unguwan Maje urban encroachment and the natural vegetation and farmlands are cleared to make way for buildings and road construction in the Graceland Area.

**Plate V: A Stadium Structure Located Within the Former Kabama Forest**
**Source: Field Survey (2015).**

**Plate VI: Residential buildings under construction Within the Former Kabama Forest**
**Source: Field Survey (2015).**

As shown in Plate V and VI, the Kabama forest was cleared for housing and infrastructures which is currently expanding into the surrounding areas.

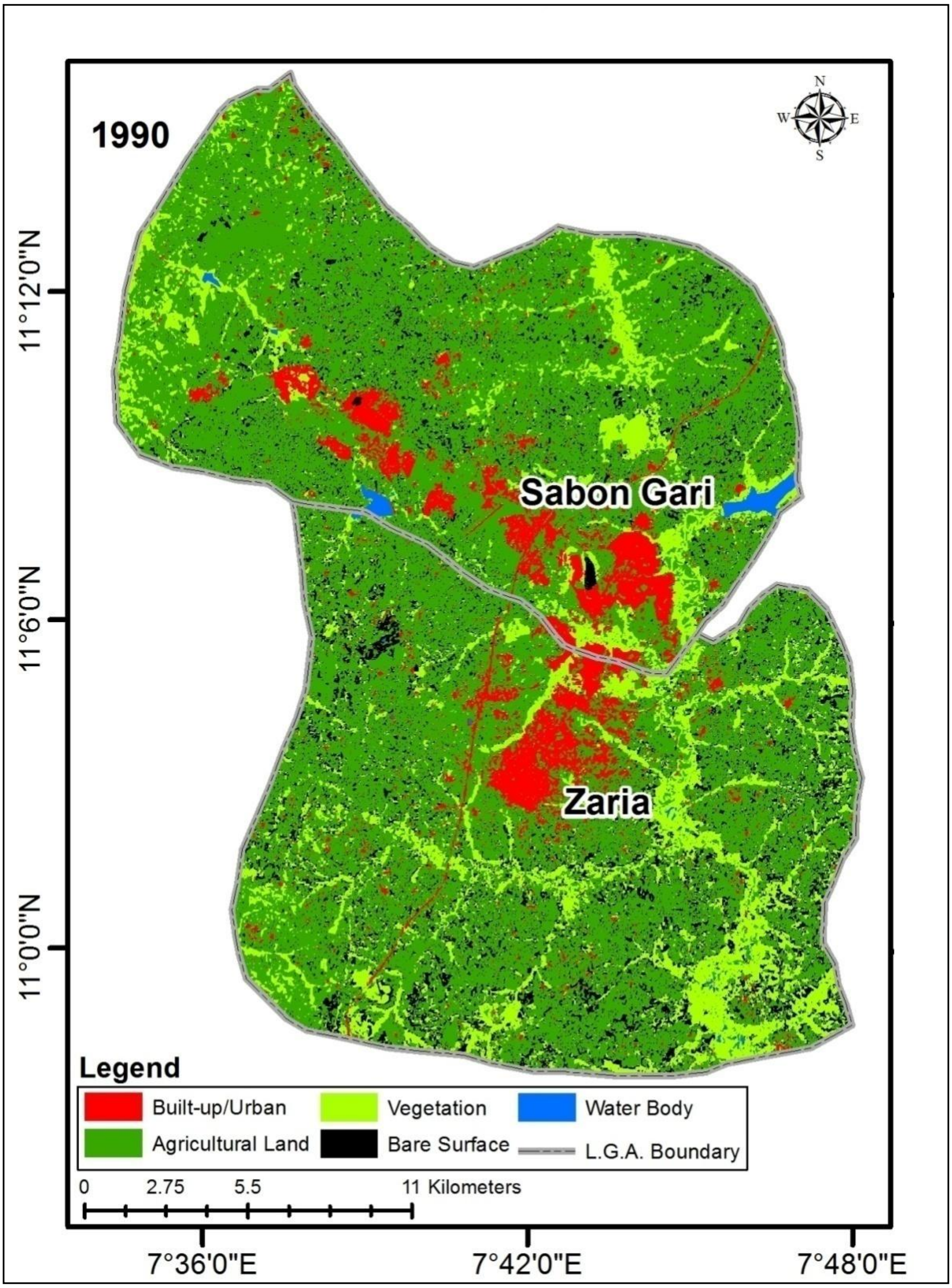


**Figure 4.5: The Spatial Extent of Land use/Land cover of Zaria (1990)**
**Source: Author's Analysis, 2015**

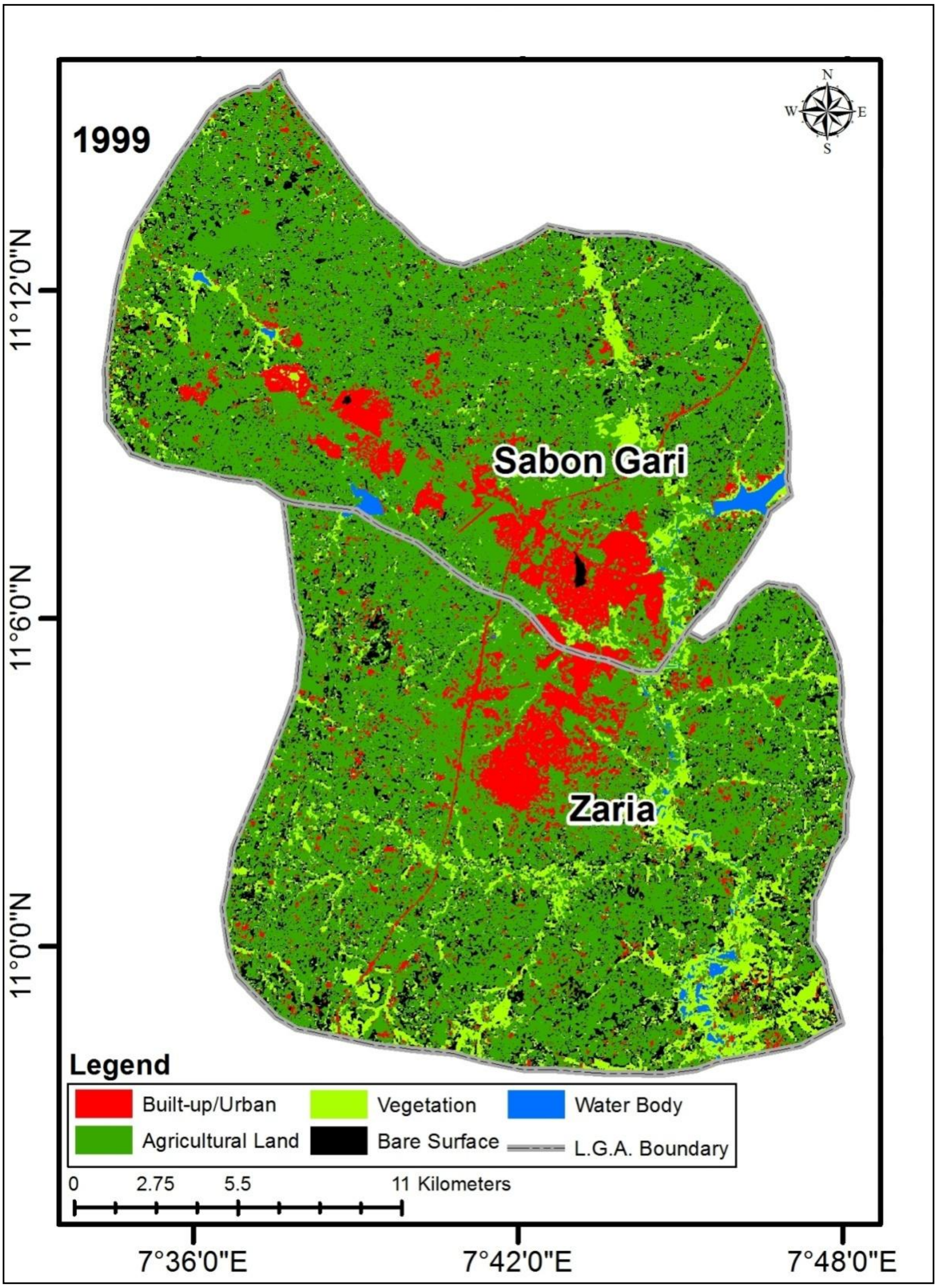


**Figure 4.6: The Spatial Extent of Land use/Land cover of Zaria (1999)**
**Source: Author's Analysis, 2015**

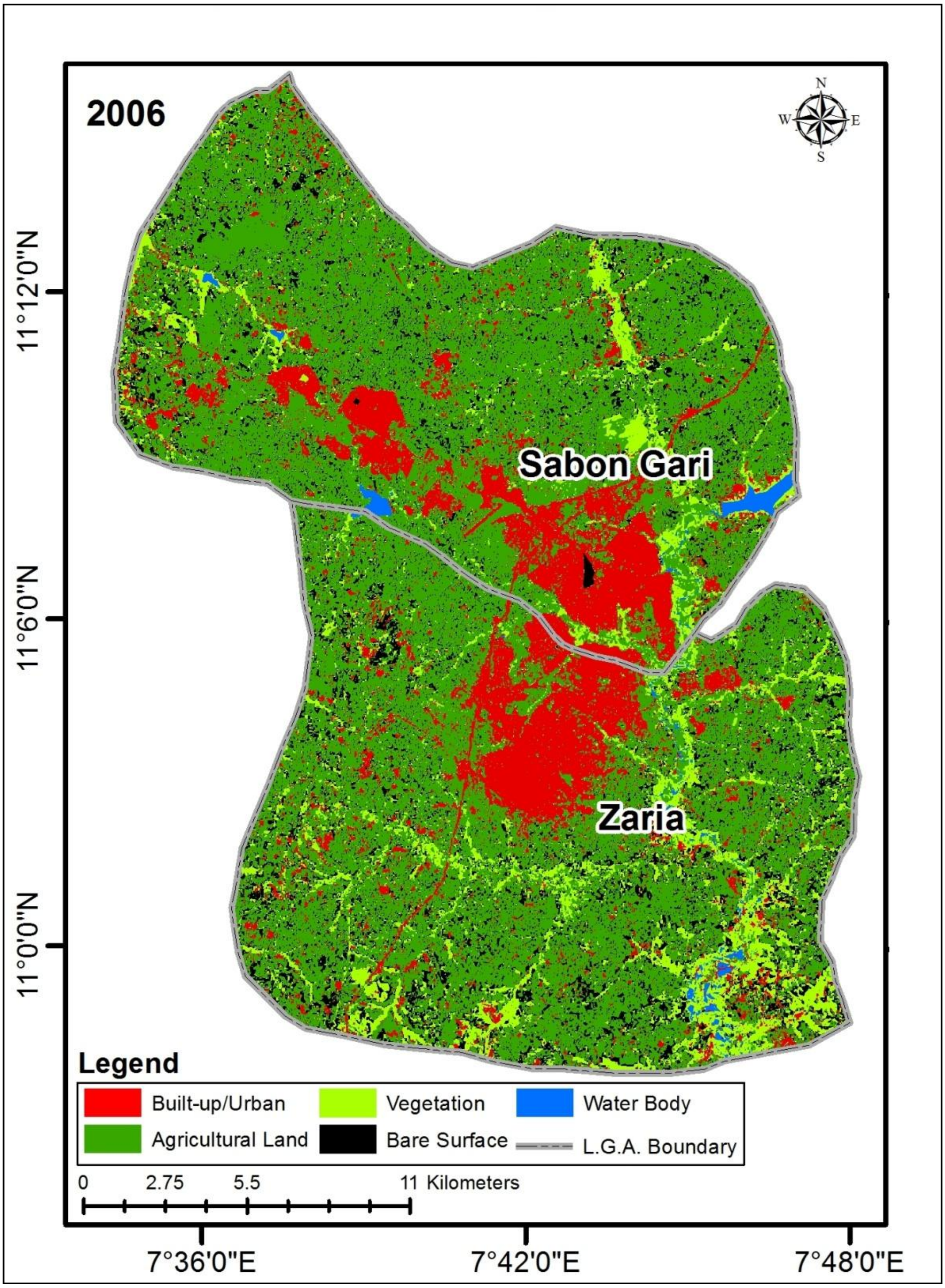


**Figure 4.7: The Spatial Extent of Land use/Land cover of Zaria (2006)**
**Source: Author’s Analysis, 2015**

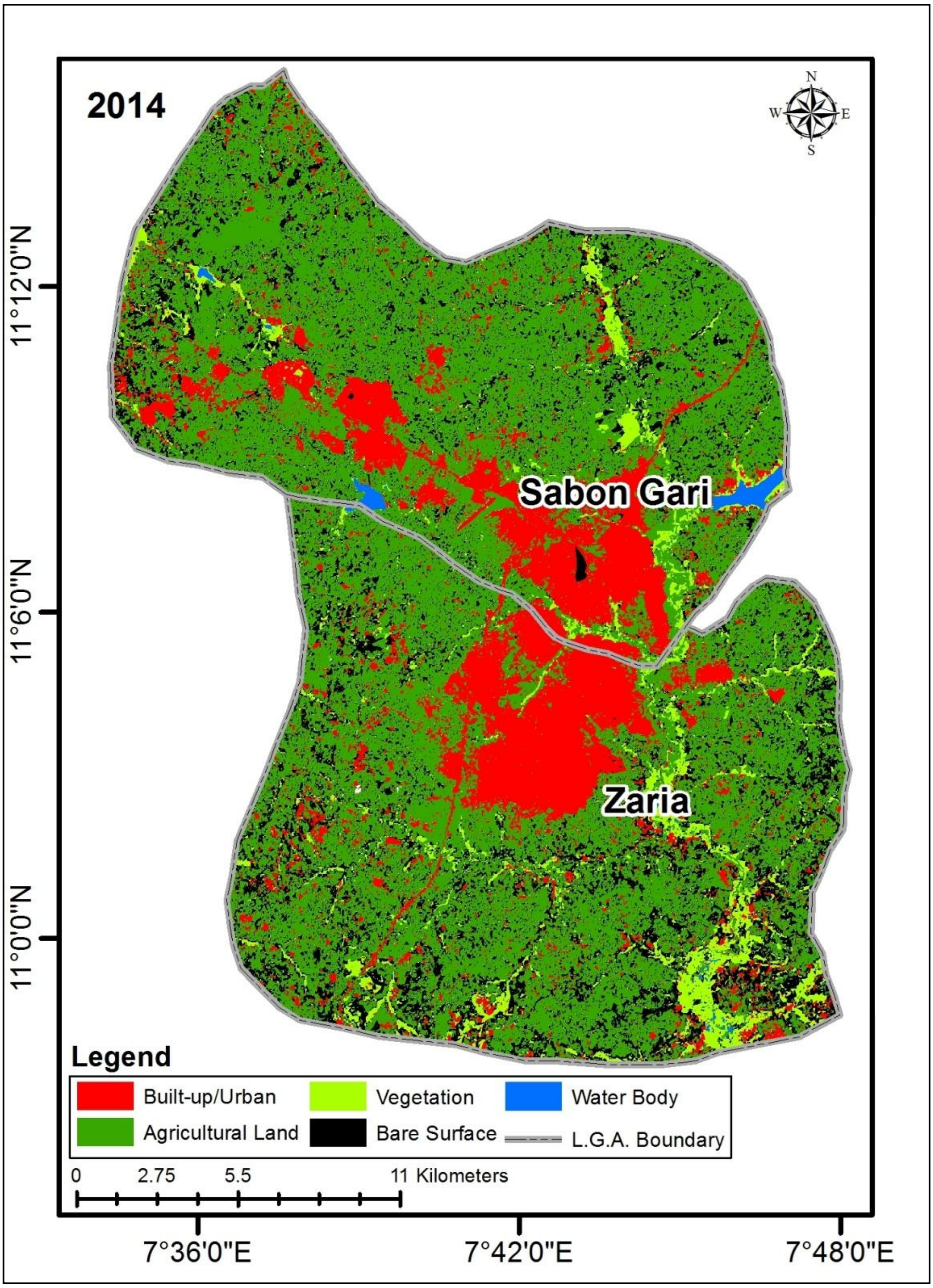


**Figure 4.8: The Spatial Extent of Land use/Land cover of Zaria (2014)**
**Source: Author's Analysis, 2015**

From the analyses in table 4.3 and figures 4.5, 4.6, 4.7 and 4.8, land use and land cover of the study area has undergone considerable changes over the examined period. While the built-up areas have expanded significantly during the twenty-four years period under study, the agricultural lands, vegetation and water bodies declined. Growths in population and physical developments have led to the sprawling of urban area. For instance, the Kabama forest was cleared for housing and infrastructures, the Palladan area and the Graceland has witnessed an extension of buildings into the hinterlands as more people relocate, also Zaria city witnessed more structures springing up outside the walls.

## 4.4 THE MAGNITUDE OF URBAN-INDUCED LANDUSE/LANDCOVER CHANGES

The magnitude of urban-induced landuse/landcover changes between 1990 and 2014 was determined by using the overlay and erase tool in ArcGIS, where the remaining areas after erasing represent areas changed to built-up (urban-induced changes). The magnitude of urban-induced changes in each period is shown in Table 4.4.

**Table 4.4: Extent of Urban-Induced Landuse/Landcover Changes**

| Landuse/Landcover Changed to Urban | 1990-1999 | | 1999-2006 | | 2006-2014 | | 1990-2014 | |
|---|---|---|---|---|---|---|---|---|
| | (km²) | % | (km²) | % | (km²) | % | (km²) | % |
| Agricultural Land | 8.5 | 50.66 | 12.58 | 46.03 | 6.08 | 52.10 | 27.16 | 48.67 |
| Vegetation Land | 4.64 | 27.65 | 8.38 | 30.66 | 4.36 | 37.36 | 17.38 | 31.15 |
| Bare Surface | 3.64 | 21.69 | 6.33 | 23.16 | 1.21 | 10.37 | 11.18 | 20.04 |
| Water Body | 0.02 | 0.11 | 0.04 | 0.15 | 0.02 | 0.17 | 0.08 | 0.14 |
| **Total** | 16.78 | 100 | 27.33 | 100 | 11.67 | 100 | 55.80 | 100 |

**Source: Author's Analysis, 2015**

From Table 4.4, the magnitude of other land use that changed to built-up areas show that agricultural lands and natural vegetation had the highest proportion of landuse/landcover that change to built-up areas (48.67% and 31.15% respectively) from 1990-2014. This signifies a progressive encroachment of built-up areas into these landuses/landcover types, where agricultural land, vegetation land and bare surfaces had its highest magnitude of change between 1999 and 2006 with (46.03%), (30.66%) and (23.16%) respectively.

## 4.5 THE RATE OF URBAN-INDUCED LANDUSE/LANDCOVER CHANGES

The rate of urban-induced environmental changes is shown in table 4.5. The rate of urban-induced landuse/landcover changes was obtained by dividing the magnitude of change by the number of study years.

**Table 4.5: Rate of Urban-Induced Landuse/Landcover Changes**

| **Period Change** | | | **Rate of Change** | |
|---|---|---|---|---|
| **($km^2$)** | **($km^2$)** | **%** | **($km^2$)** | **%** |
| **1990-1999 (9Years)** | 16.78 | 41.57 | 1.86 | 4.62 |
| **1999-2006 (7Years)** | 27.34 | 68.26 | 3.42 | 8.53 |
| **2006-2014 (8Years)** | 11.67 | 13.82 | 1.46 | 1.73 |
| **1990-2014 (24Year)** | 55.8 | 138.2 | 2.33 | 5.76 |

**Source: Author's Analysis, 2015**

The rate of urban-induced landuse/landcover change from the study showed a high annual rate of change (8.53%) in 1999-2006, followed by 1990-1999 with an annual rate of 4.62%, while the overall annual rate of change from 1990-2014 showed about 5.67%. This suggests increased urbanization against decrease in other land uses or increase human activities and urban expansion. It is noteworthy that the decreasing rate in 2006-2014 reflect a lower rate of urban induced land use land cover change.

# CHAPTER FIVE

# SUMMARY, CONCLUSION AND RECOMMENDATIONS

## 5.1 INTRODUCTION

This chapter describes the summary of the major findings of this work, conclusion derived from the findings as well as recommendations.

## 5.2 SUMMARY OF FINDINGS

This study on urban-induced landuse/landcover changes in Zaria was carried out using Geographic Information Systems and Remote Sensing techniques. The extent of this study covers Zaria (Sabon-Gari and Zaria LGA), the study analysed extent of urbanization, extent of landuse/landcover changes, magnitude and rate of urban-induced landuse/landcover changes in the study area between 1990 and 1999, 1999 and 2006, 2006 and 2014.

From the results of this study, the built-up area showed a consistent increase over time and this is basically because of increased population and consequent conversion of other land uses into residential areas. Also, the extent of urbanization throughout the study period witnessed the highest extent between 1999 and 2006.

The magnitude of other land use that changed to built-up areas showed agricultural lands and natural vegetation having the highest change to built-up areas throughout the study period, which signifies a progressive encroachment of built-up areas into other land uses. The rate of urban-induced landuse/landcover change showed an annual rate of change to be 5.67 percent for the study period.

Finally, it was observed that land use land cover had changed significantly over the period of study (1990s-2014). The built-up is encroaching into farmlands particularly in areas such as Zango, Hanwa, Line Zomo, Kwangila, Tukur Tukur and in both the southern and eastern parts of Zaria city. Built-up areas have encroached into Tukur-Tukur forest plantation and Kabama forest plantation in kwangila. Built-up areas are also encroaching into Galma wetlands particularly in Gyellesu, SabonGari, Jushin-Waja and also along Kubani wetlands especially behind G.R.A and Tudun-Wada. This encroachment is as a result of increase in population growth and activities such as commercial activities, educational activities, residential housing, and industrial activities which is a function of urbanization.

## 5.3 CONCLUSION

This study has demonstrated that the recent advancements in remote sensing and GIS technologies provide powerful tool for mapping and detecting changes in land use/land cover. For understanding the extent, rate and magnitude of land use and land cover dynamics, digital image processing techniques (Remote sensing and GIS) has enable speedy, accurate and objective interpretation of the multispectral data received from satellites. This has helped in a major way to observe the LULC at local, regional and global levels.

The study witnessed an increase in extent of urban growth throughout the study period. Also, the extent of landuse/landcover changes showed an increase in built-up areas and a significant decrease in natural vegetation and agricultural lands. The magnitude of urban-induced landuse/landcover changes showed agricultural lands and natural vegetation having the highest change to built-up areas for the study periods and signifies a progressive encroachment of built-up areas into other land uses. The rate of urban-induced landuse/landcover changes from the study showed an annual rate of change of (5.67%) for the study period. This shows that due to the rapid population growth in Zaria, there is an increase in the diversity of functional activities and growing demand for lands for residential housing and other land-based activities.

### 5.4 RECOMMENDATIONS

The study has indicated that urbanisation and its functional activities are gradually taking over the marginal lands. The findings of this research can assist in providing information for planners and decision makers, and can also support sustainable urban development initiative. However, based on the aforementioned findings of this research, the following are recommended: Regular landuse change studies should be carried out more frequently to detect urban induced landuse/cover changes that should be for sustainable urban development.

i. There is a need to encourage and plan for balanced growth in our cities. This is to be achieved by targeting some areas for growth and environmental protection and proper growth management legislations should be introduced at various levels of governments to identify lands with high natural resource, economic and environmental value and protect them from development.
ii. Site and services should also be intensified by urban planning authorities in which public services such as water and sewer lines, roads and schools be in place before new development is approved. Governments should as well make decisions in accordance with comprehensive plans that are consistent with plans for adjoining areas in Zaria so as to create a serene environment.
iii. Urban planning authorities need to explore the use of remote sensing and GIS for evaluation of urban growth. A computer-generated data base and information system

in GIS environment enhances continuous data collection, analysis, interpretation and updating data. This would provide support to planners in development of planning.

iv. Urban planning authorities need to explore the use of remote sensing and GIS for evaluation of urban growth. A computer-generated data base and information system in GIS environment enhances continuous data collection, analysis, interpretation and updating data. This would provide support to planners in development of planning.

v. Urban planning authorities need to explore the use of remote sensing and GIS for evaluation of urban growth. A computer-generated data base and information system in GIS environment enhances continuous data collection, analysis, interpretation and updating data. This would provide support to planners in development of planning.

vi. Satellite remote sensing data with repetitive and synoptic viewing capabilities, as well as multispectral capabilities, are found to be useful in mapping and quantifying the extend of urban area in different time periods, and a tool for monitoring the ecological changes in the urban core and in the peripheral land-use planning. The use of remote sensing needs to be introduced for monitoring the activities of developers. This will help in reducing unplanned built-up areas and the associated loss of natural surroundings and biodiversity.

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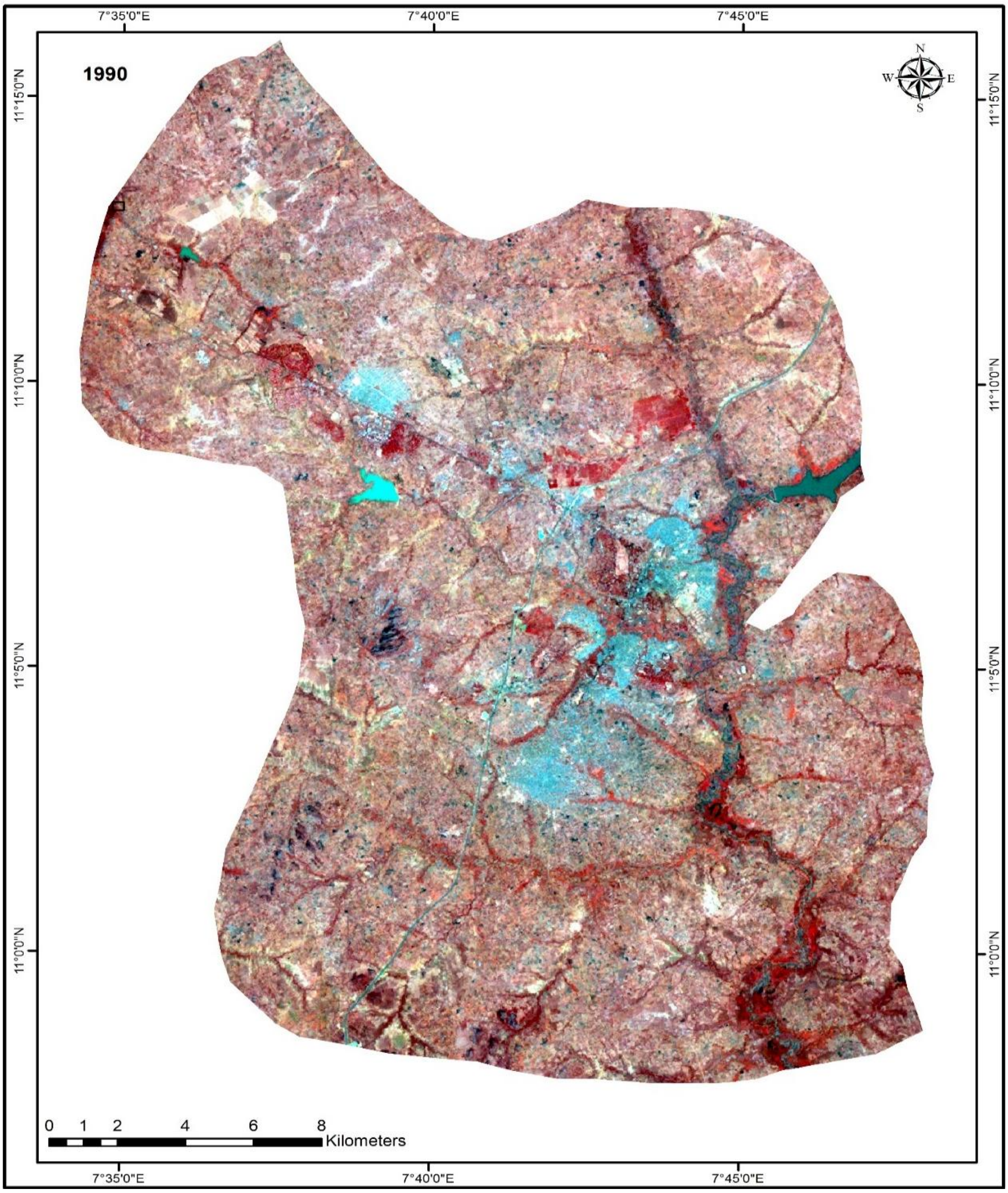
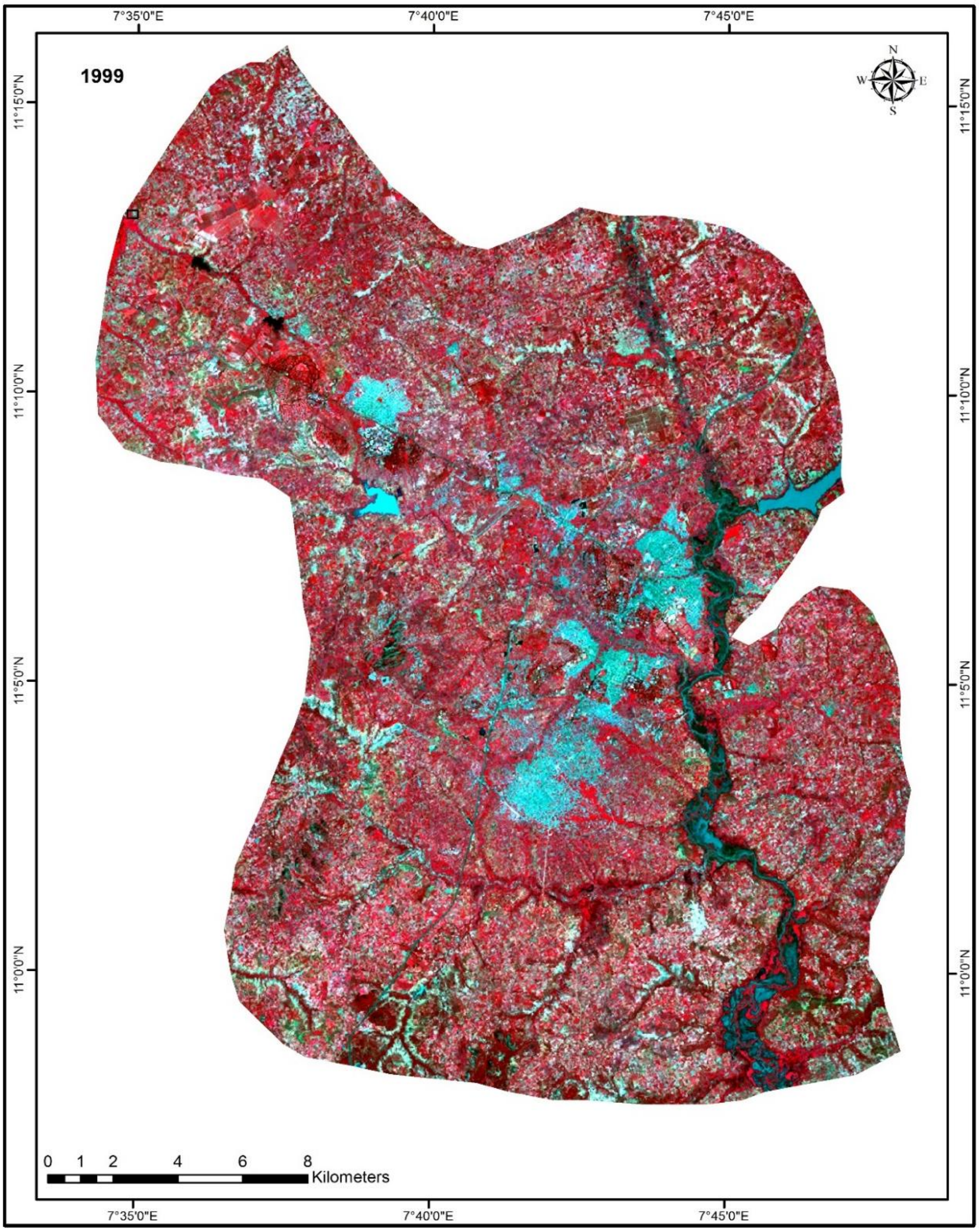
**Appendix I: Landsat Thematic Mapper (TM) (1990)**



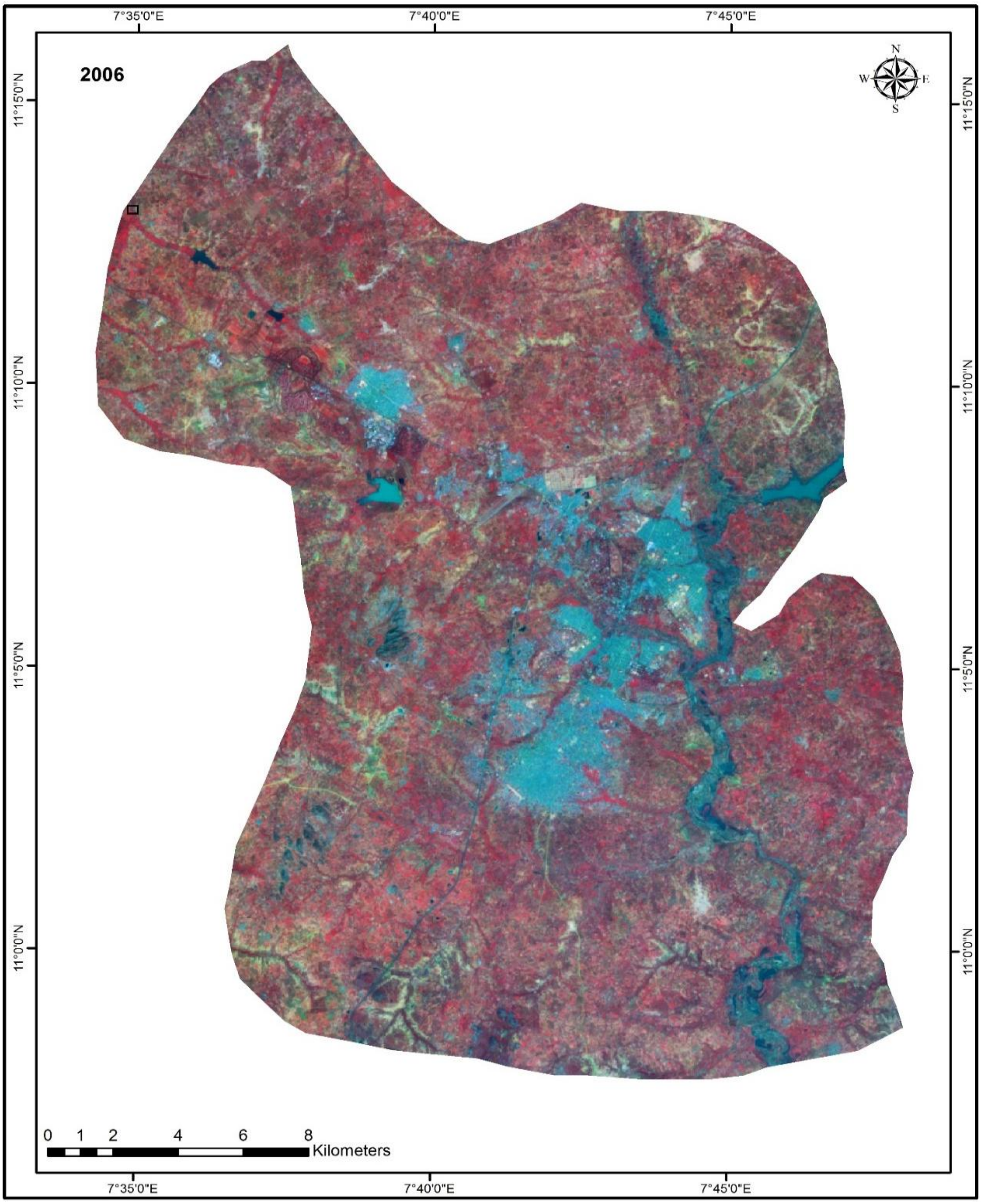

**Source: National Centre for Remote Sensing, Jos.**

**Appendix II: Landsat Enhanced Thematic Mapper Plus (ETM+) (1999)**



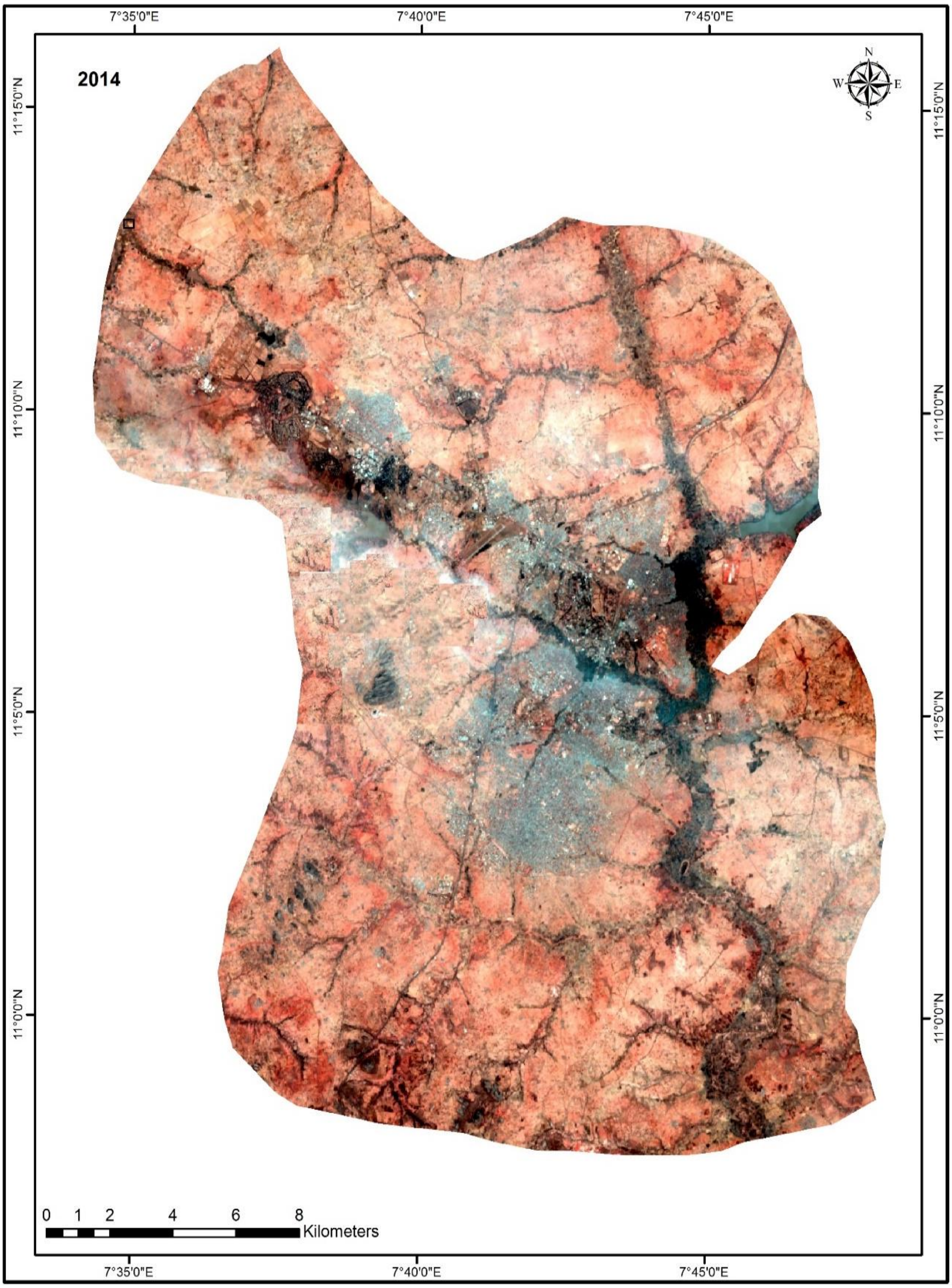

**Source: National Centre for Remote Sensing, Jos.**

**Appendix III: Landsat Enhanced Thematic Mapper Plus (ETM+) (2006)**




**Source: National Centre for Remote Sensing, Jos.**

**Appendix IV: Landsat Enhanced Thematic Mapper Plus (ETM+) (2014)**




**Source: Global Land Cover Facility**