LAND USE AND LAND COVER CHANGES IN KARU LOCAL GOVERNMENT AREA OF NASARAWA STATE, NIGERIA

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DECLARATION

I hereby declare that this research project titled “Land use and Land Cover Changes in Karu Local Government Area of Nasarawa State, Nigeria” is my personal work under the supervision of Dr. A.K. Usman and Prof. S.A. Yelwa, Department Of Geography And Environmental Management, Ahmadu Bello University, Zaria. All materials consulted in the course of this work are dully acknowledged and referenced.

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DEDICATION

This research work is solely dedicated to my parents and all members of my family for their prayers, suggestion and encouragements.

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All thanks to the Almighty God for seeing me through my academic program successfully. My personal gratitude goes to my able supervisors in persons of Dr. A.K. Usman and Prof. S.A. Yelwa, for their fatherly love, care and help in every area to make this project a success. To my parents who have shouldered the responsibility of my academics to this point. I also wish to express my gratitude to all my lecturers of geography department and my course mates that have in one way or the other contributed to the success, and my friends for their support and contributions to this project work.

ABSTRACT

This study examined the land use and land cover (LULC) changes in Karu Local Government Area of Nasarawa State. Landsat data of 2000, 2005, 2010 and 2015 were utilized for this study. Theimage classification of the study area was conducted using Maximum Likelihood Classification and five (5) LULC classes were identified. In addition, land use and land cover change matrix and the annual rate of land use and land cover for the study periods were calculated. The results of the LULC classification revealed that built up increased from 928.7Ha in 2000 to 4098.8Ha in 2015 while vegetation decreased from 179187.7Ha in 2000 to 144764.8Ha in 2015. The LULC change matrix revealed that from 2000to 2015 about 161287.8Ha (61.2%) of the study area remained unchanged. From 2000 to 2015 built up was growing at an annual rate of 22.8% while vegetation decreasing at an annual rate of 1.3%. Therefore,NasarawaUbarn Development Board and other agencies responsible for the land use planning of the LGA should also stand up to their responsibilities to ensure proper sustainable use of the land.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

The world's land surface estimated to cover about 13,340 million ha (Verheye, 2011) and about 54% of this land surface is disturbed by both human activities and natural factors (Briassoulis, 2011). The change in land use land cover (LULC) at all level is associated with several natural and human induced factors (Rahdary, Soffianian, Najfabdai, Khajeddin and Pahlavanravi, 2008). The natural or biophysical causes of land use land cover change(LULCC) include: slope, climate change, soil type, wildfire, pest infestation, flood and drought (Garedew, 2010; Shiferaw, 2011). Human induced or anthropogenic driving forces of LULCC grouped as the direct effects of human activity (proximate causes) and indirect effects of human activity (underlying driving forces) (Morie, 2007). The former comprises agricultural expansion, wood extraction and infrastructure expansion while the later includes demographic, economic, technological, policy and institutional and cultural factors (Geist and Lambin, 2002). The human induced causative factors increasingly recognized as a dominant force in LU/LCC (Lamichhane, 2008; Chang-Martínez, Mas, Valle, Torres and Folan, 2015). Briassoulis (2011) reported that one-third to one-half of the global land surface change by human activities such as logging, agricultural expansion, over grazing, fire management, forest harvesting and urban and suburban construction and development.

Land use land cover change also known as land change is a general term for human modification of Earth's terrestrial surface (Rahman, Hasan,Islamand,Maitra, 2011;Erle, 2016). Although human beings have been modifying land to obtain food and other essentials for thousands of years, current rates, extents and intensities of LULCC are far greater than ever in history, driving unprecedented changes in ecosystems and environmental processes at local, regional and global scales. These changes encompass the greatest environmental

concerns of human populations today, including climate change, biodiversity loss and pollution of water, soils and air. Monitoring and mediating the negative consequences of LULCC while sustaining the production of essential resources has therefore become a major priority of researchers and policymakers around the world.

Land cover refers to the physical and biological cover over the surface of land, including water, vegetation, bare soil, and/or artificial structures. Land use is a more complicated term. Natural scientists define land use in terms of syndromes of human activities such as agriculture, forestry and building construction that alter land surface processes including biogeochemistry, hydrology and biodiversity (Erle, 2016).

LULC is a major issue of concern with regard to change in the global environment (Qian, Zhou, Hou, 2007).The rapid growth and expansion of urban centres, rapid population growth, scarcity of land, the need for more production, changing technologies are among the many drivers of LULCC in the world today (Barros, 2004).

According to Masek, Lindsay, Goward (2000),LULCCs respond to socioeconomic, political, cultural, demographic and environmental conditions and forces which are largely characterized by high human populations. LULCC has become one of the major concerns of researchers and decision makers around the world today. LULC dynamics are widespread, accelerating significant processes majorly impelled by human actions and at the same time resulting to changes that impact human livelihood. The LULC dynamics modify the availability of different important resources including vegetation, soil, water, and others (Bruijnzeel, 2004).

Land cover change is a natural and / or anthropogenic phenomenon. However, it results more often from human activities than naturally occurring. Studies by Turner (1989) showed that landscapes influenced by natural rather than anthropogenic disturbances may respond differently, with natural disturbances increasing landscape complexity. The natural

causes include storms, landslide, and diseases and pest of existing vegetation as well as fire which is the most prominent one in most areas. LULC is the response of the increased use of nature to meet the numerous diverse human survival and developmental needs. Meyer and Turner II (1992) categorized the main driving force of land cover change into technology capacity, socioeconomic organization, level of development and culture.

Land use/cover changes have been in the lime light for reasons of importance attached to its impact on the earth and its occupants (Meyer and Turner II, 1992; Verburg, Overmars, Huigen, Groot and Veldkamp, 2006). On the whole, these changes have significant short and long term impacts on the functions of the physical, chemical and biological components of earth Lambin, Geist and Lepers (2003). Change in land cover and land use and subsequent impacts may be positive or negative spatially and temporally. However, the balance is mostly tilted to the negative in tropical forest areas (Ingram and Dawson, 2005). These negative changes in the long term reduce the continuous ability of the earth to produce goods and services on which humans survive (Dale, Brown, Hobbs, Huntly, Naiman, Riebsame, Turner and Valone, 2000). Most land cover changes cause a net loss of vegetation from the landscape and disturb the underlying soil resulting in a net release of carbon stored in vegetation and soils to the atmosphere adding up to atmospheric concentrations and potentially leading to global warming (Dye, 2003). For example, Wright (2005) asserts that approximately half of the potential tropical closed-canopy forest has already been removed and the land converted to other uses and a minimum loss of about 28% biodiversity was recorded in Singapore as result of habitat conversions (Brook, Sodhi and Ng, 2003). Lambin, Geist and Lepers (2003) cautions that not all impact is negative since many forms of land-use/cover changes are associated with continuing increases in food and fibre production which contribute to the survival humans.

The diverse effects of land use/cover change may be permanent or reversible depending on the type and cause of the change. Analysis by Rudel, Coomes, Moran, Achard, Angelsen, Xu and Lambin (2005) shown that 38% of the world appreciated in forest cover after a period of decline in the 1990s. Turner, Pearson, Bolstad and Wear (2003) observed a recovery of forest after small scale farms were abandoned in the Southern Appalachian Mountains in the 1900s. The effects of changes are not restricted to the location of the change and combine directly and indirectly in unexpected manner. Land cover alterations in up slopes, such as those brought about by clear- cutting, can result in short-term increases in stream discharge and sedimentation downstream (Baron, Hartman, Kittel, Band, Ojima, and Lammers, 1998).

Furthermore,Heilig (1994) mentioned unprecedented increase of population; the growing affluence in Europe, North America, and parts of Asia and Latin America; the worldwide changes in lifestyles, which are partly explained by rising per capita income; and the growing influence of geopolitical, economic, and military structures and strategies as important drivers most are which are usually ignored in discussions. According to Veldkamp and Lambin (2001) most spatial focus on proximate cause like distance to roads and towns rather than underlying drivers for the sake measuring convenience. The negative contribution of the rapid human population growth to the large pressure on land resources has been noted by most literature on land use/cover change (Lambin and Ehrlich, 1997; Meyer and Turner II, 1992; Verburg, Overmars, Huigen, Groot and Veldkamp, 2006; Verburg, Veldkamp and Bouma, 1999; Wright, 2005). However, Turner, Pearson, Bolstad and Wear(2003) found that land use may intensify without associated change in land cover if development occurs under natural conditions. Essentially the driving forces are usually remote in space and time from the observed changes, and often involve macro-economic transformations, technological effects, socio-political factors and policy changes which are difficult to expect (Geist and

Lambin, 2001; Serneels and Lambin, 2001). This is true fordeforestation which stands out among land cover change process in most countries due to the sharp contrast in the transition from forest to cleared land.

Today, the developing countries are more affected by faster extents in the built up areas. Angel, Sheppard and Civco (2005) and Kwarteng and Small (2010) indicated that the built-up area of developing-country cities will increase from 200,000 km² in 2000 to more than 600,000 km² by 2030, while their total population will double. Within this group of countries, Africa held a peculiar situation, despite its place as the least urbanized region in the world (39.1%); it had the highest urban growth: 3.3% per year between 2000 and 2005, UN-Habitat (2008).

In most Nigerian cities, urbanization has brought serious losses of agricultural land and water bodies (Jajere, 2013). LULCC is responsible for a variety of urban environmental issues like decreased air quality, increased runoff and subsequent flooding, increased local temperature, deterioration of water quality, among others. The major drivers of urbanization include population growth, poverty, standard of living, environmental pressure all of which are broad grouped into push and pull factors (UN-Habitat, 2012).

The Karu Local Government Area like many other settlements around the Federal Capital Territory (FCT) Abuja in Nigeria is experiencing unprecedented and rapid rate of LULCC. The relocation of the nation's Headquarters to Abuja has brought economic prosperity to the surrounding settlements. Karu LGA, being one of them has been transformed into a vibrant urban area. As a development corridor to the FCT for more than two decades Karu has become one of the fastest growing urban areas in Nigeria (Rikko and Laka, 2013).Therefore, determining the trend and rate of LULCCconversion is necessary for the development and planning in order to establish rational land use policy (Shalaby and Tateishi, 2007). For this purpose, the temporal dynamics of remote sensing data can play an

important role in monitoring and analyzing the effect of these landuse and landcover dynamics. Accurate and up-to-date land information on effect of urban expansion changes is necessary to understand both human causes and environmental consequences of such changes (Aboel, Shalaby and Ryutaro, 2004).

1.2 STATEMENT OF THE RESEARCH PROBLEM

Land Use Land Cover (LULC) dynamics are widespread, accelerating, and significant processes majorly impelled by human actions and at the same time resulting to changes that impact human livelihood (Steffen and Tyson 2001). The LULC dynamics modify the availability of different important resources including vegetation, soil, water, and others (Agarwal, Green, Grove, Evans andSchweik, 2002).Rapid urban expansionusually happens at the expense of other LULC types with the destruction of natural landscape and public open space, which has an increasing impact on the global environmental change, Liu (2009). So, the depletion of these green covers, adversely affects many aspects of natural process, and ultimately affected the environmental performance of the settlement. Better understanding of historical LULC patterns provides a means to evaluate complex causes and responses in order to betterproject future trends of human activities on land. Therefore, the need to study LULCC hasbecome a central component in current strategies in managing natural resources and monitoring environmental changes.

Several studies have been carried out to analyze land use and land cover changes. For instance, Ejaro and Abdullahi (2013) analyzed the spatial and temporal changes in land use and land cover in Suleja Local GovernmentArea (LGA) of Niger State between 1987 and 2012. The study utilizedILWIS 3.3 software for the processing and classification of the tri-date (1987, 2001, and 2012) satellite images. Post-classification Comparison Method was used to analyze the LULCC. The results obtained show that the proportion of area covered by built up land, farm land and bare soil is on the increase, while there is decline in vegetation.

Built up land increased from 7.0 km^2 (or 5.2%) in1987 to 17.9 km^2 (or 12.5%) in 2012, farmland from 50.1 km^2 (or 36.7%) to 63.0 km^2 (or 46.2%) and a declinein vegetation from 68.7 km^2 (or 50.4%) in 1987 to 43.1 km^2 (or 31.6%) in 2012. The study revealed thaturbanization is largely responsible for the significant change and modifications in land use and land cover inSuleja LGA.

Isma'il, Ezra, Abdulkadir, Muhammad and Hadiza (2015) examined urban growth and housing problems in Karu Local Government Area of Nasarawa State in Nigeria. Findings revealed a strong correlation between urban growth and housing problems in the area. However, the research only concentrated on the analogue and traditional ways of assessing residential areas. It also failed to look at the effect of LULC.Building on their shortcoming, this research applied geospatial techniques in assessing the LULC that occurred between 2000 and 2015 and the effect of such in the environment.

Nigussie (2016) conducted a study to examine land use land cover changes and driving forces behind thechanges in the Bale Eco-Region (BER), Ethiopia. Satellite image of Landsat5 TM 1986 and 1996, Landsat7 (ETM+) 2006 and Landsat8 (OIL/TIROS) 2016. In addition, field observations, Key informant interview (KII) and Focus Group Discussion (FGD) were also conducted. ERDAS Imagine 9.2, ArcGIS 9.3 and IDRSI Selva 17.00, softwares were used for satellite image processing and map preparation and LULCC prediction respectively. The main finding of this study revealed an expansion of agriculture/settlement and reduction of woodland and forest over the last 30 years between 1986 and 2016. Agriculture/settlement increased by 173369 ha, with a corresponding 296692 ha and 85184 ha decline in the area of woodland and forest respectively. If the current rate of LU/LCC continues, agriculture/settlement is predicted to increase by 28% in 2026. In contrast woodland and forest are predicted to shrink by 24% and 17% respectively. Analysis of LULCC under different institutional set-ups between 2006 and 2016 showed highest

expansion (1285 ha/year) of agriculture/settlement in the lowland Kebele under Wereda land administration followed by 290 ha/year in Kebele under the national park.

This study utilized remotely sensed data and GIS tools to analyze the spatial and temporal changes of LULC in Karu LGA.

In order to achieve the aim of this research work, the following guiding questions were advanced:

1. What are the LULC classes in the study areaduring the study period (2000, 2005, 2010 and 2015)?
2. What is the extent of LULCC in the study area?
3. What is the rate of LULCC in the study area?

1.3 AIM AND OBJECTIVES

The aim of this study is to examine the land use and land cover changes (LULUCC) in Karu Local Government Area of Nasarawa State. The aim will be achieved through the following objectives are to;

i. identify and map the LULC types inthe study areaduring the study period (2000, 2005, 2010 and 2015)
ii. determine the extent of LULCC in the study area
iii. assess the rate of LULCC in the study area

1.4 SIGNIFICANCE OF THE STUDY

Urban planners and administrative bodies require reliable information to assess the consequences of landuse and landcover changes, to ensure a sustainable functioning of cities and to minimize negative impacts of rapid urbanization. Urban expansion in the developing world often takes place in an unplanned manner and administration is unable to keep track of growth-related processes. Although satellite imagery provides a synoptic view of the urban

mosaic, remote-sensing data can be an important complement to limited in situ measurements in urban areas.

The settlements are developing haphazardly and uncontrolled leading to land use conversions and patterns that are unfavourable for sustainable development, service and infrastructural provision, encroachment and loss of quality arable lands, surface water bodies and biodiversity, congestion, slum formation, housing shortages, poor environmental condition and challenges, poverty, inadequate and lack of access to social services and infrastructure; hence, the need to assess the impacts of landuse and landcover change inKaru LGA of Nasarawa State, Nigeria with the use of geospatial techniques.

1.5 SCOPE OF THE STUDY

The spatial scope for the study Area is limited to KaruLocal Government Area which is consist of Agada, Aso, Gitata, Gurku, KafinShanu, Karshi I, Karshi II, Karu, Panda, Tattara and Uke wards.The content scope is to analyse the Spatio-temporal changes of landuse and land cover change inKaru Local Government Area. The study identified and mapped the various land use land cover, the extent and rate of landuse and land cover change in the area with the using Geospatial techniques for the period of 15 years (between 2000 and 2015).

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 CONCEPTUAL FRAMEWORK

2.1.1 Land Cover and Land Use

The terms land cover and land use are the two main components of land change. Land cover is more easy to notice than land use. As the term land cover denotes the surface cover over the land. Land cover refers to the physical and biological cover over the surface of land, including vegetation, water and bare soil; some workers also include artificial structures as land cover. On the other hand, land use is more intricate as it is interpreted differently by different scientists. Natural scientists, refers to the term as the use of the land surface for human activities such as agriculture, forestry and building of structures, whilst the social scientists define land use as the manner in which the land is managed in terms of socio-economic purposes (Ellis, 2010). According to Meyer and Turner II (1994), the concepts of land cover and land use are distinct but they are closely related in terms of their characteristics on the earth's surface. Land cover is easily observed directly, however, land use is different in that a single land cover type can be used in many ways. For example, forest can be used for many purposes such as logging, hunting, firewood collection and recreation, to mention a few.

Changes in land cover result from land use; and changes in land cover affect land use. However, land cover may change if land use remains unaltered. Several environmental impacts such as biodiversity loss, soil erosion and degradation, water flow, water quality and climate change are considered to result from alteration in the physical state of the earth's surface (Peprah, 2015).

2.1.2The Land Use and Land Cover Change

Many researchers argue that Land Use Land Cover Change(LULCC) emerged as a major aspect in the wider debate of global change, and that change originates from human-induced impacts on the environment and their implications for climate change (Ginblet, 2006). The indicators of these changes can be clearly seen in the current major global concerns such as increasing concentrations of carbon dioxide (CO_2) in the atmosphere, loss of biological diversity, conversion and fragmentation of natural vegetation and accelerated emission of greenhouses gases (Woldeamlak, 2002). Every parcel of land on the Earth's surface is unique in the cover it possesses. Land use and land cover are distinct yet closely linked characteristics of the Earth's surface. The use to which we put land could be grazing, agriculture, urban development, logging, and mining among many others; while land cover categories could be cropland, forest, wetland, pasture, roads, and urban areas among others. The term land cover originally referred to the kind and state of vegetation, such as forest or grass cover but it has broadened in subsequent usage to include other things such as human structures, soil type, biodiversity, surface and ground water.

Urban encroachment among other phenomenon of landuse land cover has a wide range of theoretical discussions and empirical analysis (Khan, 2000). For instance, while attempts have been made to simulate incremental urban change in the rural areas of the Pearl River Delta in China using physical models based on cellular automata developed, measurements of the resultant peri-urban settlement pattern were attempted (Ujoh and Kwabe, and Ifatimehin, 2010). Furthermore, different methods for identifying the distinctive features of urban and rural areas in urbanizing regions have been explained using ideas drawn from fuzzy sets (Oluseyi, 2006). However, the negativities associated with rapid urbanization, particularly the environmental consequences in cities and peri-urban areas, are among the most documented issues in urban environmental research. In the studies that focus on mega cities and on medium and small sized urban places, there is a consensus of opinion

in the literature concerning urbanization processes and the associated consequences. For example, it has been noted that although there are relatively few mega cities in Africa (i.e. cities with 10 million inhabitants or more), the urbanization process, unlike in Asia and Europe, is taking place in the absence of significant industrial expansion. Furthermore, the process is manifested primarily by an outward expansion of built-up areas and the conversion of prime agricultural lands for residential and industrial purposes (Oluseyi, 2006)

Theoretical models for both the residential and agricultural cases have derived explicit functional relationships between the extent of land use, or fringe distance, and model attributes such as population size and commuting costs. For example, urban land use expands at the expense of agriculture as demand for housing grows. Monte and Farhan(2013) analyzes relationships between urban fringe distance and attributes of the economic system in place, including wage rates and relative demand characteristics for housing and agricultural produce. The Muth approach possesses two shortcomings from the perspective of the present application. First, the extent of agriculture is unbounded and we cannot observe the advance of either urban or agricultural land use into unutilized lands. This compromises the framework's applicability to the case of natural areas conversion. The present model allows for two fringe distances associated with urban land use and farming, and therefore accounts for the empirical observation that both farms and urban space encroach on natural areas. Such encroachments have been reported for large metropolitan areas in the US, both in New Jersey. A second shortcoming stems from the conceptualization of linkages between city and hinterland (Monte and Farhan, 2013). The urban sector is modeled as a residential industry maximizing profits, and individuals who may or may not demand locally-grown produce populate the city. In the present formulation, I attempt to make the nature of the structural relationship between hinterland and city more consistent with historical observation.

Land use affects land cover and changes in land cover affect land use. A change in either however, is not necessarily the product of the other. Changes in land cover by land use do not necessarily imply degradation of the land. However, many shifting land use patterns driven by a variety of social causes, result in land cover changes that affects biodiversity, water and radiation budgets, trace gas emissions and other processes that come together to affect climate and biosphere (Houet and Hubert-Moy, 2006).

Settlements represent the most profound human alteration of the natural environment through a spectrum of urban land use activities (Olawole, Msimang, Adegboyegaand Adesina, 2010 and Fred, 2012) which include, but are not restricted to, transportation, commercial, industrial, residential, institutional, and recreational land uses. The expansion that ensues as a result of increase in the demand for these land uses explains the underlying and fundamental causes of urban sprawl: population increase. Urbanization is the process that refers to the growth both in size and numbers of urban centres. Several studies (Chomitz and Kamari,1998;Fabiyi, 2006;Boubacar and Boa, 2010;Fred, 2012) reveal that the proliferation of urban centres has been phenomenal from the turn of the 20th century. Urban sprawl is considered synonymous with unplanned, incremental urban development, characterized by a low density mix of land uses on the urban fringe. Urban sprawl is defined as the physical pattern of low density expansion of large urban areas mainly into the surrounding agricultural areas. Sprawl is commonly used to describe physically expanding urban areas. Such a modified landscape reveals a situation where cities are spreading, thereby minimizing the time and distances between and in and out of the cities.

DeFries, Asner and Houghton (2004) believe that while urban centers are growing in population and sprawl (extent), the periurban areas are undergoing rapid transformation with land coming under increasingly intense pressure through construction to provide space for an array of urban land uses. Thus, with rapid population increase and a finite urban land area

therefore, available land per individual shrinks pitilessly. The result is an urgent need for proper geo-management of land and the concomitant availability of a detailed, accurate and up-to-date geo-information. Most importantly, the sprawling nature of cities is critically potent in providing explanations for the major impacts that are evident in increased energy, land and soil consumption. This is because these impacts threaten both the natural and rural environments, raising greenhouse gas emissions that cause climate change and elevated air and noise pollution levels which often exceed the agreed human safety limits. Thus, urban sprawl produces many adverse impacts that have direct effects on the quality of life of people living in cities.

Land cover can be altered by forces other than anthropogenic. Natural events such as weather, flooding, fire, climate fluctuations, and ecosystem dynamics may also initiate modifications upon land cover. Globally, land cover today is altered principally by direct human use, by agriculture and livestock raising, forest harvesting and management and urban and suburban construction and development. There are also incidental impacts on land cover from other human activities such as forest and lakes damaged by acid rain from fossil fuel combustion and crops near cities damaged by tropospheric ozone resulting from automobile exhaust (Erle, 2016).

Hence, in order to use land optimally, it is not only necessary to have the information on existing land use and land cover but also the capability to monitor the dynamics of land use resulting out of both changing demands of increasing population and forces of nature acting to shape the landscape (Erle, 2016). Conventional ground methods of land use mapping are labor intensive, time consuming and are done relatively infrequently. These maps soon become outdated with the passage of time, particularly in a rapid changing environment. According to Erle(2016), monitoring changes and time series analysis is quite difficult with traditional method of surveying. In recent years, satellite remote sensing techniques have been

developed, which have proved to be of immense value for preparing accurate land use and land cover maps and monitoring changes at regular intervals of time. In case of inaccessible region, this technique is perhaps the only method of obtaining the required data on a cost and time - effective basis.

2.1.3 Land Cover Mapping

The objective of land cover mapping is to simulate the earth surface as much as possible by delineating the different features as they exist in nature. Remote sensing has continued to play a key role in providing information from satellite images and/or aerial photograph for characterizing spatial variation in land cover and monitoring temporal changes in land resources at various scales through classification procedures (Gholz, Nakane and Shimoda, 1996). Aerial photography had been the main source of land cover and use information, but high acquisition, processing and interpretation costs have reduced its use. Professionals in the field have resorted to the utilisation of multispectral satellite imagery for reasons of cost reduction, large areal coverage and availability in digital format (Bauer, Yuan, Sawaya, and Loeffelholz, 2005).

Multispectral image classification is the procedure used to automatically categorize all pixels in an image into land cover classes or themes based on the spectral patterns in the image data. The classification type described above is known as Spectral pattern recognition (Lillesand and Kiefer, 1994). Categorization is numerically based on the different combinations of spectral reflectance and/or emittance from the different land cover features which is represented as DN values. According to Hayes and Cohen (2006) associating individual pixel in an image with a single, discrete category assumes that each pixel represents a homogenous area on the ground however this becomes a matter of concern when the feature of interest is at a lower spatial resolution than that of the image.Classification methods broadly exist in two forms namely supervised and unsupervised.

2.1.4Image Classification Techniques

The land cover themes are derived by classification, which plays a major role in this type of study. Lillesand and Kiefer (2008) described Image Classification as a means of sorting image pixels into their various land cover classes depending on the spectral response pattern within the data (Adu-Poku, 2010). The two main types of classification method are, supervised and unsupervised approach. These techniques can be combined to form what is termed as Hybrid classification which is performed to improve the accuracy or efficiency of the classification (Lillesand and Kiefer, 2008). Any of the two methods, either supervised or unsupervised approach may be used to perform either hard or soft classification. Hard classification allocates one class to each pixel which may not give the correct results for classification, especially for coarse spatial resolution images. On the other hand, soft classification is able to detect class proportion within a pixel and the results is a more accurate classification.

Classification systems are useful in representing land cover using remotely sensed imagery. The classes of interest are mostly perceived and so supervised image classification techniques are used by most researchers (Campbell, 1996). Supervised classification procedure relies largely on the analyst's familiarity with the area of interest and availability of adequate data in order to spectrally characterize the classes by selecting pre-determined cover types known as training areas (Kerle*et al.*, 2004). Supervised classification technique distributes each pixel to the land cover class that is similar to the training set created. For example, the maximum likelihood classification is commonly used to assign each pixel to the class which has the highest probability of membership. This type of classification assumes the membership of a class, which is a typical description of a 'hard' classifier. It is therefore suitable to use hard classification when the area represented has similar coverage. Hard classification might not be appropriate for remotely sensed images (Campbell, 1996).

Unsupervised classification unlike supervised makes less demand on the analyst's knowledge in partitioning the image data. Cluster algorithms iteratively partition the image spectrally by determining statistical groups based on the numerical information (DN values) present in the image. However, the analyst is required to specify the desired number of classes in the data set and merge and or split some groups in the output of the classifier. Hence unsupervised classification is not entirely independent of human intervention (Canada Centre for Remote Sensing, 2003).

Pixels can have multiple or partial membership, this provides a means of solving the problem of mixed pixel in remotely sensed image (Smith, Ustin, Adams, and Gillespie, 1990; Wang, 1990). Soft classifiers defer the decision about the class membership of a pixel in favour of an expression of the degree of membership it exhibits in each of the land-cover classes under consideration. The reasons for using a 'soft' classifier include the examination of classification uncertainty, but are most commonly directed to the potential of uncovering the proportional constituents of mixed pixels-a process called sub-pixel classification.

2.1.5 Change detection

Monitoring land cover and land use change are increasingly reliant on land use/land cover maps produced from multi temporal remotely sensed data. The goal of change detection is to discern those areas on digital images that depict change features between two or more imaging dates (Sader and Hayes, 2001). It exhibits the ability to quantify temporal effects from multitemporal data sets (Singh, 1989). Change detection has been an important tool in monitoring land use/cover change and deforestation in many studies (Bauer et al., 2005; Hayes and Cohen, 2006; Mertens and Lambin, 2000). Change detection procedures involve the use of multitemporal data set to distinguish areas that experienced a change in land cover: short or long term (Lillesand and Kiefer, 1994). The underlying principle of change detection is that a change in land use/cover must result in a change in surface reflectance; however, the

perceived change must be substantial than those cause by differences in sensor properties, atmospheric conditions and seasonal change effects. Change detection procedures require data set with accurate spatial registration and recorded on the same day of the year for the change detection to be effective. Although the list of change detection approaches is a non-exhaustive one, Singh (1989) has reduced them to two basic approaches namely; simultaneous analysis of multitemporal data and comparative analysis of independently produced classifications from different dates.

However strong these approaches are in detecting changes, there are some weaknesses. The first approach is made up of techniques such as univariate image differencing, image ratioing, vegetation index differencing, principal component analysis, change vector analysis and direct multidate classification. The output of the above change detection techniques are pixel values usually indicating qualitatively "change or no change. The weakness includes unclear way of setting threshold between change and no change (Sader and Hayes, 2001); high sensitivity to inter-image misregistration and provision of little or no information on the nature of change (Singh, 1989).

The second approach requires two or more independent classifications of satellite images (Campbell, 2002). Post classification change detection prominently stands out in this category. It is the most commonly used quantitative method of change detection (Chen, 2002). It operates on two or more independently classified images as inputs and results in change map and change matrix. The reality of detected change is dependent upon the classification accuracy of the maps compared (Mertens and Lambin, 2000) However the post-classification approach provides ''from–to'' change information and the kind of landscape transformations that have occurred can easily be calculated and mapped (Bauer et al., 2005) Food and Agriculture Organization of the United Nations successfully applied post

classification change detection technique in a survey of forest cover and change process in 1990 (FAO, 1996).

The technique employed in any change detection analysis is of crucial importance. The type of method implemented can profoundly affect the qualitative and quantitative estimates of the change (Muttitanon and Tripathi, 2005) and the type of image processing methods to adopt.

2.1.6 Accuracy Assessment

An error matrix is an array of numbers ordered in rows and columns which expresses the number of sample units (i.e. pixels and clusters of pixels) which will be assigned to a particular category relative to the actual category as shown by reference data (Congalton, 1996). The general acceptance of the error matrix as the standard descriptive reporting tool for accuracy assessment of remotely sensed data has significantly improved the use of such data.

Accuracy is obtained by averaging all accuracies for each class. The overall accuracy for a class is determined by the quantity of samples to be tested for that class (Yang, Stehman, Smith, and Wickham, 2001). Kappa analysis is important because of the possibility to test for the quality of a LULC map compared to if the map had been generated by randomly assigning labels to areas (Congalton, 1996). The proportion of agreement achieved after removing the proportion of agreement that could be expected to occur by chance is represented by the kappa coefficient (Foody, 1992). This Kappa coefficient is represented on a scale between 0 (no reduction in error) and 1 (complete reduction of error). A coefficient of 1 shows complete agreement, and is mostly multiplied by 100 to give a percentage measure of the accuracy of the classification. A measure of agreement between model predictions and reliability can be

determined by the kappa value, (Congalton, 1991) and also to determine if the values contained in an error matrix represent a result significantly better than random (Jensen, 1996).

2.2 LITERATURE REVIEW

2.2.1 Application of Remote Sensing and GIS Techniques in LULCC Study

Geographical Information Systems (GIS) in conjunction with Remote Sensing (RS) has been recognized as a powerful and effective tool in LULCC analysis (Weng, 2002; Rimal, 2011; Abdullah, Alqurashi and Kumar, 2013). They provide accurate, cost effective and timely information and methods for monitoring, modeling and mapping of LULCC across a range of spatial and temporal scales. The information from GIS and RS also helps to assess the extent, direction, causes, and effects of the LULCC (Reis, 2008; Oumer, 2009; Rimal, 2011). In LULCC assessment some studies have utilized RS techniques; others have integrated remote sensing techniques with GIS. GIS is the technology which has been used to view and analyse data from a geographic perspective (Rimal, 2011).

It is a useful tool to measure the LULCC trends between two or more time by using statistical and analytical functions (Abdullah, Alqurashi and Kumar, 2013). It provides a flexible environment for collecting, storing, displaying and analyzing digital data necessary for LULCC detection and tools for land use planning and modeling (Reis, 2008; Rimal, 2011). In the context of LULCC, RS means the ability to detect change on the earth's surface through space-borne sensors (Abdullah, Alqurashi and Kumar, 2013). RS becomes useful tool for understanding landscape dynamics over time and space, irrespective of the causal factors. This is as a result of the fact that it provides multi-temporal and multi- spectral remotely sensed data (Oumer, 2009; Rimal, 2011).

Application of RS for LULCC analysis depends on: (i) sensor capability, (ii) wealth of information captured, (iii) objective of the intended study and (iv) spatial and spectral properties of satellite images acquired by different versions of a particular sensor instrument

(Oumer, 2009). Landsat imagery provides a better understanding of land resources. The most important reason for this is a continuous improvement in radiometric and spectral property of images over time (Oumer, 2009). Since the commencement of Landsat program in 1972 Landsat Multispectral Scanner (MSS), Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) data have been broadly employed in LULCC studies, mainly in forest and agricultural areas (Reis, 2008).

Understanding the dynamics and trends in land use and land cover change is a first step in decision making to combat the negative effects of the process. In the light of the quest for understanding, frequent monitoring becomes a tool to obtain such understanding. According to Lambin (1994) deforestation monitoring calls for the application of remote sensing and GIS in collection, processing and interpretation of data in assessing the nature, magnitude and rates of change. The earliest assessments aimed at providing reliable information on the process of on-going change in response to shortages of forest products. Identifying areas of current and potential deforested areas, quantifying and where possible establish a link with the driving forces at play (Achard et al., 1998; Lambin and Ehrlich, 1997; Van Laake and Sanchez-Azofeifa, 2004). However, Lambin and Ehrlich (1997) argued that broad scale assessment provides less information on the complexity social relationships, adaptations to specific ecological conditions and the local socioeconomic context.

Maktav, Erbek and Jürgens (2005) showed that traditional data collection methods such as demographic data, census and sample maps were not satisfactory for the purpose of urban land use management. Accurate information of land use and land cover change is therefore highly essential to many groups. To achieve this information, remotely sensed data can be used since it provides land cover information. Remote sensing refers to the science or art of acquiring information of an object or phenomena in the earth's surface without any physical contact with it. And this can be done though sensing and recording of either

reflected or emitted energy or the information being processed, analyzed and applied to a given problem (Campbell, 2002).

Remote sensing is important for estimating levels and rates of deforestation, habitat fragmentation, urbanization, wetland degradation and many other landscape-level phenomena. Such useful information can be then integrated into many regional to global scale models, including those that are used to develop parameters for carbon fluxes and hydrological cycles. Therefore, remote sensing data can be used as the basis for answering important ecological questions with regional to global implications (Vogelmann, Helder, Morfitt, Choate, Merchant and Bulley, 2001). Herold, Couclelis and Clarke (2005) also noted that one of the advantages of remote sensing is its ability to provide spatially consistent data sets covering large areas with both high detail and high temporal frequency, including historical time series.

Over the past decades almost all the remote sensing researches have given more attention to natural environment than urban areas. The reason was that urban areas have complex and heterogeneous by nature (Melesse, Weng, Thenkabail and Senay, 2007). However, Herold, Couclelis and Clarke (2005) reported that with the availability of high resolution imagery together with suitable techniques, urban remote sensing become a rapidly gaining interest in the remote sensing community. Supported by advanced technology and satisfying social needs, urban remote sensing has become a new field of geospatial technology and applicable in all socioeconomic environments (Melesse et al, 2007).

Following this, a number of applications of remote sensing for urban studies have shown the potential to map and monitor urban land use and infrastructure. Moreover, Herold and Menz (2001) showed urban land use information in high thematic, temporal and spatial accuracy, derived from remotely sensed data, is an important condition for decision support of city planners, economists, ecologists and resource managers. Generally, land use and land

cover changes have a wide range of impacts on environmental and landscape attributes including the quality of water, land and air resources, ecosystem processes and functions (Rimal, 2011). Therefore, the use of remote sensing data and analysis techniques provide accurate, timely and detailed information for detecting and monitoring changes in land cover and land use.

Zubair (2006) analyzed change detection in land use /land cover of Ilorin, Kwara state using Remote Sensing and GIS. Land sat images of 1972, 1986 and 2001, Land use/land cover vegetation maps as well as administrative maps of State was used. The result revealed that between the period of 1986 and 2001, there was a reduction in the expansion of Ilorin compared to the period between 1972 and 1986. The results also revealed that between1972-2001 the city has expanded at the rate of 27.62% per annum. The researched concluded that there is likely going to be crowdness brought by compactness in Ilorin by 2015.

Daniel and Ayobami (2007) assessed changes in land use land cover in some part of south-western Nigeria over 16 years. Satellite imageries of 1986 and 2002 were used. The result showed that the disturbed/degraded forest constitute the most extensive type of land use land cover in the study area. The increasing population and economic activities were noted to be putting pressure on the available land resources. It was also discovered that 98.3% and 63.7% of the area covered with high forest in Ikeji forest reserve and Akure forest reserve respectively were converted to shrub lands / farm lands over the period of 16 years.

Václavík and Rogan (2009) carried out astudy toanalyse trends in land use/land cover changes (LULCC) in the context ofpolitical and economic transformation of the Czech Republic, using the greater Olomoucregion in the period between 1991 and 2001 as a case study. Landsat ThematicMapper (TM) and Enhanced Thematic Mapper Plus (ETM+) images from 1991 and2001 were acquired and processed for maximum likelihood classification to produceland use/land cover maps for both times with overall map accuracies between 0.8and

0.84. Major land changes were identified using post-classification comparisonand trend surface analysis. Results showed significant marginalization of intensiveagricultural activities (12%), a shift in forest composition from mixed to deciduous forest (6%) and an overall increase in residential development on arable land(3.5%).

Dialloand Bao (2010)used remote sensing and GIS technologies to assess Bamako's land cover change within a twenty-year period. For this purpose, three remotely sensed data acquired respectively on 14 November 1986, Landsat Thematic Mapper (TM), 25 October 1999, Enhanced Thematic Mapper Plus (ETM+), and 26 September 2006 (ETM+) were classified into five land use/land cover classes (forest, built up, non-forest, bare land and water). The results showed that over the time span, the built up area has steadily been increasing; with area expansion from 41.27 km^2 (16.98 %) in 1986 to 102.48 km^2 (42.17 %) in 2006. In contrast, forest and bare land were about 3.58 % (8.69km^2) and 48.45 % (117.73 km^2) in 1986; the percentage decreased to about 2.89 % (7.03 km^2), and 15.71 % (38.17 km^2) in 2006, respectively.

Balogun, Adeyewa, Balogun&Morakinyo (2011) analyzed urban expansion and land use changes in Akure, Nigeria using Remote Sensing and Geographic Information System techniques. Landsat for 1986, 2002 and 2007 (21-year time span) were used. The satellite imageries were classified using the Maximum likelihood classification approach. The results showed substantial change in land use and land cover of Akure. The results indicated a rapid increase in built up and arable land but terrible depletion of the dense forest. It was also observed that future changes by the year 2020 may likely follow the trend observed between 1986 and 2007 as the projection results indicated that built-up and arable land will increase rapidly and the dense forest would have been drastically reduced by the year 2020.

Ezeomedoand Igbokwe (2013) mapped and analysed Land use and Landcover patterns and changes in Onitsha Nigeria using high resolution satellite images. Multitemporal

data consisting of existing Topographical map, SPOT-5, and IKONOS images were processed using spatial analysis tools of resampling, georeferencing, classification and post-classification overlay, to map the patterns and extent of landuse and landcover in the study area as well as determine the magnitude of changes between the years of interest, 1964, 2005 and 2008 respectively. The result of the study shows that the built-up areas have been on a constant positive and mostly uncontrolled expansion from 8.12% of the study area in 1964 to 41.64% in 2005 and to 67.62% in 2008. On the other hand, vegetation, including cultivated and uncultivated agricultural lands has been on a steady decline, from 79.10% in 1964 to 51.78% in 2005 and a mere 18.74% in 2008.

Rawat, Biswas and Kumar (2013) used geospatial techniques to assess land use/cover dynamics of Ramnagar town located in the foothill zone of the Uttarakhand State. Landsatsatellite imageries of two different time periods, i.e., Landsat Thematic Mapper (TM) of 1990 and 2010 were acquired from USGS Earth Explorer. Maximum Likelihood Supervised Classification methodology has been employed and the images of the study area were categorized into five different classes, viz. built-up area, vegetation,agricultural land, water bodies and sand bar. The results indicate that during the last two decades,built-up area and sand bar of the Ramnagar town area have been increased from about 8.88% (i.e.,2.83km^2) in 1990 to 3.98% (i.e., 1.27km^2) in 2010. Other land categories such asvegetation, agricultural land and water body have decreased by about 9.41% (i.e., 3.00km^2), 0.69%(i.e., 0.22km^2) and 2.76% (i.e. 0.88km^2), respectively. The study reveals that the Ramnagar townis expanding towards the southern direction along the National Highway-121.

In 2013, Rikko noted that Greater Karu Urban Area (GKUA) has been experiencing a large influx of population due to unprecedented rate of urbanization from all parts of Nigeria and elsewhere. This has led to rapid expansion and sprawl of the young settlement resulting

in land use and land cover changes, transforming the entire landscape from rural to urban. The techniques of Remote Sensing and Geographical Information System (GIS) were used to monitor and map urban sprawl. The built up areas were obtained from LandSat and Nigerian Sat1 imageries of four different periods covering a 35-year period. Further analysis of the imageries revealed significant dynamic changes in the growth of the settlements in GKUA over time. The study shows a discontinuous spread of settlements leap-frogging into each other along the Keffi-Abuja High way, fast spreading into the hinterland and converting viable agricultural lands into urban development, an evidence of rapid sprawl. The study also shows more intense physical development along the high way and settlements closer to the Federal Capital Territory like Mararaba, Karu, Nyanya and Masaka than settlements farther away. This study has provided quantitative and qualitative data for effective planning, policy and decision making for a more sustainable development of settlements in GKUA.

AdjeiBuor and Addrah (2014) examined forest degradation and biodiversity loss in the Lake Bosomtwe Basin ofGhana between 1986 and 2008 from a geospatial perspective. The study was conducted usingan integrated approach with Remote Sensing and GIS techniques, and supported with socioeconomicdata for forest cover change detection and biodiversity loss. A supervised per-pixelclassification approach using a maximum likelihood algorithm was employed to generate landcover maps from Landsat Thematic Mappers of 1986 and 2002, as well as ETM+ of 2008imagery. Statistical analyses of the land cover classifications indicate that forest cover aroundthe basin has experienced remarkable loss in the past 22 years. Specifically, between 1986 and2008, the basin lost 18.0% of the total forest cover as a result of anthropogenic activities. Landcover changes were mainly caused by extensive farming and building, with increases of16224.5Ha and 7139.3Ha respectively.

Oloukoi, Oyinloye and Yadjemi (2014) assessed the effects of urban expansion of Ile-Ife city and appraises the changesthat occurred in the landscape from 1986 to 2009. The study

made use of information extracted fromLandsat TM 1986, ETM+ 2002 and Ikonos 2009 images. GPS observations of notable pointswithinand around the city were overlaid on the topographic map and on the satellite imageries in ordertoappraise the changes in the land use and land cover over the period. The land consumption wasanalyzed using the computed land consumption rate (LCR) and land absorption coefficient (LAC)from 1986 to 2009. The average annual rate of urban expansion of Ile-Ife is 3.5% which translated toa gain of 2256.7 ha in the surrounding rural areas from 1986 to 2002 and about 1434.7 ha between2002 and 2009. The land is being transformed as shown by the land consumption rate whichprogressed from 1.1% in 1986 to 1.2% in 2002 and remained stable till 2009. The land absorptioncoefficient has increased from 0.013 to 0.014, confirming the high demand for land both within thecity and in the suburbs.

Kafi, Shafri and Shariff (2014) analysed land use land cover change detection using remotely sensed data from Landsat 7 ETM+ and Landsat 8 were utilized for the purpose of LULC change detection in Bauchi city. Three change detection algorithms were used to detect areas of change. They include supervised, unsupervised and post classification comparison. While the unsupervised classification was found to be less effective, the supervised classification produced good results with overall accuracies of 93.5% and 89.7% for the 2003 and 2013 respectively. Finally, "from-to" change was obtained using the post classification comparison.

Atubi,Awaritefe and Toyon (2018)analyzed land use and land cover changes in Warri Metropolis between 1964 and 2014 and projected changes to the next 5years, 10years and 25years planning periods. Data used are aerial photographs, satellite images, topographical maps, and census data. Remotely sensed data (1964 and 2014) were classified and overlaid in a GIS environment using Arc-GIS version 9.3 software. GIS-derived data were subjected to rigorous statistical analysis of ANOVA, New Ducan Multiple Range Test and Time Series

Analysis. Results of GIS analysis indicated that built-up sprawled other categories. Built-up expanded from 8.36km^{2}in 1964 to 54.2km^{2}in 2014. Forest reduced from 52.23km^2 in 1964 to 22.23km^2 in 2014. Mangrove reduced from 63.79km^2 in 1964 to 29.6km^2 in 2014. Scattered cultivation reduced from 103.30km^2 in 1964 to 71.6km^2 in 2014. Water bodies increased from 16.46km^2 in 1964 to 22.04km^2 in 2014. Using Analysis of Variance (ANOVA) the model at $p<0.5$ indicated significant changes in land use and land cover. Duncan New Multiple Range Test compared the means and indicated significant differences in land use and land cover in decadal remotely-sensed data for the periods. This implies that there is a significant change in land use and land cover in Warri Metropolis between 1964 and 2014. Multiple Regression Model showed population growth, changes in built-up and forest explained changes in land use. Time Series Model indicated a calculated value of 4.985 which is higher than the critical table value = 1.6 at n-2 df. This implies that land use and land cover will change significantly in the near future (5 years, 10 years and 25 years planning periods). Markov Transition Estimator, forecasted agriculture will occupy 7,67km^2 (22.7%) of total land area in 5-years planning period, forest, 5, 141km^2 (15.4%) built-up area 12, 689km^2 (38%), water bodies 8,04km^2 (41%). In 2024, (10years planning period), agriculture is forecasted to occupy 6,498km^2 (19.4%) of total land area, forest 3,59km^2 (9.725%) built up area, 2,603km^2. In 25 years planning period, 1939, agriculture is forecasted at 5,842km2 (1.75%), forest 2,561km^2 (7.6%), built up area 17,007km^2 (51%) and water bodies 7,908km^2 (23.6%) of total mapped area. Markov projection clearly indicates that built up area will grow increasingly at the expense of other categories.

Bello,Ojo and Gbadegesin(2018) analysed the effects of LULC on Eleyele reservoir for a period of 32 years. Landsat images of 1984, 2000 and 2016covered by path 191 and rows 55 were acquired, a modified version of Aderson scheme of LULC classification was usedto stratify the images, while the LULC map was analysed and projected until year 2032

using Marcov model. The result of the Land Use Land Cover analysis revealed that built up area increased from 688.30 ha to 952.68 ha and from 952.68 ha to 2164.5 habetween years 1984 to 2000, and 2000 to 2016 respectively. LULC maps of 2000 and 2016 showed the open water alsoreduced from 101.6 ha in year 2000 to 61.74 ha in 2016. Transition mapping showed that 8.5% of vegetation was converted to built up while 1.9% of built up area was transitioned to vegetation cover in 1984 and 2000 respectively. Land Use Land Cover MARKOV chain analysis shows that by projection,the reservoir area will reduce further to 39.08 ha by the year 2032.

CHAPTER THREE

STUDY AREA AND METHODOLOGY

3.1INTRODUCTION

This chapter presents the data and the methodological framework adopted for this research. It also explains the various sources of data, types and their corresponding characteristics.

3.2 THE STUDY AREA

3.2.1Location

Karu Local Government Area is in Nasarawa State with designated Planning Area covering a spatial extent of about 800sqkm. It extends from the eastern boundary of the Federal Capital Territory (FCT) Abuja, (Old Nyanya) to Gora about 15 kilometers to Keffi. It is located between Latitudes $8^{o}40'00''$N and $9^{o}25'00''$E and between Longitudes$7^{o}30'00''$E and $8^{o}10'00''$E. The study area shares common boundaries with the FCT Abuja to the west, Keffi and Kokona Local Government Areas (LGA) to the East, NasarawaLGA to the South in Nasarawa State and Jaba Local Government Area of Kaduna state to the North (Figure 3.1).

3.2.2Climate

Karu LGA has a tropical continental climate with marked seasonal variations. The area is influenced by two distinct air masses that have much effect on the climate. The northeast trade winds, which are usually dry and dusty, are pronounced between November and March. This period is referred to as Harmattan. The second type is the wind-bearing tropical maritime air masses that originate from the Atlantic Ocean and bring rain with it.

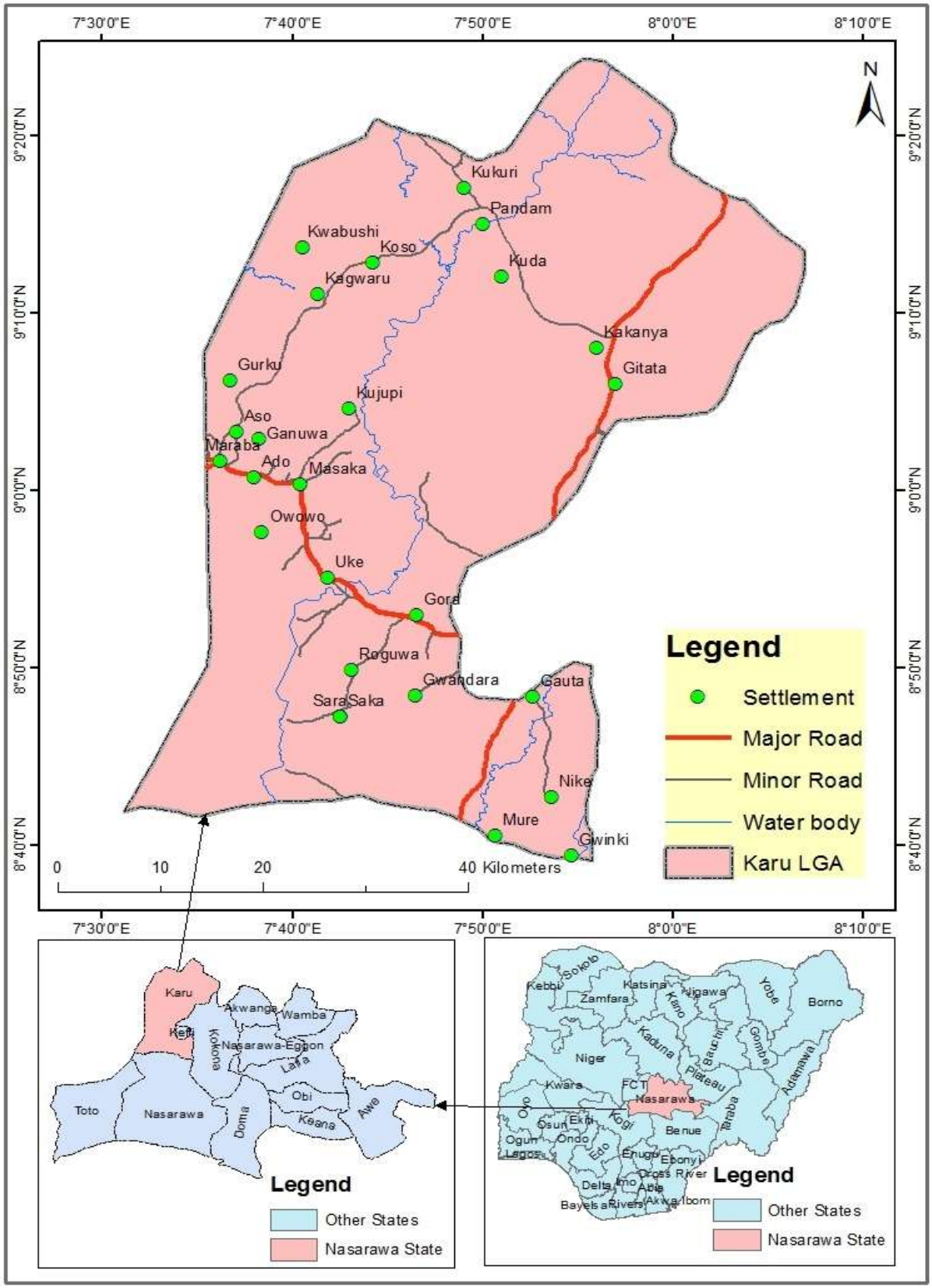

Figure 3.1: The Study Area
Source: Modified from Administrative Map ofKaru Local Government Area (2018).

The variations in the onset of rainfall are attributed to the fluctuations of the boundary between these two air masses. Rainfall is heavy in the southern part of the state and reaches an average of 1000mm per month between April and September. In the extreme north, the monthly average is 500mm. The pattern of temperature and rainfall determines the types of crops, animals and food production. The first rain of the year is usually experienced in the state in March/April and usually falls in thunderstorm showers. The rain reaches its peak in August (Schwedtferger, 2007).

The air temperature varies with season. The highest temperature of 31^{o}C is recorded in April while the minimum are usually recorded during the harmattan season that is between December and January.

3.2.3Soil

The soil in most parts of the state falls under the ferruginous tropical soils. Most of the soils contain 30-40 percent clay at a reasonable depth, because of intensive leaching. The soils in the upland areas are rich in red clay and sand but poor in organic matter. The plains in the state have under gone considerable changes over the years due to combined actions of both physical and chemical weathering (Tomlinson, 1963: Wright and McCurry1970).

3.2.4Vegetation

Karu LGA lies within the northern Guinea Savanna ecological zone (Olaganathan*et al.*, 2014). The vegetation is typically of woodland type and deciduous in character. The dominant tree species include *isoberline, doka, bridelis, terminalia, acacia, vitrex*, among others. Grasses and shrubs occur in tussocks and the predominant family is the *androgenae*.

The state high rainfall, with an average of 1500-2000mm per annum, thereby giving it denser vegetation. However, human occupation and rapid increase in population have had significant impact on the natural vegetation. Efforts have been made by individuals and

government to replenish the destroyed natural vegetation with trees like Mango, Cashew, Guava, Malina among others.

Settlements in Karu like many other settlements around the Federal Capital Territory (FCT) Abuja are experiencing unprecedented and accelerated pace of urban encroachment. The establishment of the FCT in Abuja since 1975 and the proximity of the settlements around the territory brought sudden prosperity to the area and have transformed it from isolated frontier to a vibrant economic region.

3.2.5Population and People

According to the 2006 National Census, KaruLGA has a population of 205,477 people which was projected to 526,331 by 2016 (National Population Commission, 2016).Up to early 1980s the study area remained somewhat a cultural island of the native Gbagis. The opening-up of the area to urban settlement and modern commerce owes its origins to the development of Abuja, the new federal capital. Immigrants from virtually all over Nigeria drawn to the employment or business opportunities created by the growth of Abuja from late 1980s find it convenient to reside in close-by settlements of adjoining states, such as the present study area. It is these immigrants that dominate the urban population of the study area. These include Igbo, Hausa, Yoruba, Tiv, Gbagyi, Koro, Yeskwa, Gwandara and Gade. Other settlers include: Mada, Eggon, Hausa, Fulani, and other Nigerian ethnic groups who migrated to the area to take advantage of its economic potentials (Yari*et al.*, 2001).

3.2.6 Settlements

Karu LGA represents new towns designed to help take off, or reduce the pressure on Abuja in terms of accommodation and shops for building materials. Due to inappropriate planning and poor financing however, the development of these centers has not comes up as expected and this has resulted in the number of environmental problems currently being experienced in the towns, including problems of refuse management, pollution, drainage and

erosion control, crime, poor living environment and haphazard development among others (Marcus and Bimbol, 2007). Settlement pattern are largely nucleated, showing a strangely continuous ribbon appearance along Keffi – Abuja expressway. The major settlements in the area include Mararaba, Masaka, Ado New Karu and New Nyanya some few minutes' drive from the FCT. The settlements stretch in some places over a Kilometer on both sides of the Abuja- Keffi Highway (Yari*et al.,* 2001).

3.3 METHODOLOGY

3.3.1Reconnaissance Survey of the study Area

A reconnaissance survey was carried out to get acquainted with the study area and for the selection of training sites. It was observed during the survey that there was ongoingdevelopment in different parts of the study area as vegetated lands were cleared for the erection of different structures. The knowledge acquired was helpful during the selection of training sites and Visual image interpretation.

3.3.2 Types and Sources of data

The types of data utilized for this study include the following;

- Administrative map of the study area
- Topographic map of the study area at a scale of 1:50000
- Landsat satellite imageries

The administrative map was used to access the boundaries of the study area while topographic map was also used to access the land use and land cover, relief, terrain, drainage etc. of the study area. Landsat 8 was used for 2015 respectively. All Landsat data were collected via the USGS (United State Geological Survey) website as a standard product. The administrative topographic maps of the study area were sourced from the Nasarawa State Ministry of Land and Survey.

The information about the Landsat data that were used for land use and land cover analysis are briefly described in Table 3.1.

Table 3.1: Landsat Data characteristics

Date Acquired	Satellite	Spatial Resolution (m)	Path/Row
17/12/2000	Landsat 7	Bands 1-5,7: 30x30	188/54
13/11/2005	Landsat 7	Bands 1-5,7: 30x30	188/54
13/12/2010	Landsat 7	Bands 1-5,7: 30x30	188/54
19/12/2015	Landsat 8	Bands 2-7: 30x30	188/54

Source: Satellite Imageries Metadata

3.3.3 Data Processing

3.3.3.1 Scan line Correction

All the Satellite images were free from scan lines except that of 2005. The scan lines were corrected using the fill nodata tool in the Raster Analysis extension of Quantum GIS 2.18 software.

3.3.3.2 Layer Stacking

For the purpose of land use and land cover classification and image analysis, it was necessary to produce a colour composite image of the study area. This was done by stacking all the spectral bands of each year together in ArcGIS 10.5

3.3.3.3 Image Subseting

This was carried out using ArcGIS 10.5. The Landsat ETM image was imputed into the GIS environment and the Area of Interest (AOI) was carved out using the coordinates of the study area.

3.3.3.4 Image Classification

Image training is the first and essential step in image classification; it is the process of careful selection of land use classes to be represented in the image. The LULC categories that were identified are: (1) urban or built-up area, (2) vegetated areas (including the forest, farmland, and shrub), (3) water bodies (mainly including rivers and lakes) and (4) Other (bare

land) and (5) rock outcrop. For this study, high resolution satellite imagery from Landsat (USGS) image was utilized in identification of training samples of different land use classes as given above. This was followed by a supervise classification of the training samples. Spectral signature files were generated to be used in supervised classification using a maximum likelihood algorithm. The spectral signatures included image created for each image of each analysis year. LULC maps were produced for each of the 4 years containing all five LULC types in each of the resulting maps.

3.3.4Data Analysis

Objective i: identify and map the LULC types in the study area during the study period

To be able to achieve this objective, the extent of each land use land cover obtained from image classification was computed in Hectares using raster calculator in ArcGIS 10.5

Land cover maps derived from classification of images usually contain some sort of errors due to several factors that range from classification techniques to methods of satellite data capture. Therefore, evaluation of classification results is an important process in the classification procedure. The accuracy assessment was done by generating 500 equal random points for the classified images, using the accuracy assessment tool in Erdas Imagine 9.2. The error matrix was generated using the same accuracy assessment tool in Erdas Imagine 9.2 by comparing the randomly selected pixels with the corresponding referenced data.

Objective ii: determine the extent of LULCC in the study area

In order to evaluate the changes that have taken place from one land use land cover to another, a pair-wise comparison of the LULC output maps as well as their statistical inventories were made. The LULC maps of the study area obtained from image classification for the periods of 2000, 2005, 2010 and 2015 were used for the analysis. The conversion matrix map was generated in ArcGIS 10.5using the ‘combinatorial and’ tool in the spatial analyst extension.

Objective iii: assess the rate of LULCC in the study area

The extent of landuse and landcover change (LULCC) was determined by using quasi-years image differencing techniques. This involves subtracting the LULC of the referenced year from the base year. The formula is as follows.

$E_T = B - A$

Where:

A = LULC extent of base year (2000, 2005 and 2010).

B = LULC extent of referenced year (2005, 2010 and 2015).

The rate of the LULC change was determined summing up the magnitude of change and divide each of the years by the total.

$$Percentage\ change\ (\%\triangle) = \frac{Observed\ change \times 100}{(Base\ year)}$$

To obtain the annual rate of change in LULC, the extent or percentage change is divided by number of study year.

$$Annual\ Rate\ of\ change = \frac{\%\triangle}{No\ of\ Study\ year}$$

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1INTRODUCTION

This chapter present the result of all the analysis carried out in the course of this study. The results obtained form the basis of the data analysis presented here in the form of maps, charts, and statistical tables.

4.2 LANDUSE AND LANDCOVER CLASSES

The LULC classification were generated using ArcGIS 10.5 and the results are shown graphically in Figure 4.1 and LULC statistics are presented in Table 4.1.

Table 4.1: Land Use Land Cover Statistics

NAME	2000		2005		2010		2015	
	Ha	%	Ha	%	Ha	%	Ha	%
Built up	928.7	0.35	1188.6	0.45	2650.5	1.00	4098.8	1.55
Water	139.1	0.05	590.6	0.22	602.7	0.23	285.0	0.11
Vegetation	179187.7	67.87	160840.0	60.92	152895.6	57.91	144764.8	54.83
Bare land	78807.3	29.85	97113.1	36.78	104781.5	39.69	111137.2	42.10
Rock	4951.0	1.88	4281.5	1.62	3083.4	1.17	3727.9	1.41
Total	264013.7	100	264013.7	100	264013.7	100	264013.7	100

Source: ***Authors Analysis, 2018***

Five major landuse and landcover types were identified in the study area (Figure 4.1). These include build up, water bodies, bareland, vegetation,rock. The reduction in the area coverage by Water land cover in 2000 and 2015 was due to the time the Landsat images were acquired asareas that are usually covered by water in the study area were classified as bare land because they were dry.

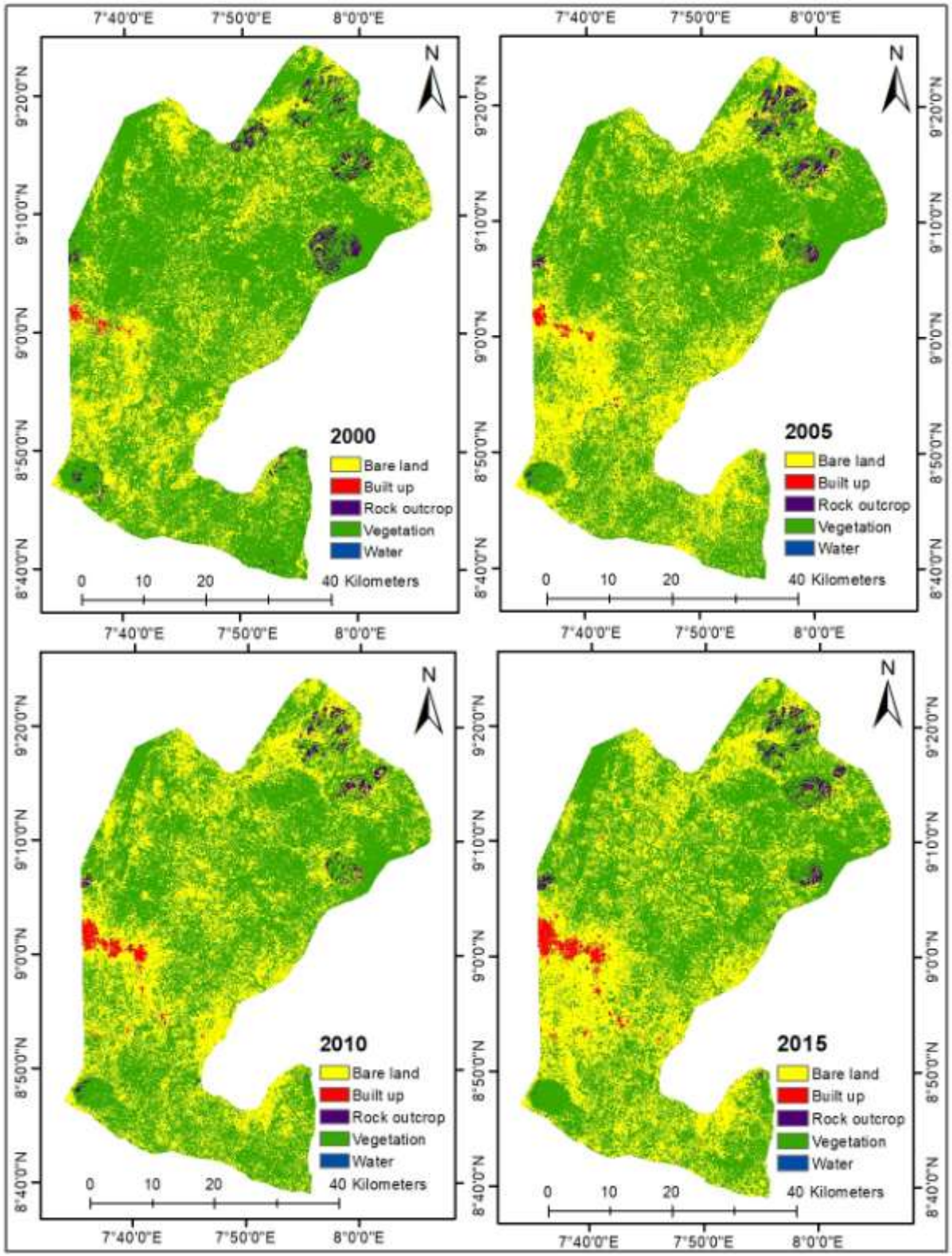

Figure 4.1:Classified LULC Maps of the Study Area
Source: ***Authors GIS Analysis, 2018***

Vegetation shows a progressive decrease in the classification across the years with a corresponding value of approximately 68% (2000), 61% (2005), 58% (2010), and 55% (2015) accordingly. This may not be unconnected to the fact that many areas including farmlands were converted to built-up areas, as the area is witnessing rapid influx of people, and the demand for housing was also high.

Due to the size of the built areas in relation with other land cover features, the percentage coverage of the built areas in the classification scheme are 0.35% (2000), 0.45% (2005), 1% (2010), and 1.55% (2015) respectively.This result is in line with the findings of Ezeomedoand Igbokwe (2013) which revealed that the built-up areas in Onitsha metropolis have been on the increase from 8.12% of the study area in 1964 to 41.64% in 2005 and to 67.62% in 2008

Similarly, Bare land shows a persistent increase from 30% in 2000, 37% in 2005, 40% in 2010 to 42% in 2015. This implies that other land use and land covers have been transformed to bare land in the form of tarred roads, roof tops, pavements etc. However, these change or transformation is not limited to a particular LULC types as bare land for instance could be converted to either build up through road construction as the case may be. Therefore, each class has an equal chance of increasing or decreasing as a result of the increase or decrease arising from any of the land use or land cover types. This is attributed to pavements from tarred roads, building roofs among others.

4.2.1 Accuracy Assessment of Image Classification

Evaluation of classification results is an important process in satellite image classification procedure. This is necessary to ascertain the level of correctness and reliability of the classification output. Kappa statistics/index which provides a more rigorous assessment of classification accuracy was also computed for each classified map. The Kappa coefficient expresses the proportionate reduction in error generated by a classification process compared

with the error of a completely random classification. Table 4.2, 4.3, 4.4 and 4.5 show the accuracy assessment of 2000, 2005, 2010 and 2015 image classification results respectively.

4.2.1.1 Accuracy assessment of image classification Landsat TM (2000)

Table 4.2: Error matrix of 2000 Image Classification

	Built up	Water	Vegetation	Bare land	Rock outcrop	Producer's Accuracy	User's Accuracy
Built up	85	12	0	3	0	85%	83%
Water	3	93	4	0	0	93%	81%
Vegetation	1	3	85	3	8	85%	89%
Bare land	8	3	0	88	1	88%	80%
Rock outcrop	0	0	8	3	89	89%	82%
Total	97	111	97	97	98		
Overall Classification Accuracy = 88%							
Overall Kappa Statistics = 0.85							

Source: Author's GIS analysis (2018)

Landsat TM image 2000 was classified into 5LULC categories. Built up and vegetation were classified with lower producer's accuracy (85%) than other classes. This is as a result of errors particularly mixing with bare land and water. Water, rock outcrop and bare land were classified with higher producer's accuracy of 93%, 89% and 88% respectively. The overall classification accuracy of the image was 88% while the overall Kappa coefficient was 0.85

4.2.1.2 Accuracy assessment of image classification Landsat ETM. (2005)

Table 4.3: Error matrix of 2005 Image Classification

	Built up	Water	Vegetation	Bare land	Rock outcrop	Producer's accuracy	User's accuracy
Built up	83	12	2	3	0	81%	83%
Water	9	84	3	4	0	82%	84%
Vegetation	1	0	89	3	7	81%	89%
Bare land	9	7	2	81	1	85%	81%
Rock outcrop	0	0	14	4	82	91%	82%
Total	102	103	110	95	90		
Overall Classification Accuracy = 84%							
Overall Kappa Statistics = 0.81							

Source: Author's GIS analysis (2018)

Landsat ETM image (2005) was also classified into 5 LULC classes with built up and vegetation having the same producer's accuracy of 81% while rock outcrop, bare land and water have 91%, 85% and 82% respectively. The overall classification accuracy was much better (84%) and the overall Kappa coefficient was 0.81

4.2.1.3 Accuracy Assessment of Image ClassificationLandsat ETM (2010)

Table 4.4: Error matrix of 2010 Image Classification

	Built up	**Water**	**Vegetation**	**Bare land**	**Rock outcrop**	**Producer's accuracy**	**User's accuracy**
Built up	87	6	2	5	0	91%	87%
Water	5	83	7	4	1	85%	83%
Vegetation	1	5	84	4	6	79%	84%
Bare land	3	4	3	89	1	82%	89%
Rock outcrop	0	0	10	6	84	91%	84%
Total	96	98	106	108	92		
Overall Classification Accuracy = 85%							
Overall Kappa Statistics = 0.82							

Source: Author's GIS analysis (2018)

In the classification of Landsat ETM(2010), the producer's accuracy of vegetation (79%) was lower than other classes. This is as a result of error due to omission and misclassification to rock outcrop, bare land, vegetation and built up. Higher producer's accuracy of about 91% was also observed for built up and rock outcrop. The overall classification accuracy was 85% while the Kappa coefficient was 0.82.

4.2.1.4 Accuracy Assessment of Image Classification Landsat 8 OLI (2015)

Table 4.5: Error matrix of 2015 Image Classification

	Built up	Water	Vegetation	Bare land	Rock outcrop	Producer's accuracy	User's accuracy
Built up	91	5	0	4	0	91%	91%
Water	3	86	7	3	1	84%	86%
Vegetation	1	7	81	5	6	81%	81%
Bare land	5	2	3	90	0	91%	90%
Rock outcrop	0	2	9	6	83	92%	83%
Total	100	102	100	108	90		
Overall Classification Accuracy = 86%							
Overall Kappa Statistics =0.83							

Source: Author's GIS analysis (2018)

The accuracy assessment of image classification of Landsat8_OLI image (2015) of the study area reveal that the producer's accuracy of vegetation (81%) was the lowest. This is due to error of omission and misclassification to water, rock outcrop bare land and built up. Rock outcrop has the highest producer's accuracy of 92%, built and bare land have the same producer's accuracy (91%) while water has 84%.The overall classification accuracy was 86% while the Kappa coefficient was 0.83.

4.3EXTENT OF LANDUSE AND LANDCOVER CHANGES

The ArcGIS 10.5 Tabulate Intersection tool was use to generate the land use land cover change matrix for 2000-2005, 2000-2010, 2000-2015, 2005-2010, 2005-2015 and 2010-2015.The results are presented in Table 4.2. To generate a graphical representation of the land use and land cover change matrix, the ArcGIS 10.5 'Combinatorial And' tool in the spatial analyst extension was used and the results are presented in Figure 4.2 to 4.7.

Table 4.6: Land Use and Cover Change Matrix

Land use/Land cover		2000-2005		2000-2010		2000-2015		2005-2010		2005-2015		2010-2015	
From	**To**	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Bare land	**Bare land**	47469.5	60.2	45181.5	57.3	45648.2	57.9	64343.0	66.3	61777.5	63.6	69511.8	66.3
Bare land	**Built up**	508.5	0.6	1517.4	1.9	2481.3	3.1	1571.8	1.6	2829.7	2.9	1588.4	1.5
Bare land	**Rock outcrop**	867.8	1.1	558.9	0.7	825.6	1.0	309.1	0.3	682.4	0.7	1067.4	1.0
Bare land	**Vegetation**	29734.3	37.7	31311.1	39.7	29730.7	37.7	30706.0	31.6	31734.5	32.7	32517.6	31.0
Bare land	**Water**	227.3	0.3	238.4	0.3	121.6	0.2	183.1	0.2	88.9	0.1	96.3	0.1
Built up	**Bare land**	316.7	34.1	130.8	14.1	106.8	11.5	136.2	11.5	114.6	9.6	222.4	8.4
Built up	**Built up**	601.6	64.8	790.2	85.1	815.5	87.8	1034.4	87.0	1056.5	88.9	2421.1	91.3
Built up	**Rock outcrop**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Built up	**Vegetation**	5.0	0.5	4.0	0.4	4.7	0.5	9.3	0.8	10.0	0.8	5.7	0.2
Built up	**Water**	5.3	0.6	3.8	0.4	1.7	0.2	8.8	0.7	7.6	0.6	1.4	0.1
Rock outcrop	**Bare land**	1544.5	31.2	1865.7	37.7	1468.2	29.7	1220.6	28.5	822.9	19.2	385.4	12.5
Rock outcrop	**Built up**	1.3	0.0	1.6	0.0	3.4	0.1	0.3	0.0	0.4	0.0	0.1	0.0
Rock outcrop	**Rock outcrop**	1970.5	39.8	1594.1	32.2	1755.1	35.4	2485.8	58.1	2730.8	63.8	2290.1	74.3
Rock outcrop	**Vegetation**	1427.0	28.8	1485.8	30.0	1724.1	34.8	555.9	13.0	726.5	17.0	406.7	13.2
Rock outcrop	**Water**	7.7	0.2	3.8	0.1	0.2	0.0	18.9	0.4	1.0	0.0	1.2	0.0
Vegetation	**Bare land**	47718.6	26.6	57555.3	32.1	63854.2	35.6	38848.1	24.2	48199.5	30.0	40787.1	26.7
Vegetation	**Built up**	76.4	0.0	336.2	0.2	794.2	0.4	36.8	0.0	178.7	0.1	69.5	0.0
Vegetation	**Rock outcrop**	1441.6	0.8	930.3	0.5	1147.2	0.6	278.4	0.2	307.4	0.2	365.6	0.2
Vegetation	**Vegetation**	129656.3	72.4	120074.0	67.0	113279.9	63.2	121577.6	75.6	112126.5	69.7	111657.1	73.0
Vegetation	**Water**	294.7	0.2	292.0	0.2	112.1	0.1	99.2	0.1	28.0	0.0	16.3	0.0
Water	**Bare land**	63.7	45.8	48.2	34.7	59.9	43.0	233.7	39.6	222.4	37.7	230.6	38.3
Water	**Built up**	0.8	0.6	5.1	3.7	4.4	3.2	7.3	1.2	33.9	5.7	19.7	3.3
Water	**Rock outcrop**	1.6	1.2	0.1	0.1	0.0	0.0	10.0	1.7	7.4	1.2	4.9	0.8
Water	**Vegetation**	17.3	12.4	20.8	15.0	25.4	18.3	46.8	7.9	167.3	28.3	177.7	29.5
Water	**Water**	55.6	40.0	64.8	46.6	49.4	35.5	292.8	49.6	159.6	27.0	169.9	28.2
Total		264013.7	500	264013.7	500	264013.7	500	264013.7	500	264013.7	500	264013.7	500

Source: ***Authors Analysis, 2018***

During the study period between 2000 and 2015 about 189733.5hectares (62%) of the study area landscape remained unchanged. This implies that 38% of the total landscape of the study area was converted from one land use land cover type (LULC) to the other. The level of conversion varies amidst the LULC types. Bare land was mainly converted to vegetation, rock outcrop and vegetation were predominantly changed to vegetation and bare land respectively.

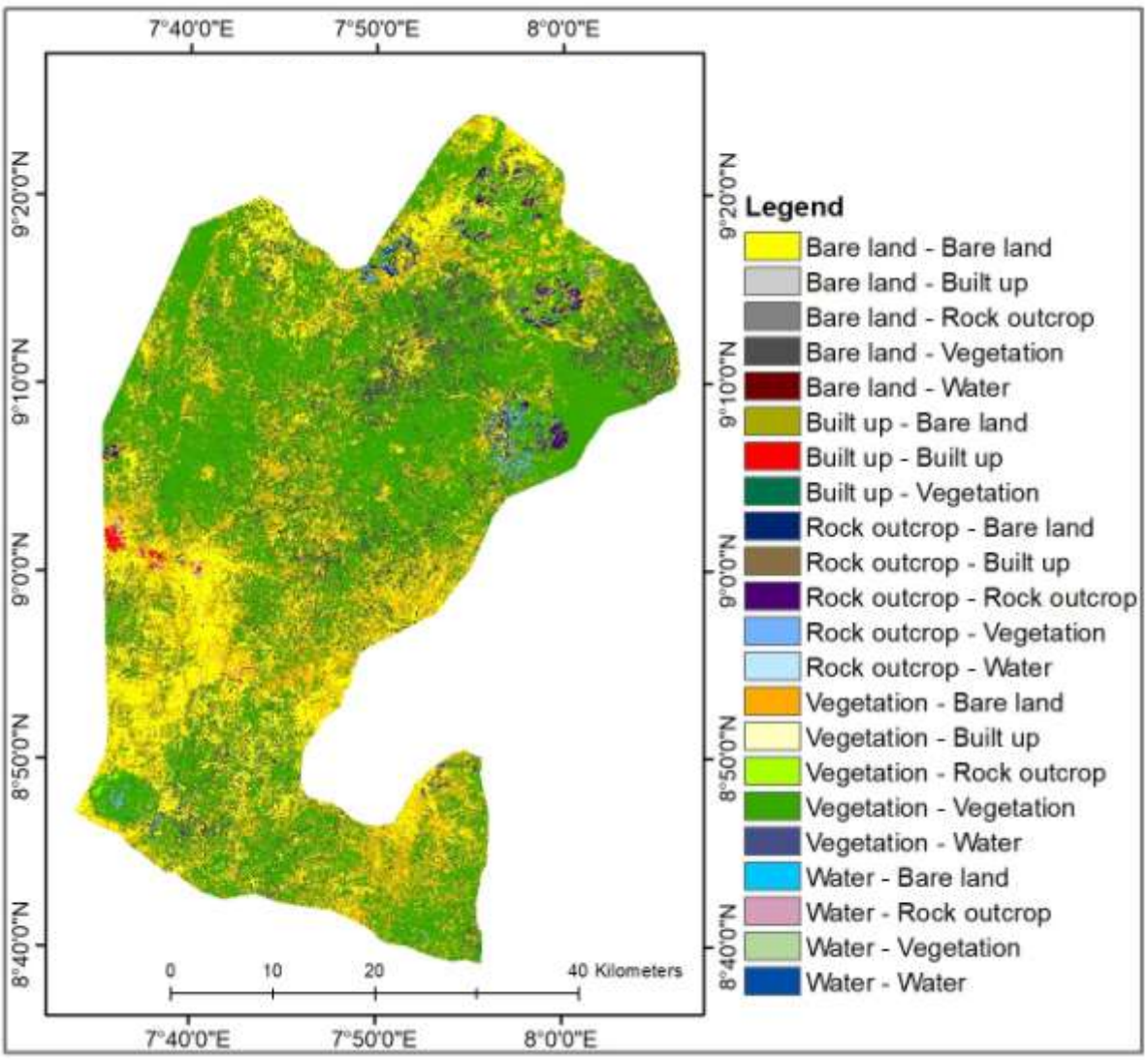

Figure 4.2: Land Use and Land Cover Change matrix for 2000 and 2005
Source: ***Authors Analysis, 2018***

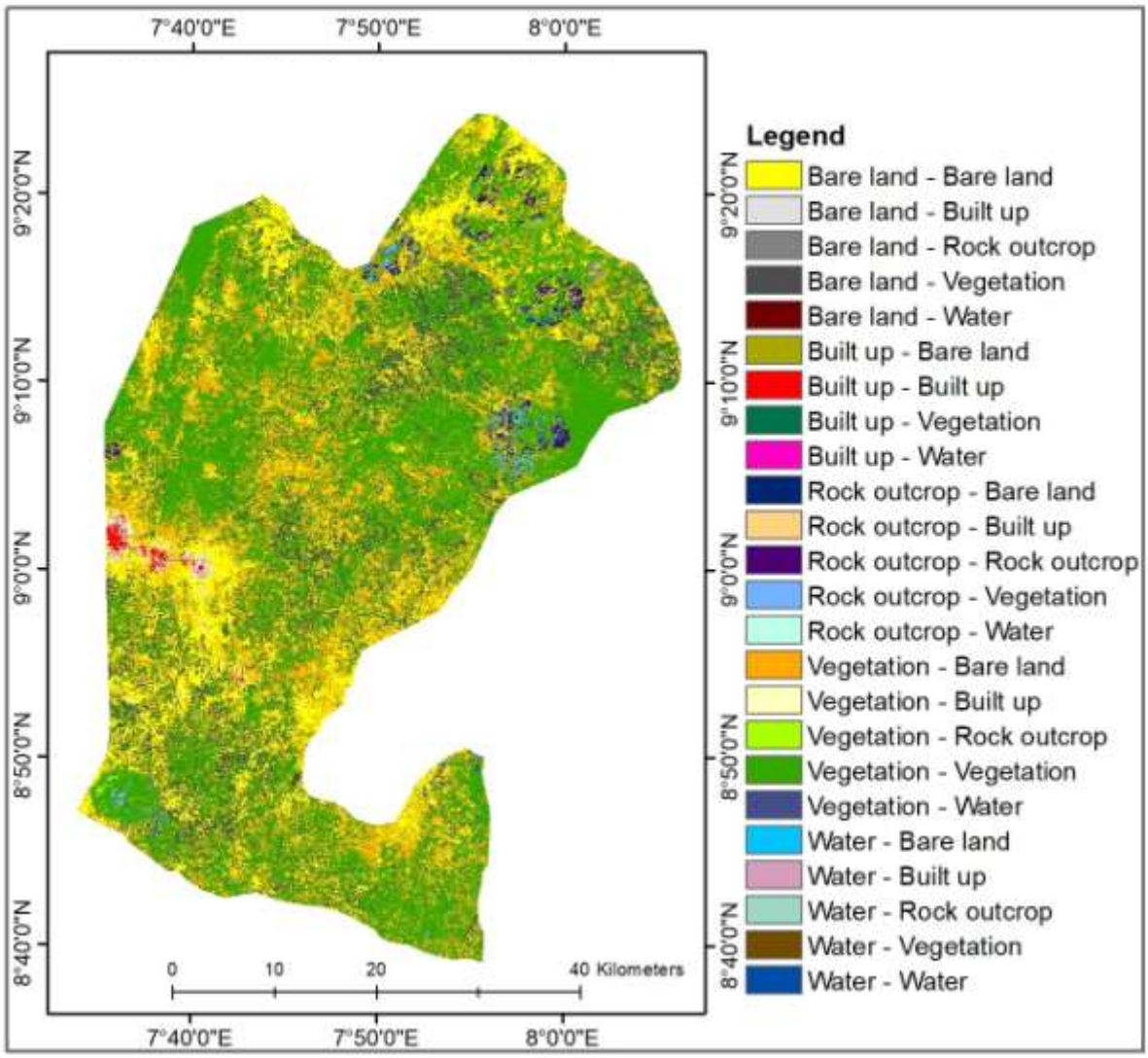

Figure 4.3: Land Use and Land Cover Change matrix for 2000 and 2010
Source: ***Authors Analysis, 2018***

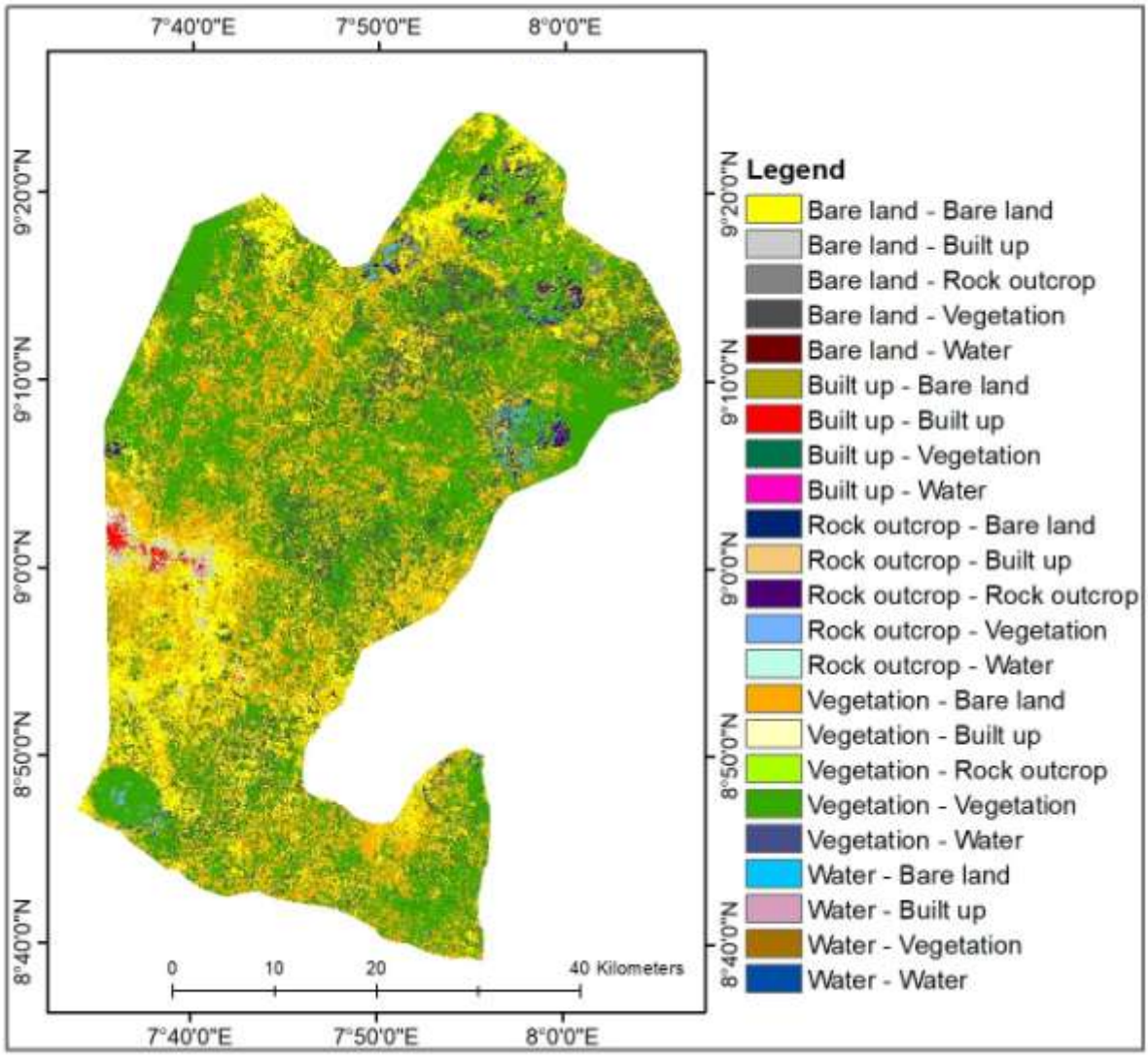

Figure 4.4: Land Use and Land Cover Change matrix for 2000 and 2015
Source: ***Authors Analysis, 2018***

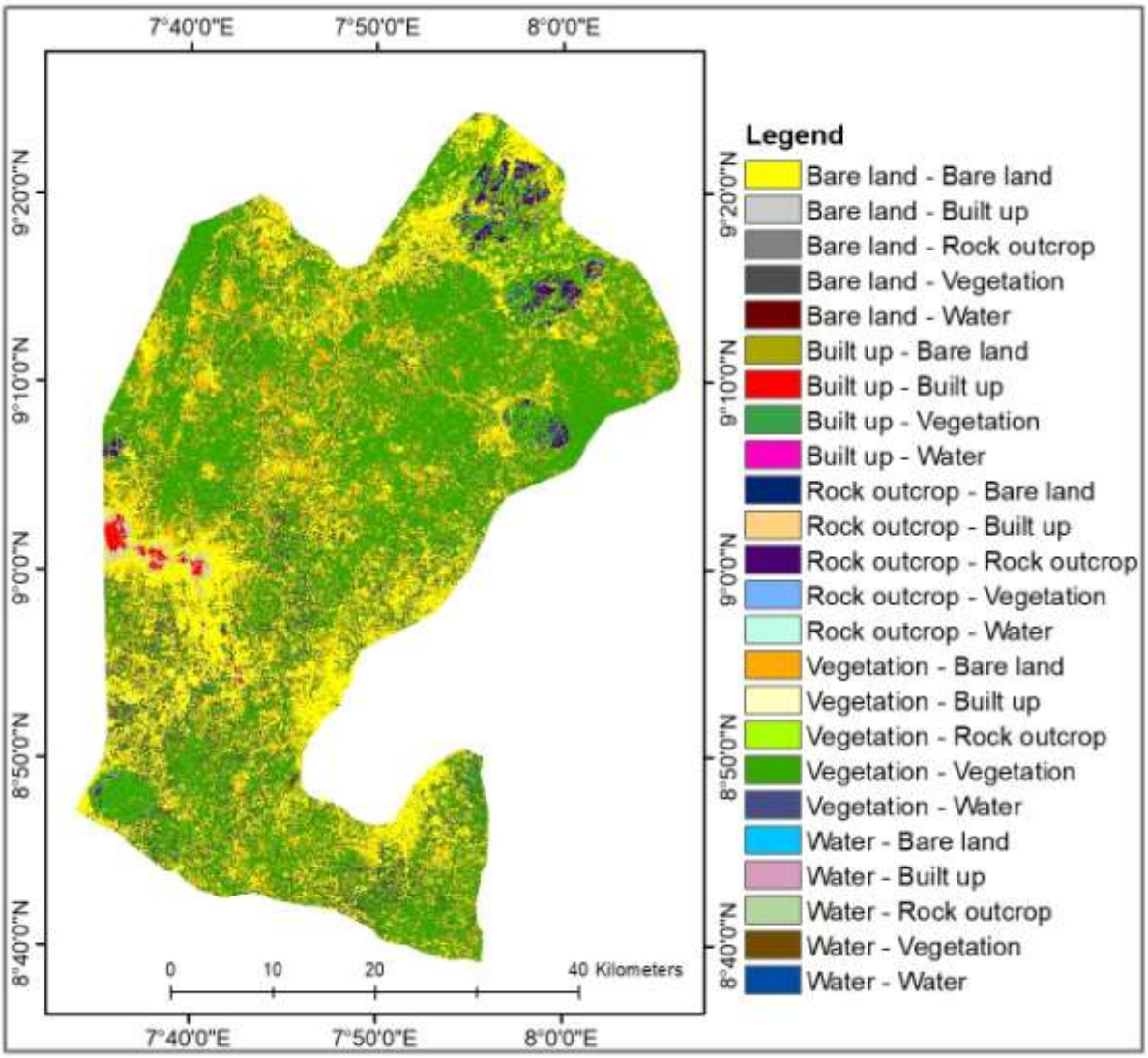

Figure 4.5: Land Use and Land Cover Change matrix for 2005 and 2010
Source: ***Authors Analysis, 2018***

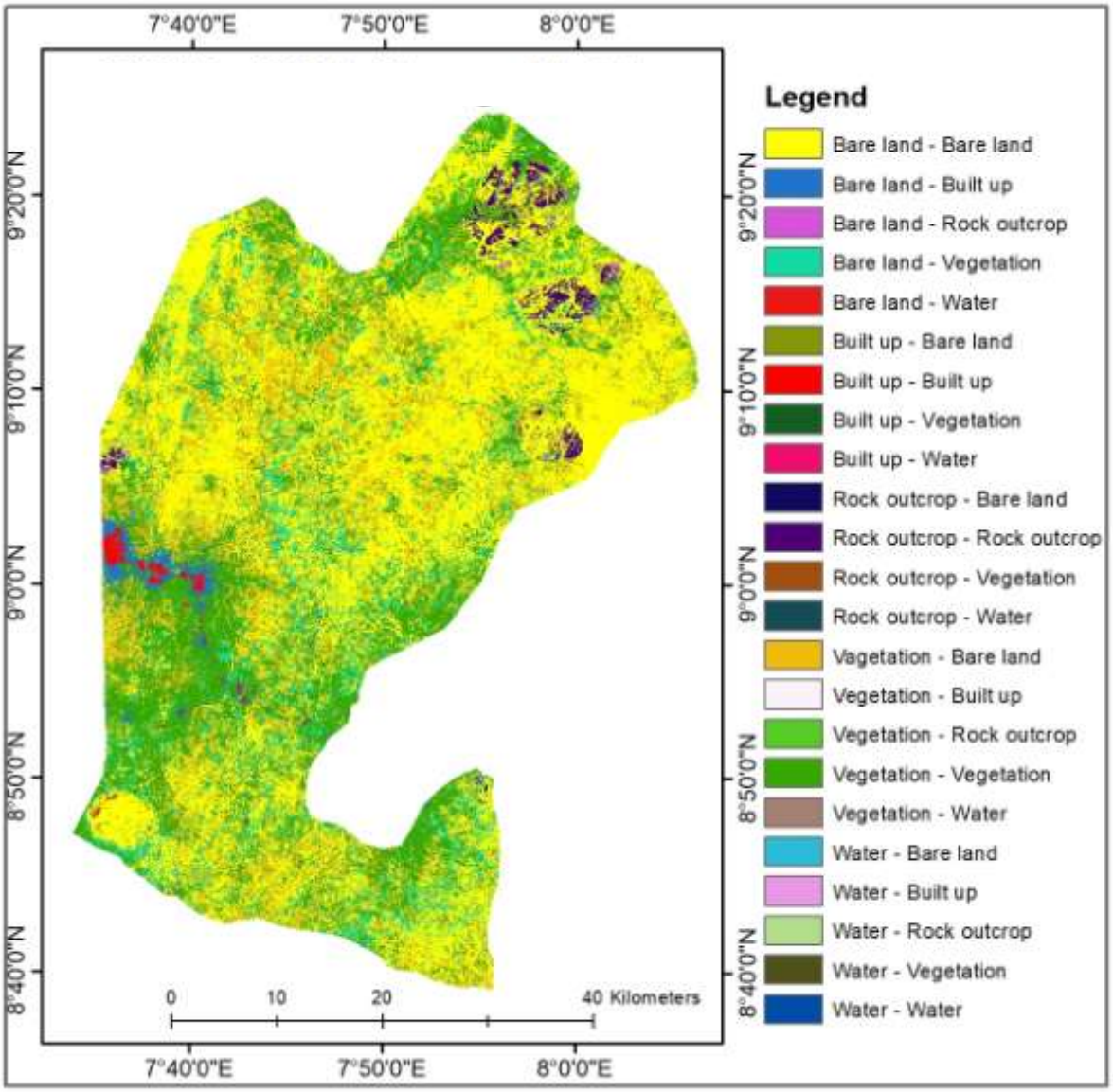

Figure 4.6: Land Use and Land Cover Change matrix for 2005 and 2010
Source: ***Authors Analysis, 2018***

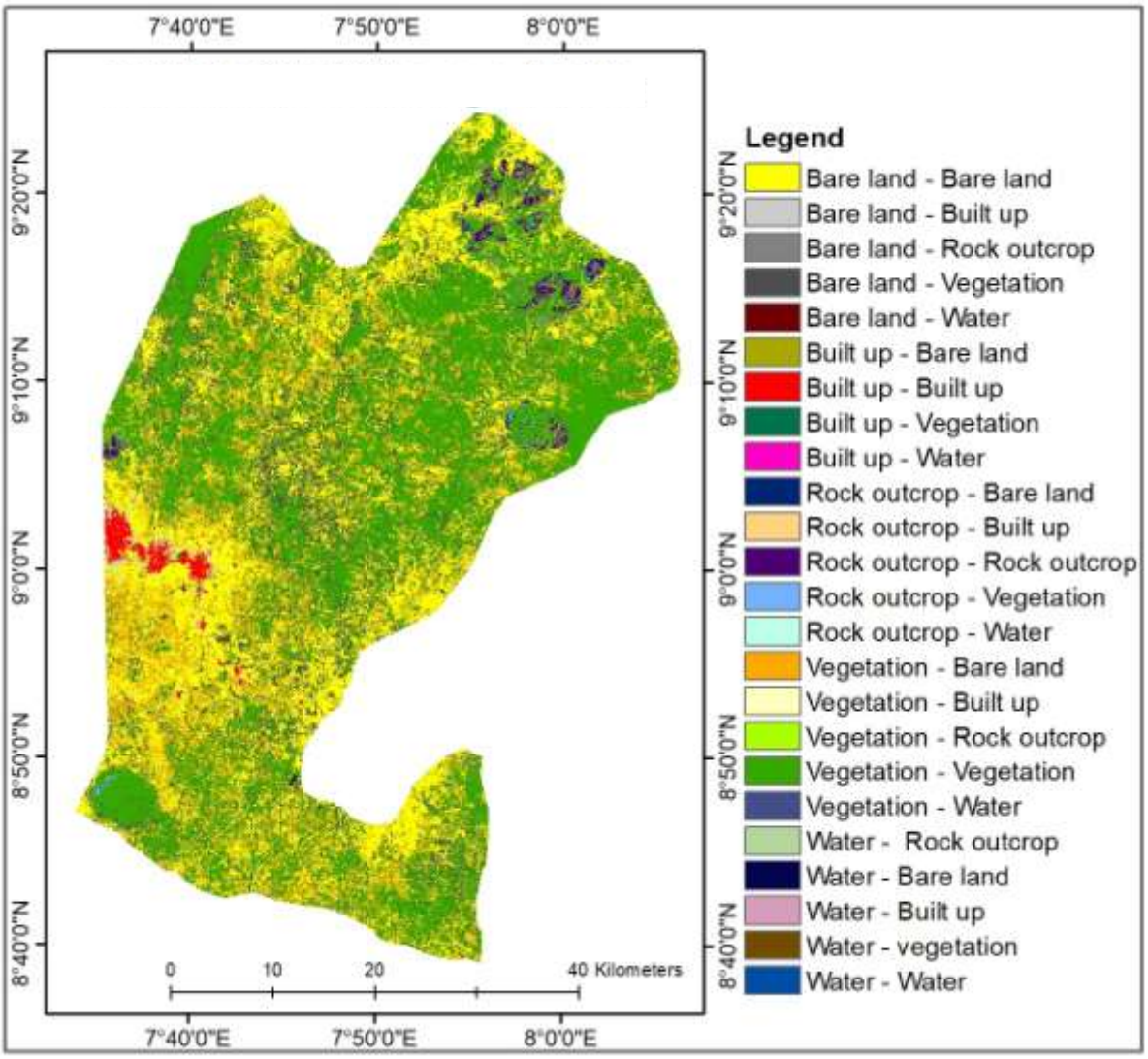

Figure 4.7: Land Use and Land Cover Change matrix for 2005 and 2015
Source: ***Authors Analysis, 2018***

4.4RATE OF LANDUSE AND LANDCOVER CHANGE IN KARU LGA

The annual magnitude and rate of change of the various land use and land cover types between 2000 and 2015in the study area were calculatedand the results are presented in Table 4.3.

Table 4.7: Annual Magnitude and Rate of LULCfrom 2000 to 2015.

	Magnitude	**Rate**
Class Name	Ha	%
Built up	211.3	22.8
Water	9.7	7
Vegetation	-2294.9	-1.3
Bare land	2155.3	2.7
Rock outcrop	-81.5	-1.6

Source: Authors Analysis 2018

The results of the analysis revealed that from 2000 to 2015 built up was increasing at an annual rate of 22.8% (211.3 Ha). This is an indication that there was an accelerated urban development in study area during the study period. From 2000 to 2015 water increased at an annual rate of 7%. From 2000 to 2015, vegetation was decreasing at the rate of 1.3% (2294.9Ha). The reduction in vegetation in the study area could be as a result of increase in construction activities such as road and buildings for residential, commercial and industrial purposes.From 2000 to 2015 bare land was growing at the rate of 2.7% (2155.3Ha). This could be as a result of increase in agricultural activities and urban development. From 2000 to 2015rock outcrop depreciated at an annual rate of 1.6%.

This implies that bare surfaces and built up are the land coversthat are significantlyincreasing while vegetation is the single land cover that is rapidly depleting in the study area. Bareground also indicated a persistent increased landuse see.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1INTRODUCTION

This chapter presents the findings, conclusion and recommendation of this research. Key implications are discussed.

5.2SUMMARY OF FINDINGS

This study examined the land use and land cover (LULC) changes in Karu Local Government Area of Nasarawa State. Landsat data of 2000, 2005, 2010 and 2015 were utilized for this study. Land use and land cover mapping of the study area was conducted using maximum likelihood classification and five (5) land use and land cover were identified. In addition, land use and land cover change matrix and the annual rate of land use and land cover growth for the study periods were calculated. The results of the land use and land cover classification revealed that built up increased from 928.7Ha in 2000 to 4098.8Ha in 2015 while vegetation decreased from 179187.7Ha in 2000 to 144764.8Ha in 2015. The LULC change matrix revealed that from 2000to 2015 about 161287.8Ha(61.1%) of the study area remained unchanged. From 2000 to 2015 built up was growing at an annual rate of 22.8% while vegetation decreasing at an annual rate of 1.3%.

5.3 CONCLUSION

This study demonstrates the importance of integrating remote sensing and GIS technologies for effective urban monitoring and encroachment of vegetation cover particularly in Mararaba, Karu Local Government area of Nasarawa State.From the results of this analysis it can be concluded that there is rapid urban development in the study area which maybe responsible for the reduction in vegetation in the study area. People's perception about the urban growth has been greatly tied to proximity to the federal capital city, Abuja, rural urban migration, job search, better standard of living and cheap accommodation.

5.4RECOMMENDATION

Based on the findings of this study, it is certain that one of the major causes of LULC in the study area is the influx of people into the area in search of cheaper accommodations, and its proximity to the federal capital city. Moreover, the lack of development control in the organization of the city has accounted for the unplanned nature, and a host of social vices. On this account and others, the studyrecommends the following.

- There is a need for state agencies particularly Nasarawa urban development board, and the Nasarawa Urban Development Board to rise up to its statutory responsibilities by developing strategies towards meeting the demand for urban infrastructures and service, and also to provide plans for continuous operations.
- As urban growth is a spatial phenomenon and on-going, sustainable plan should be put in place to accommodate issues surrounding crowdedness, and over-burden on public infrastructure, this could help improve the quality of life of people living in the study area.
- A study of this nature should be carried out in other LGAs facing similar challenges so as to alleviate and if possible eradicate the problems associated with urban expansion.

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