LAND USE LAND COVER CHANGES IN DUTSE (1986-2014), JIGAWA STATE, NIGERIA

BY

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA IN PARTIAL FULFILLMENT FOR THE REQUIREMENT OF THE AWARD OF MASTER OF SCIENCE DEGREE IN REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

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DECLARATION

I declare that the work in the dissertation entitled "***Land Use Land Cover Changes in Dutse (1986-2014), Jigawa State, Nigeria***" has been performed by me in the Department of Geography under the supervision of Dr. B. Akpu and Dr. I.I. Abbas. The information derived from the literature has been duly acknowledged in the text and list of references provided. No part of this dissertation was previously presented for another degree or diploma at any university.

Zangina Aminu Sulaiman --------------------------- --------------------------

Signature ***Date***

CERTIFICATION

This dissertation entitled "**LAND USE LAND COVER CHANGES IN DUTSE (1986-2014), JIGAWA STATE, NIGERIA**" by Zangina, Aminu Sulaiman meets the regulations governing the award of the degree of master of Remote Sensing and Geographic Information System, Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

Dr. B. Akpu Chairman, Supervisory Committee	-------------------------- Signature	-------------------- Date
Dr. I.I. Abbas Member, Supervisory Committee	----------------------------- Signature	--------------------- Date
Dr. I.J. Musa Head of Department	--------------------------- Signature	---------------------- Date
Prof. Kabiru Bala Dean, Postgraduate School	-------------------------- Signature	----------------------- Date

DEDICATION

This dissertation is dedicated to my mother Hajiya Hadiza M. Zangina and my brother Alhaji Suleiman Zangina for their remarkable interest in education.

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ABSTRACT

The purpose of this research is to analyse Land Use/Cover Changes in Dutse, Jigawa State, Nigeria. The following objectives of the study were achieved, which are to; establish the extent of land use/land cover coverage in the area in 1986, 2000 and 2014, determine the rate and magnitude of land use/land cover changes in the area between 1986-2000, 2000-2014 and 1986-2014, and analyze the extent to which urban growth influences land use/land cover changes in the area. Landsat TM and ETM^+ satellite imageries of 1986, 2000 and 2014 were used respectively. The imageries were processed using ERDAS IMAGINE 9.2 software. A supervised classification approach using maximum likelihood classifier and Transition Change Analysis were carried out using IDRISSI 17.0 Selva Edition version. Results from the analysis revealed changes in land use/cover categories between 1986 and 2014. Built up area was 20.4% in 1986 and increased to 28.4% in 2000. Further increase was witnessed in built up area to about 38.2% in 2014. Cultivated land was 29.0% in 1986 and to about 31.0% in 2000, but a decrease was observed to about 26.2% in 2014. It further revealed that bare surfaces was 23.3% in 1986 and decreased to about 18.8% in 2000. A slight increase in bare surfaces was witnessed to about 20.0% in 2014. While other land use land cover categories decreased or slightly increased over the study period. The most dramatic increase experienced in built-up area is shown from 2000 to 2014. The results further revealed that about 7.2% bare surfaces changed into built-up from 1986-2014. About 14.8% of cultivated land changed into built-up from 1986-2014. Vegetation witnessed a remarkable changed into built-up of about 4.5% from 1986-2014. It was concluded from the study that there are various transformations in land use land cover of the area during the study period. There is need for Jigawa State Government to equip the planning authorities and other ministries involved in decision making with adequate spatial data to ensure broad based decisions. Land use suitability analysis of the study area is also recommended.

CHAPTER ONE

INTRODUCTION

1.1: BACKGROUND TO THE STUDY

Land is about the most important natural resources on which all activities are based. Though, humans have been modifying land to obtain food and other essentials for thousands of years, current rates, extents and intensities of land use and land cover change (LULCC) are far greater than ever in history, driving unprecedented changes in ecosystems and environmental processes at local, regional and global scales (Ejaro and Abdullahi, 2013).

Land use land cover changes (LULCC) with its impacts on the environment has been one of the increasing focuses of global changes (Oladele and Oladimeji, 2011). In the past two centuries the impact of human activities on the land has grown enormously, altering the entire landscapes, and ultimately impacting the earth's nutrient and hydrological cycles as well as climate (De Sherbin, 2002). The advancement in the concept of environmental mapping has greatly increased research on land use land cover change thus providing an accurate evaluation of the spread and health of the world's forest, grassland, agricultural resources and urban development and this has become an important research priority (Oladele and Oladimeji, 2011).

Meyer (1995) asserted that every parcel of land on the Earth's surface is unique in the cover it possesses. Land use and land cover are two distinct yet closely linked characteristics of the Earth's surface. The use to which land is put could be grazing, agriculture, urban development, logging, and mining among many others. While land cover categories could be cropland, forest, wetland, pasture, roads, 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 (Meyer, 1995).

Land-use and land-cover change, as one of the main driving forces of global environmental change, is central to the sustainable development debate (Rimal, 2011). Land use and land cover change is perhaps the most pronounced form of global environmental changes since it occurs at spatial and temporal scales and is very relevant to our daily existence. The changes in land use and land cover are likely to affect natural resources and ecosystems as well as urban human activities in complex ways (Oladele and Oladimeji, 2011).

Land use and land cover change has been reviewed from different perspectives in order to identify the drivers, their process and consequences (Rimal, 2011). More so, the change in land cover occurs even in the absence of human activities through natural processes, whereas land use change is the manipulation of land cover by human being for multiple purposes- food, fuelwood, timber, fodder, leaf, litter, medicine, raw materials and recreation. The increase in population and human activities are increasing the demand on the limited land and soil resources for agriculture, forest, pasture, urban and industrial land uses (Rimal, 2011). Information on the rate and kind of changes in the use of land resources is essential for proper planning and management. In addition, land use information are needed in the analysis of environmental processes and problems that must be understood if living conditions and standards are to be improved or maintained at current level (Sreenivasulus and Bhaskar, 2010).

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 (Meyer, 1995). Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. Land cover can be altered by forces other than anthropogenic (Primack, 2006). Natural events such as weather, flooding, fire, climate fluctuations, and ecosystem dynamics may also initiate modifications upon land cover (Ravenga *et al*., 2000). Globally, land cover today is altered principally by direct human use: by agriculture and livestock raising, wood harvesting and management and urban and suburban construction and development (Zubair, 2006).

Land use land cover (LULC) changes in tropical regions are of major concern due to the widespread and rapid changes in the distribution and characteristics of tropical forests (Myers 1993; Houghton, 1994). However, changes in land cover and in the way people use the land have become recognized over the last 15 years as important global environmental changes in their own right (Turner, 2002).

It is obvious with most developing cities, poor land management has often bedeviled land use planning with adverse consequences. Ejaro and Abdullahi (2013) asserted that the major consequences of the globally recognized rapid land use and land cover changes are; land degradation, agricultural yield depletion, loss of biodiversity and ecosystem functioning. They further stressed that due to poorly planned human interference, many Africa countries have experienced untold environmental degradation and ecological deterioration in the past century, with little or no real solution to alleviate many of these concerns.

Adesina (2005) reported that land use/land cover change occurs when people cut forests, woodlands and shrublands for myriad of purposess at a pace exceeding the rate of natural regrowth. This phenomenon is significant in three countries in Africa which include Ghana, Nigeria and South Africa. This ascertain the fact that, due to human activities a great change in land use/land cover is experienced. This might not be different in Dutse.

With Remote Sensing technology, data can be truly secured in an effective scale (Dwivedi & Screenivas, 1998). The strength of remote sensing with its synoptic overview allows independent, fast, up-to-date and relatively cost effective transformation of data (images) into information (Fouad, 2003). Thus, for measuring, analyzing and understanding the urban context, the dynamic interrelations and its permanent changes, spatial, spectral, and temporal information is crucial (Rao and Venkataratnam, 1991; Dwivedi, 1992; Singh, 1994). Remotely sensed data are inherently suited to provide information on land cover characteristics and their changes over time, at various spatial and temporal scales (Ahmed, 2011). The rapid development of Geographic Information Systems (GIS) and its successful application in studying land use land cover is well known and most impressive, especially in support of urban and regional planning and design (Holmberg, 1994). The huge capabilities of these systems to manipulate, analyse and display spatial data, for many complex land use planning problems is now apparent. GIS can be a powerful tool for understanding and managing the results of land use land cover changes. Hence, the need for this study to use geospatial analysis is very much appreciated particularly in Dutse, Jigawa State.

1.2: STATEMENT OF THE RESEARCH PROBLEM

The human pressure on natural ecosystems and protected areas is steadily increasing. Land use is considerably a local environmental issue, but in recent times is becoming a force of global significance. Globally, changes into forest, waterways, air and farmlands are being driven by the need to provide food, water, shelter and fibre to more than six billion people (Foley, De Fries, Asner and Barford, 2005).

The conversion of open lands to urban uses is not new. What is different today is the rapid rate of conversion (Boyce and Martin, 1993). In recent times, cities and towns in developing countries have been observed to be experiencing unprecedented change in both function and areal coverage (Olawole, Msimanga, Adegboyega and Adesina, 2011).

The changes in urban areas leads to various population pressures, climatic variability, and fragmentation of tenure and traditional systems, contribute to changes in land use/land cover. It also, leads to diminishing of yields and worsening food insecurity in rural areas mostly at the fringe of the rapidly growing urban settlements due to the conversion of arable land into built-up environment to incorporate growing residential and industrial estates (Vernon, 2002; UN-Habitat, 2003; Ifatimehin & Ufuah, 2007).

However, the effects of land use land cover changes (LULCC) at the local or micro scale can be more problematic when related to land degradation issues such as run-off water quality due to sediment and pollution, soil wash and subsequent loss of soil fertility, surface run-off and flooding in addition to loss of environmental resources such as vegetation used directly by the poor (Ndabula *et al*., 2013). Common understanding of causes of LULCC is dominated by simplifications which blame LULCC on population and poverty growth, but recent observations showed that human responses to economic opportunities as mediated by institutional factors are the actual drivers of LULCC (Wang, 2010).

For example, Adesina *et al*. (1999) report that 400,000 hectares of vegetation cover is lost annually in Nigeria, most of which is deliberately removed to make way for mineral exploitation, development of infrastructure such as roads and railway as well as expansion of settlements. The loss of natural vegetation has great implications such as destruction of wildlife habitat, depreciation or outright wiping off of genetic pool, loss of food and medicinal herbs and promotion of desertification and drought among others, and building up of greenhouse gasses (Adesina, 2005).

Olawole *et al*. (2011) applied remote sensing and GIS techniques in monitoring and assessing urban encroachment into agricultural land in Harare province, Zimbabwe, between 1976 and 2000. The study revealed that between 1976 and 1989 built-up area gained 10,086 hectares increasing from 18.78 % to 24.13 % while 8,072 hectares of forest cover was degraded reducing its areal extent to 18.83 % from 23.11 %. By 2000 the built-up aerial extent increased from 24.13 % in 1989 to 30.58% in 2000. Farm land lost 2,547 hectares (1.38%) of land under cultivation between 1976 and 2000. Water bodies gained 184 hectares, an increase of 0.10%, from 0.75 % in 1989 to 0.85 % in 2000.

Ishaya, Ifatimehin and Okafor (2008) used Landsat TM and ETM^+ to measure the rate of urban expansion and loss of vegetation cover in Kaduna town between 1990 and 2000. The study revealed that built-up area was expanding at about 167.86 hectares annually while vegetation cover was declining at a faster rate of 297.5 hectares annually. It also revealed that bare land a component of urban expansion also increased to about 183.5% While other land uses decreased within the study period such as Range land (-794.9%), Forest Land (-406.3%) and River and Water body (-336.6%).

Ifatimehin and Ufuah (2007) used Landsat TM and NigeriaSat1 to measure the rate of urban expansion and loss of vegetation in Lokoja between 1987 and 2005. The results revealed that the built-up area and other land use types which are components of urban expansion such as bare land increased at the expense of other land use/land cover. The annual rate of urban expansion was about 187.8 hectares.

Dutse town is the administrative Headquarters of Jigawa State created in 1991 from the old Kano State. Like any other state capital, Dutse is experiencing a spatial growth which leads to changes in other land use/cover of the area. Aliyu (2005) in assessment of land use changes in Dutse between 1976 and 2000 revealed that there was vegetation loss of about 37% between 1976 and 2000 while there was loss of agricultural land of about 7% within the said period. The research focused mainly on changes in vegetation and agricultural land.

Based on the researcher’s knowledge no work has been done on land use/land cover changes in Dutse. Hence, this research assessed land use/land cover changes in Dutse town between 1986 and 2014.

In order to analyze land use/land cover changes in Dutse town, attempt will be made to find answers to the following research questions:

i) What is the area coverage of land use/land cover in 1986, 2000 and 2014?

ii) What is the magnitude and rate of land use/land cover between 1986 and 2014?

iii) To what extent was urban growth responsible for land use/land cover changes in the area?

1.3: AIM AND OBJECTIVES

The aim of this study is to analyze land use/land cover changes in Dutse between 1986 and 2014, using geospatial techniques.

The specific objectives of the study are to:

i) establish the extent of land use/land cover coverage in the area in 1986, 2000 and 2014.

ii) determine the rate and magnitude of land use/land cover changes in the area between 1986-2000, 2000-2014 and 1986-2014.

iii) analyze the extent to which urban growth influences land use/land cover changes in the area.

1.4: SCOPE OF THE STUDY

The research covered Dutse town and some western part of Kiyawa L.G.A. which has area coverage of about 161.048 square kilometers of land. The study analyses land use/land cover changes in Dutse town. In addition, the research covered changes of about twenty eight years i.e. from 1986 to 2014.

1.5: JUSTIFICATION OF THE STUDY

Urban areas are dynamic and complex in nature making conventional methods of data collection very tedious and tasking (Ifatimehin & Ufuah, 2007). Remote Sensing and Geographic Information System (GIS) are effective and efficient tools for land use studies (Amujabi, 2006) because it is economical to use and quick in updating of maps than the conventional method. The study area chosen is the administrative headquarters of Jigawa State created in 1991 and one of the likely targets land use/land cover changes and this makes the study area one of the best places to assess the changes in land use/land cover that have taken place over the years in the area. It is evident that the rapid change of land use/land cover can lead to discomfort and other environmental problems as such there is need for a research in the study area in order to cushion its effect. The research will aid in public-policy decisions for more effective allocation of urban land for community and economic development, for better-managed community planning and growth, as well as for the efficient delivery and use of public services. The research is useful for both the government and the city planners.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1: INTRODUCTION

This chapter describes the conceptual framework and land use/land cover models. The chapter contains review of related literature on land use/ cover changes.

2.2: CONCEPTUAL FRAMEWORK

Remote Sensing is the means of acquiring information about a target, phenomena or object by a means of a device or sensor separated by a distance. Remote sensing is the science of acquiring, processing, and interpreting airborne or satellite images and related data that record the interaction between electromagnetic energy and matter (Sabins, 1999).

Geographic Information System (GIS) is an integrated means of collecting, processing, analyzing, storing and retrieving of spatial data over time. In recent times, the use of remote sensing data and analysis has made important contributions in documenting the actual changes in urban land use and the series of remote sensing data reveal that land cover changes do not always occur in a progressive and gradual way, but rather it shows periods of rapid and sudden changes (Lambin, Geist, & Rindfuss, 2006; Ramankutty *et al.*, 2006). Geospatial technology has greatly expanded opportunities for data integration and analysis for land use studies.

With the speed and spread of geospatial technologies, ever more complex spatial analysis are possible and the number and range of land use/land cover indices or metrics has increased dramatically. These can include analysis of patch size, number, diversity and distributions, factual analysis of boundaries and edges, adjacency analysis, and investigation of natural and human-induce disturbances (Cullinan & Thomas, 1992; Mladenoff, White, Pastor & Crow, 1993;

Spies, Ripple & Bradshaw, 1994). Due to increasing changes in land use/land cover, mainly by anthropogenic activities, detection of such changes, assessment of their trends/pattern and analysis of the recent urban land cover dynamics through the integration of geospatial analysis which has the capability of providing base and detailed information on changes, alterations and modifications is possible (Mladenoff *et al.,* 1993). Geospatial technology has been used extensively in urban land use/cover change as asserted by Lu, Mausel, Brondízio and Moran (2004).

Timely and accurate assessment of change detection of Earth's surface features is extremely important for understanding relationships and interactions between human and natural phenomena in order to promote better decision making (Lu *et al.,* 2004). Like any other ecological units land use/land cover is dynamic in structure, function and spatial pattern resulting in highly varied mosaics of different habitat types (Forman & Godron, 1986). Whether they are natural or altered by human activities or are defined as either fine or coarse spatial scales, environments are spatially heterogeneous (Wiens, 1995). This means land cover are composed of more than one element such as water bodies, lands, vegetation etc. Natural processes can alter landscapes, for example, volcanic eruptions, earth quakes and other natural disasters (Croizat, 1960; Franklin, MacMahon, Swanson & Sedell, 1985). However, landscape is altered by human induced activities such as agriculture, infrastructure, urban expansion or forestry practices which are on the increase (Franklin *et al*., 1985). The resulting damages usually lead not only to fragmented land cover, but also to the disruption of local settlements that depend upon the ecosystem to sustain their communities (Latifovic, Fytas, Chen, & Paraszczak, 2005; Ouyang, Gregory, Hsiang-te & Fei, 2007; Sergrey & Oganes, 2009).

2.2.1: Change Detection

Change Detection is one of the main applications of remotely sensed data. A rich amount of literatures has been published by different researches in trying to quantify and assess urban land use change. Change detection is the process of identifying differences in the state of an object or phenomena by observing it at different times, over a certain period of time (Singh, 1989). This is commonly applied to detect changes in urban land use/land cover using geospatial technology and on deforestation, regeneration, selective logging, to mention but a few (Mahmoodzadeh, 2006). The basic premise in using remotely sensed data for change detection is that changes in objects of interest will result in changes in reflectance values or local textures that are separable from changes caused by other factors such as differences in atmospheric conditions, illumination and viewing angles and soil moistures (Deer, 1995).

The objective of change detection is to compare spatial representation of two points in time by controlling all variances caused by differences in variables that are not of interest and to measure changes caused by differences in the variables of interest (Green, Kempka & Lackey, 1994). Mausel, Lu, Brondizo and Moran (2004) mentioned four aspects of change detection which are important when monitoring different resources which includes: Detecting that changes have occurred, identifying the nature of the change, measuring the area extent of the change and assessing the spatial pattern of the change.

Lu *et al*. (2004) also stated that due to the importance of monitoring change of earth features, research of change detection techniques is an active one and new techniques are constantly developed. For example, Spectral mixture analysis (Adams *et al*., 1995), the Li-Strahler canopy model (Macomber & Woodcock, 1994), Chi-Square transformation (Ridd & Liu, 1998), Fuzzy sets and Artificial Neural Networks (ANN) (Gopal & Woodcock, 1996). Change detection involves the application of multi-temporal datasets for spatial analysis. Remotely sensed data such as Landsat Thematic Mapper (TM), Landsat Enhanced Thematic Mapper plus (ETM^+), Satellite Probatoire d'Observation de la Terre (SPOT), QuickBird, Radar and Advanced Very High Resolution Radiometer (AVHRR) are the sources suitable for change detection techniques (Lu *et al.*, 2004).

However, researchers have developed change detection techniques over the last two decades. They were able to provide excellent and detailed summaries of methods and techniques of change detection. Furthermore, Coppin and Bauer (1996) summarized eleven different change detection algorithms that were found to be documented in the literature which includes.

• Mono-temporal change delineation, Post-classification comparison, Multidimensional temporal feature space analysis, Composite analysis, Image differencing, Image rationing, Multi-temporal biomass index, Multi-temporal linear data transformation, Change vector analysis, Image regression, Background subtraction.

Algebra, Transformation, Classification, Advanced models, Geographical Information System (GIS) approaches, Visual Analysis, and Other Approaches were the change detection methods identified by (Lu *et al*., 2004) and grouped them into seven categories as stated above. It is important to use the following methods of change detection in assessing change detection in land use/land cover as identified above. The categories are discussed as follows:

2.2.1.1: Algebra

Image differencing, vegetation index differencing, image regression, image ratioing, change vector analysis (CVA) and background subtraction were the algebra based category identified. These algorithms have a common characteristic, i.e. selecting thresholds to determine the changed areas (Lu *et al.,* 2004). In this category, two aspects are critical for the change detection results: selecting suitable image bands or vegetation indices and selecting suitable thresholds to identify the changed areas.

Many researchers have used these algorithms to detect changes in urban land cover for instance, Angelici, Brynt and Friendman (1977) used the difference of band ratio data and threshold techniques to identify changed areas. However, Jensen and Toll (1982) found the usefulness of visible red band data in change detection analysis in both vegetated and urban environments. Visible red band image differencing provided better vegetation change detection results than using Normalized Difference Vegetation Index (NDVI) in arid and semi-arid environments (Chavez & Mackinnon, 1994). Pilon, Howarth, Bullock and Adeniyi (1988) concluded that visible red band data provided the most accurate identification of spectral change for their semi-arid study area of north-western Nigeria in sub-Sahelian Africa. In the algebra-based change detection category, image differencing is the most often used change detection method in practice. Though, background subtraction method was not often used due to its poor change detection capability (Lu *et al*., 2004). Different authors have arrived at different conclusions about which method provided the best results among the image ratioing, vegetation index differencing, image regression, and CVA approaches, since results vary depending on the characteristics of the study areas and image data used.

2.2.1.2: Transformation

The transformation category includes Principal Component Analysis (PCA), Tasselled Cap (KT), Gramm- Schmidt (GS), and Chi-square transformations (Mausel *et al.*, 2004). Fung and Le Drew (1987) used PCA and differences in KT transformation images to detect urban land-cover changes from multi-temporal MSS and TM images and concluded that differencing greenness and brightness images from the KT transformation of MSS and TM data was most appropriate for detecting land-cover changes from multi-sensor data.

Fung (1990) examined image differencing, PCA and KT transformation for urban land-cover change detection and found that images associated with changes in the near-infrared reflectance or greenness could detect changes between vegetative and non-vegetative features. In order to improve change detection accuracy, different change detection techniques can be combined. For example, Coppin and Bauer (1994) examined forest change detection by a comparison of vegetation indices for different dates of imageries. The vegetation indices included brightness, greenness and wetness from the KT transformation, as well as NDVI, green ratios and mid-infrared ratios. The KT method seems useful in many change detection applications. The GS and Chi-square methods are relatively less frequently used in practice due to their relative complexity compared to PCA and KT. Also, GS and Chi-square methods are not available in most of the commercial remote sensing image processing software.

2.2.1.3: Classification

The classification category includes Post-classification Comparison, Spectral-temporal Combined Analysis (SCA), Expectation-Maximization algorithm (EM) change detection, unsupervised change detection, hybrid change detection and Artificial Neural Network (ANN) (Moran, Brondizio, Mausel & Wu, 1994).

Li and Yeh (1998) found that PCA of stacked multi-temporal images combined with supervised maximum likelihood classification can effectively monitor urban land-use change. Petit, Scudder and Lambin (2001) combined image differencing and post classification to detect detailed land use/land cover change in southern eastern Zambia. Liu and Lathrop (2002) applied the ANN approach to detect urban land use/land cover change using multi-temporal TM data and found that the ANN-based method is a good method detecting changes using classification. Classification methods often require a large amount of training sample data for supervised or unsupervised classification of image data. Image transformation, vegetation indices, advanced classification methods, modeling, and integration of different data sources are often used to improve classification results. Post classification is a common method use for change detection. The threshold methods such as image differencing are often used to detect the changed areas and then the classifications are used to analyze detected changed areas.

2.2.1.4: Advanced Models

Advanced model-based change detection category includes the Li-Strahler reflectance model, spectral mixture models, and biophysical parameter estimation models. In these methods, the image reflectance values are often converted to physically based parameters or fractions through linear or nonlinear models. The transformed parameters are more intuitive to interpret and better to extract vegetation information than are spectral signatures (Lu *et al.*, 2004). Ustin, Roberts and Hart (1998) and Kressler and Steinnocher (1996) used Linear Spectral Mixture Analysis (LSMA) to detect vegetation change and urban land use/land cover area change respectively. Rogan, Franklin and Roberts (2002) compared multi-temporal KT and LSMA methods for land use/land cover detection using TM images in southern California and found that the LSMA approach provided about 5% higher change detection accuracy than the KT approach.

In addition, multi-temporal Ratios of Tree Biomass (RTB) images have the capability to detect land cover change after the reflectance differences caused by environmental conditions are calibrated between multi-temporal TM images. This method of Change detection techniques has been used for successional and mature forest change detection in the Altamira and Bragantina study areas of the Brazilian Amazon (Lu, Mausel, Brondi´zio & Moran, 2002). The LSMA approach has shown to be powerful for land use/land cover change detection. When sufficient field land cover measurements are available, the Li–Strahler canopy model and the biophysical parameter estimation model are valuable for quantitative detection of land cover change. However, applications of both models are often time-consuming and difficult. Also they can provide only vegetation change detection and are not suitable for non-vegetation change detection (Lu *et al*., 2004).

2.2.1.5: Geographical Information System (GIS)

In recent years, satellite images such as SPOT, LANDSAT TM and ETM^+, AERIAL PHOTOGRAPHS, QUICKBIRD, e.t.c. are currently used for assessment of urban expansion and land use/land cover change detection (Salami, 1999; Salami, Ekanade & Oyinloye, 1999). The GIS based change detection category includes the integrated GIS and Remote sensing method and the pure GIS method. The advantage of using GIS is the ability to incorporate different source data into change detection applications (Lu *et al*., 2004).

Lo and Shipman (1990) used a GIS approach to assess the impact of new town development in Hong Kong, through integration of multi-temporal aerial photographic data of land use and found that the image overlaying and binary masking techniques were useful in revealing quantitatively the change dynamics in each category of land use. Yang and Lo (2002) used an unsupervised classification approach, GIS-based image spatial reclassification, and post-classification comparison with GIS overlay to map the spatial dynamics of urban land-use change in the Atlanta, Georgia, metropolitan area. Most previous applications of GIS approaches in change detection were focused on urban areas. This is probably because traditional change detection methods often have poor change detection results due to the complexity of urban landscapes and these cannot effectively utilize multi-source data analysis. Thus, the powerful GIS functions provide convenient tools for the multi-source data processing and are effective in handling the change detection analysis using multi-source data (Lu *et al*., 2004).

2.2.1.6: Visual Analysis

The visual analysis category includes visual interpretation of multi-temporal image composite and on screen digitizing of changed areas. This method can make full use of an analyst's experience and knowledge. Texture, shape, size and patterns of the images are key elements useful for identification of urban land use change detection through visual interpretation. These elements are not often used in the digital change detection analysis because of the difficulty in extraction of these elements. However, in visual interpretation, a skilled analyst can incorporate all these elements to help make decisions about land use change (Moran *et al*., 1994). Loveland *et al*. (2002) used visual interpretation on fine resolution data (MSS, TM and Enhanced Thematic Mapper Plus (ETM+), together with sampling design, to detect urban land use changes and estimate the change rates in the United States.

2.2.1.7: Other Change Detection Techniques

In addition to the six categories of change detection techniques discussed above, there are also some methods that cannot be attributed to one of the categories indicated above and that have not yet frequently been used in practice. For example, Wang (1993) used a knowledge-based vision system to detect land-cover change at urban fringes. Lambin and Strahler (1994b) used three indicators, vegetation indices, land surface temperature and spatial structure derived from AVHRR, to detect urban land-cover change in West Africa. Zhang *et al*. (2002) used road density and TM spectral information to form structure-based methods, spectral–structural post-classification comparison and spectral–structural image differencing to detect urban land change in Beijing, China. Henebry (1993) used measures of spatial dependence with TM data to detect grassland change. Any method to be selected depends on the analyst's knowledge of the change detection methods and skill in handling remote sensing data, the image data used and the characteristics of the study area. But based on the discussion above it is very clear that combination of two change detection methods will yield a better result. The most common change detection methods are image differencing, principal component analysis, change vector analysis and post-classification comparison.

Table 2.1 Change Detection Techniques

Categories	S/N	Techniques	Identification Factors
Algebra	1	Image Differencing	Identifies suitable image band and threshold
	2	Image Ratioing	Identifies the image band and threshold
	3	Vegetation Index Differencing	Identifies suitable vegetation index and threshold
	4	Change Vector Analysis (CVA)	Defines threshold and identifies change trajectories
Transformation	5	Principal Component Analysis (PCA)	Analyst's skills in identifying which component best represents the change and selecting thresholds
	6	Tasselled Cap Transformation	Analysts skill is needed to identify which component best represent the change and selecting threshold
	7	Chi- Square	Produces a single change image by simultaneously considering multiple bands
Classification	8	Post Classification Comparison	Select sufficient training samples data for classification
	9	Spectral Temporal Combined Analysis	Labels the change classes
	10	Expectation Maximization (EM) Detection	Estimates the priori joint class probability
	11	Unsupervised Change Detection	Identifies the spectrally similar or relatively homogeneous units
	12	Hybrid Change Detection	Selects suitable threshold to identify the change and no change areas and develop accurate classification result
	13	Artificial Neural	The ability to identifies and estimates the properties of data base on the training samples
Advance Model	14	Spectral Mixture Model	Identifies suitable end members, defines suitable threshold for each land cover class based on fraction
GIS	15	Integrated GIS and Remote Sensing Method	Defines the accuracy of different data source and their registration accuracies between the thematic source
	16	GIS Approach	Defines the accuracy of different data source and their registration accuracies between the thematic source
Visual Analysis	17	Visual interpretation	Enables an analyst to incorporate texture, shape, size and patterns into visual interpretation
Other Approaches	18	Combination of 3 indicators	It incorporates vegetation, land surface temperature and spatial structure
	19	Curve-Theorem based Approach	Identifies changes in land cover.

Source: Lu *et al*. (2004).

2.2.2: Characteristics of Landsat satellite imagery

Remotely sensed imagery provides accurate understanding and comprehensive way of modeling and projecting land cover change. With the introduction of landsat5 in 1984 and landsat7 ETM^+ in 1999, it has marked a significant advancement in remote sensing through obtaining more sophisticated advance sensor; improve acquisition and transmission of data and more rapid processing at a highly processing facility (Gyanesh *et al.*, 2009). The TM attached to landsat5 to the MSS gives it high radiometric, spectral and geometric resolutions. The landsat5 TM has a spatial resolution of 30m for the six reflective bands and 120m of thermal band. The limitation of the landsat5 TM is that it lacks on board recorders therefore acquisition is limited to real time down link only (Gyanesh *et al.,* 2009).

Table 2.2: Characteristics of Landsat Image

Band	**Wavelength Micrometers (µm)**	**Description**	**TM Resolution (meters)**	**ETM+ Resolution (meters)**
1	0.45 – 0.52	Visible blue	30m	30m
2	0.52 -0.60	Visible green	30m	30m
3	0.63 – 0.69	Visible Red	30m	30m
4	0.76 - 0.90	Near IR	30m	30m
5	1.55 – 1.75	Mid Infrared	30m	30m
6	10.4 – 12.5	Thermal Infrared	120m	60m
7	0.50 – 0.90	Mid Infrared	30m	30m

Source: Quinn (2001)

Landsat 7 ETM+ was launched in 1999, the Landsat ETM+ have spatial resolution of 30m for the six reflective bands, 60m for the thermal band, and includes a panchromatic (Pan) band with spatial resolution of 15m and has no MSS sensor and this makes it to have an additional advantage of sharp and clear imagery over landsat5 TM. The Landsat have a solid state recorder (SSR) that can hold almost 100 scenes of sensor data in 42 minutes and 29hours of housekeeping telemetry concurrently (Gyanesh *et al.*, 2009).

2.3: MODELS OF LAND USE LAND COVER CHANGE

Land use/land cover modification caused by human activities can be further discussed using the McIntyre and Hobbs Model and the Forman's model to show how land use/land cover changes due to human activities.

2.3.1: McIntyre and Hobbs Model

McIntyre and Hobbs model proposes that land use/land cover alteration tends to have a temporal attribute with an increase in modification over time. Four main stages of land cover changes are identified along a continuum (as shown in figure 2.1). Landscapes can be intact, which includes most of the original vegetation with limited clearing; variegated, which is dominated by original vegetation, but includes gradients and buffers of modified habitat; fragmented, which contains discrete patches of vegetation in a modified matrix; relictual, which contains little of the original vegetation remaining, surrounded by highly modified landscape (McIntyre & Hobbs, 1999).

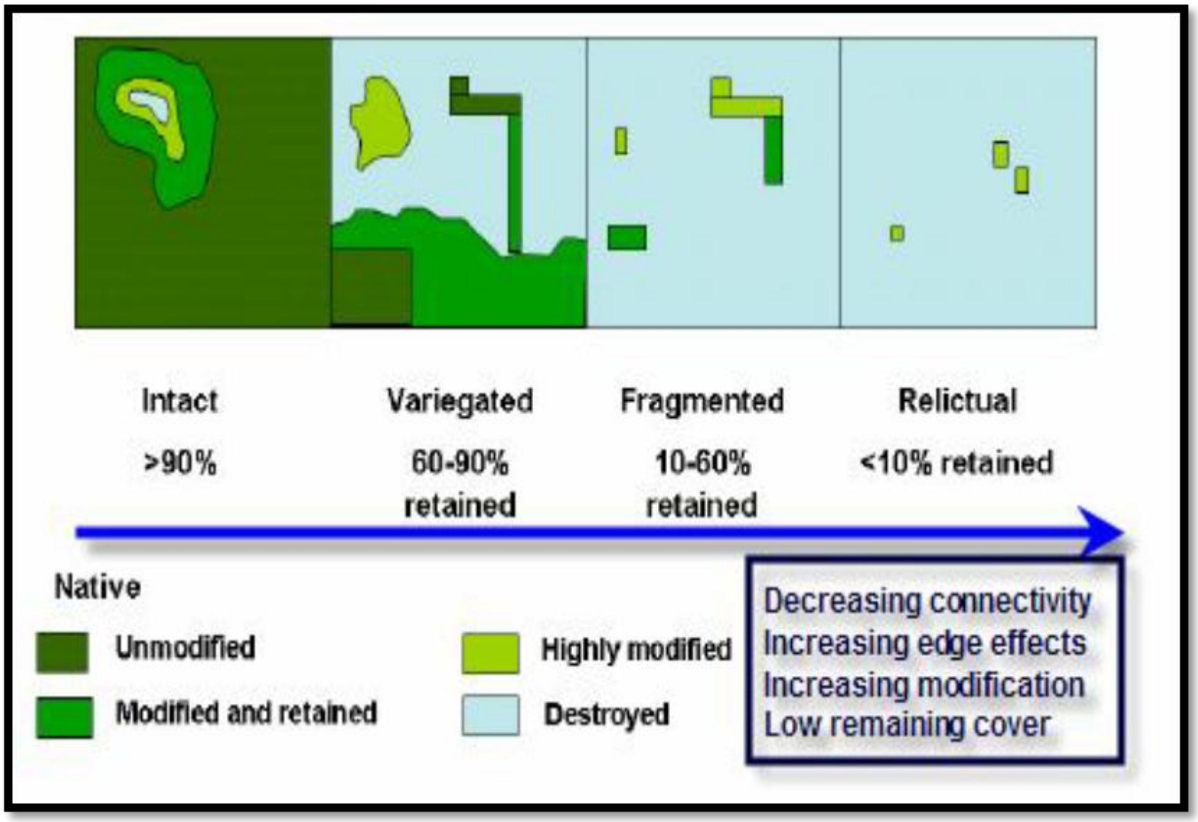

Figure 2.1: Land cover Alteration Patterns Showing Modification

Source: McIntyre and Hobbs, 1999

McIntyre and Hobbs (1999) proposed that as anthropogenic alteration of the land cover increases, the proportion of intact habitat decreased while an increase in habitat degradation is observed. Furthermore, fragmented and relictual land covers were defined by more sharply characterized patch boundaries than landscapes which were variegated or intact. Land cover modification alters the spatial configuration of the intact vegetation. The scale of modification affects the proportion of edges, shapes and sizes of fragments. As clearing increases, the distance between patches increases and landscape connectivity decreases. The quality of the remaining vegetation decreases due to changes in solar radiation, water fluxes, susceptibility to weeds' invasion, livestock grazing and loss of native biodiversity (McIntyre & Hobbs, 1999).

2.3.2: Forman's Model

Patches, Corridors and Matrix are key elements of land cover structure (Forman & Godron, 1981 in Forman, 1995). As shown in figure 2.2. Patches can be described as wide, relatively homogeneous areas that differ from their surroundings. Corridors are defined as strips of a particular patch that differ from the adjacent land on both sides and connect to two or more patches. Matrix refers to the dominant and most extensive patch type in a landscape. It is characterized by extensive cover and major control over dynamics (Forman, 1995).

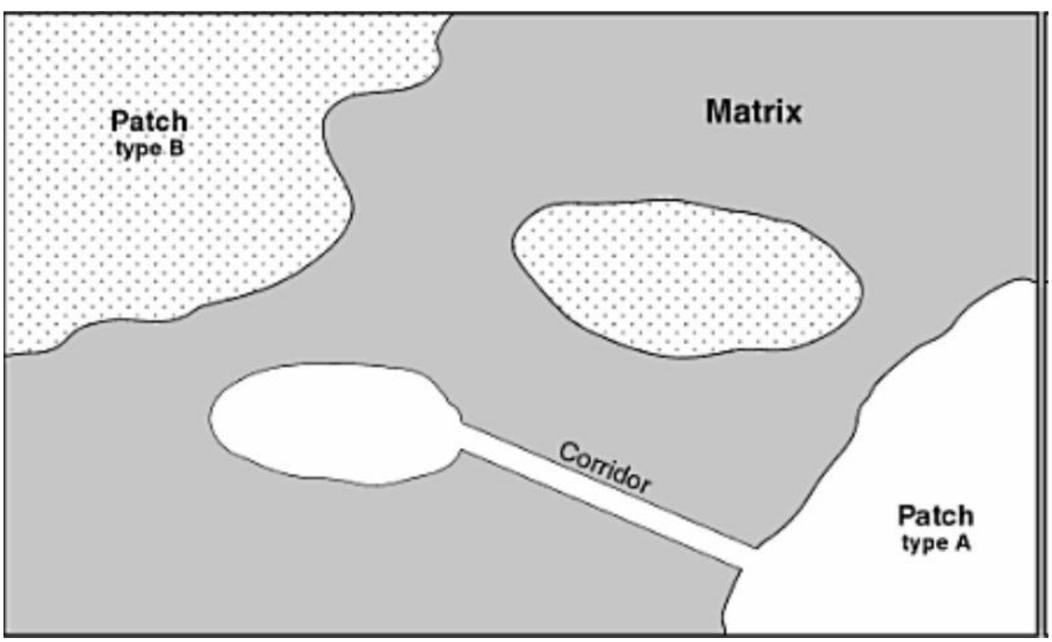

Figure 2.2: Patch-Matrix-Corridor Model

Source: Lindenmayer and Fischer, 2006

Forman's "Patch-Matrix-Corridor" model (1995) stated that there are five major patterns of man-made land cover alteration: Perforation, Dissection, Fragmentation, Shrinkage and Attrition (see figure 2.3). These modifications lead to different spatial patterns of landscapes and results in alterations of ecological processes and distribution of plants and animals (Bell, 2003). Perforation occurs through the creation of new patches for example, citing of mining sites in remote areas. Dissection involves splitting or division of the land cover into parts, for example constructing a road through a landscape. Fragmentation entails breaking up or separation into pieces or fragments, for example new land-uses can spread out from newly constructed roads. Shrinkage occurs when such fragments are reduced in size for example patch size reduction due to realignment of fences around pastures. Attrition takes place when pieces of habitat disappear entirely.

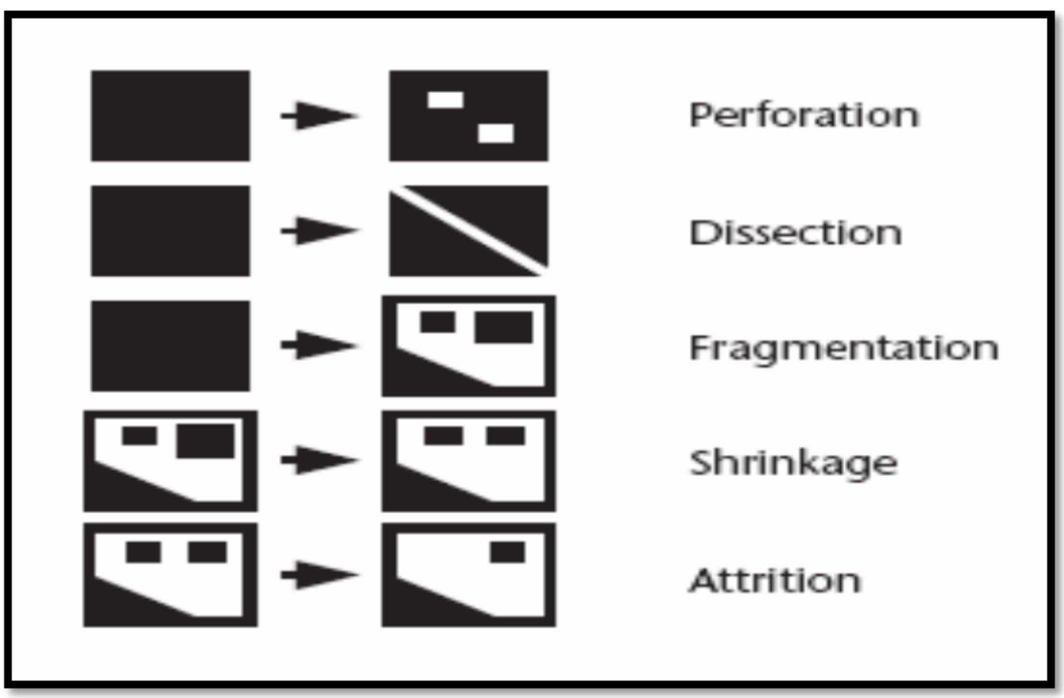

Figure 2.3: Patterns of Land Cover Modification

Source: Forman, 1995

Land cover experience continuous change giving rise to different mosaics of varying habitat types and can be best described as dynamic in structure, function and spatial pattern (Forman & Godron, 1986). Such temporal modifications include the following changes: patch number and size; number and type of corridors; number and type of dispersal barriers; the probability and spread of disturbance (Turner, O'Neil, Gardner & Milne, 1989). Bell (2003) stated that most of the disturbance factors are linked to humans and that within given land cover mosaics, habitats are interconnected allowing the flow of biotic and abiotic factors. However, as anthropogenic modification of the land cover takes place, there is a loss of connectivity through fragmentation and other patterns of land cover modification (Table 2.3). Hence, Franklin and Forman (1987) referred to land cover change as a sequence of mosaics.

Table 2.3: Spatial patterns from land cover modification

Spatial Patterns	**Patch Number**	**Patch Size**	**Interior Habitat**	**Connectivity**	**Habitat Loss**	**Habitat Isolation**
Perforation	0	↓	↓	0	↑	↑
Dissection	↑	↓	↓	↓	↑	↑
Fragmentation	↑	↓	↓	↓	↑	↑
Shrinkage	0	↓	↓	0	↑	↑
Attrition	↓	↑	↓	0	↑	↑

Key: ↓ means decrease; ↑ means increase; 0 means no change

Source: Bell, 2003

Both models are complementary since they recognize that land use/land cover alteration often yields discontinuities in vegetation and a decrease in the proportion of native land cover. Land use/land cover change leads to a decrease in the average size of reaming vegetation patches, an increase in the average distance between patches, a decrease in connectivity between patches and an increase in the ratio of patch edges to patch sizes (Lindenmayer & Fischer, 2006).

2.4: LITERATURE REVIEW

2.4.1 Land Use Land Cover Changes

Studying land use/cover changes has been an intense subject of research especially with the availability of spatial data and geospatial tools. Land use/land cover and its pattern of change is a major element that is very important in the history of global expansion and Land Use and Land Cover Change (LULCC) and its impacts on the environment has been one of the increasing focus of global changes (Bankole & Bakare, 2011). However, expansion of human settlements and its accompanying activities, especially the rapid urban expansion occurring in the developing countries, play an important role in global land use and cover change, causing changes in the ecological processes at both local and global scales. One of the factors driving land-use change includes what can be called 'development attractors' (Bankole & Bakare, 2011). These are physical features that promote new residential and commercial development. For example, main roads, existing developed areas and utilities such as electricity, postal services, industrial development and potable water supply are development attractors because new development is likely to occur in their vicinity. Land use and land cover change is perhaps the most prominent form of global environmental changes since it occurs at spatial and temporal scales and is very relevant to our daily existence. The changes in land use and land cover are likely to affect natural resources and ecosystems as well as urban human activities in complex ways (Bankole & Bakare, 2011).

Meanwhile, it is clear fact that due to human activities a lot of changes are experienced on land use/land cover in the process.

2.4.2: Geospatial studies on land use land cover changes

Pixel-based classification has remained the traditional and most widely used method of identifying and quantifying land cover changes for over decades (Zhang *et al*., 2002). Most commonly used pixel based classifications are supervised and unsupervised classifications (Mausel *et al.*, 2004). This is because they provide accurate classification results for land use/land cover classification.

Peijun, Xingli, Wen and Huapeng (2010) were reported to have used different pixel methods to monitor urban land cover and vegetation change in Xuzhon city between 1987 and 2007. The result of the statistical analysis showed that built up areas have obviously increased while farmlands have seen a continuous loss due to urban growth and human activities.

Chandrasekar, Sivasubramanian and Soundranayagam (2010) in their study of ecological consequences of rapid urban expansion in Tirunelveli, India between 1999 and 2006 showed that settlement area has enhanced to about 39.19 sq km and agricultural land has declined to about 72.65 sq km in seven years period.

Imhoff *et al*. (2004) used Enhanced Thematic Mapper plus aboard the Landsat 7 satellites to assess urban sprawls impact on the natural vegetation in the United States. The authors stated that when a mixed forest ecosystem is completely urbanized, plant growth is reduced by at least the equivalent of five full days a year as shown on the graph of NDVI over time. Similarly, they also stated that urban land transformation in the United States has reduced the amount of carbon fixed through photosynthesis by 0.04pg per year or 1.6% of the pre-urban input. They asserted that in the future, land use/land cover change due to urban growth will likely accelerate and may affect carbon dioxide levels globally.

Zhang *et al.* (2006) used remote sensing data and GIS techniques in their study of ecological consequences of rapid urban expansion between 1975 and 2005 in Shanghai, China. The results asserted that the area of urban land increased from 159.1 km^2 in 1975 to 1179.3 km^2 in 2005. There were distinct phases in the urbanization process. The slowest rate of urban expansion, 17.7 km^2 yr–1, occurred between 1975 and 1981, increasing to 52.4 km^2 yr–1 between 1990 and 1995and 54.9 km^2 yr–1 from 2000 to 2005.

Wegmann *et al.* (2012) in their study of sprawling crisis between 1975 and 2010 used remote sensing techniques in their analysis in Calcuta urban area, India. The results revealed that the dramatic increase from approximately 150 km^2 to more than 600 km^2 resulted in irreversible land cover change and loss of vegetation and pristine land cover.

Similarly, Bhalli, Ghaffar and Shirazi (2012) in their study use geo-informatics techniques (Landsat images of 1980-2010) for the assessment of urban sprawl in Faisalabad city, Pakistan. The result inferred from the classified Landsat image for year 1980 revealed that the total built-up area of Faisalabad was 5661 hectares (26 percent of total) while year 2010 classified Landsat image depicts that the total built-up area was 9480.44 hectares (44 percent) of the City. The total areal change for 30 years research span (1980-2010) was 44 percent in built up land, contrary to this non built-up /open area that decreased to32 percent during the same period.

Meanwhile, Sudhira and Ramachandra (2007) in their study of characterizing urban sprawl and metrics of landscaped use the satellite remote sensing data for Bangalore, India, of Landsat TM and Landsat ETM^{+} for 1992 and 2000 respectively. Multi-stage classification process and post-classification change detection was performed. The landscape metrics adopted were computed and compared these two time-periods to characterise sprawl. The extent of land use during 1992 and 2000 comprised of built-up with 142.54 sq. km and 186.42 sq. km respectively. Similarly the extent of non-built-up comprising open land, vegetation and water bodies made up of 1449.35 sq. km and 1405.42 sq. km respectively during 1992 and 2000. During the span of eight years, it was observed that the extent of built-up area has increased by 30.8 %.

Khaled, Ramze, Meraj and Gomaa (2012) in their study of impacts of urban growth on flood hazards in Makkah City, Saudi Arabia between 1990 and 2010 used Geographic Information System in their analysis. The results obtained show that the residential regions of Makkah city have been increased, over the period of 1990 to 2010 by 197%.

Furthermore, Barry, EL Garouani and Lahrache (2012) in their study analysed the spatio-temporal change of urban spread in Fez, Morocco using Landsat images and master plan of the city (2002-2011). The result showed that between 2002 and 2009, the frame increase of 698.09 ha. Between 2009 and 2011, 204.75 ha of built-up area were noticed, an indication that there is urban growth experienced in the study area as asserted by the researchers.

Moreover, Zubair (2006) detects changes in urban land cover of Kwara State Nigeria between 1972 and 2001 using change detection techniques of GIS and remote sensing data (Maximum likelihood Classifier was also used). The result of the analysis showed that there was rapid growth in the built-up area of about 2198.2734 Ha (2%), 9702.8136 Ha (10%) and 10815.921 Ha (11%) for 1972, 1986 and 2001 respectively which was attributed to population pressure, While the vegetation results was asserted to be 11036.494 Ha (12%), 21393.0405 Ha (22%) and 19960.2315 Ha (21%), farm lands 2437.62723Ha (25%), 7965.5733Ha (8%), 14068.4949Ha (15%), waste lands 41436.7713Ha (43%), 55561.149Ha (59%), 50317.263Ha (52%) and water body 16874.6562Ha (18%), 1326.8916Ha (1%), 787.5576Ha (1%) for the year 1972, 1986 and 2001 respectively in the study area.

Ade and Afolabi (2013) used Remote Sensing and Geographic Information System in their study of urban sprawl in the Federal Capital Territory of Nigeria between 1987 and 2007. The results asserted that the built-up area increased from 8% in 1987 to 22% in 2007 while vegetation decreased from 40% to 17%, rock outcrops decreased from 77% to 37% and water body been stable as 1% between these years.

Ujoh, Kwabe and Ifatimehin (2011) in their study of urban expansion and vegetal cover loss in and around Nigeria's Federal Capital City used Remote sensing and GIS techniques to identify, mark and measure the extent of change in the various land uses from the Landsat imageries of 1987 and 2001, and Nigeriasat-1 imagery of 2006. The results reveal that as at 1987, vegetation constituted 258.62 km^2 of the study area while built-up area was the least visible land cover type in the study area with 73.6 km^2 representing 8.83% of the study area. Between 2001 and 2006, the pattern of LULC change shows that built-up area again gained from 254.4 km^2 in 2001 to 355.04 km^2 in 2006. Vegetation and wetland vegetation declined from 175.1 and 71.68 km^2 in 2001 to 101.61 and 69.29 km^2 in 2006, respectively. The gain in built-up area of the FCC between 2001 and 2006 is 100.67 km^2 over the 5 year period (2001 - 2006). The annual rate of expansion translates to 20.13 km^2.

Nuhu, Yohanna and Geoffrey (2011) used Remote Sensing and GIS techniques in their study for appraisal of spatial growth in Mubi metropolis, Adamawa State, Nigeria. The results revealed that the built-up area covered 17.3157 km^2 in 1975 and expanded to 23.8780 km^2 in 2010. The town grew at the rate of 0.1875 km^2 and 0.4981% annually.

Ifeoluwa, Debo, Ahmed and Tobi (2011) in their study of an analysis of urban expansion and land use changes in Akure, Nigeria used multi-temporal remote sensing data and geographic information system (GIS) techniques with field survey to detect the land use and land cover change in Akure between 1986 and 2007. The result showed that there are changes in land use and land cover of Akure through their different classification scheme (arable land, bare-surface land, built-up/settlement, dense forest and water bodies with a percentage change of 11.24, -5.86, 28.36, -33.87 and 0.13, respectively between 1986 and 2007). The result further revealed through projection that change by 2020 may likely follow the trend observed between 1986-2007.

Njungbwen and Njungbwen (2011) in their study of urban expansion and loss of agricultural land in Uyo urban area between 1969 and 2004 used aerial photographs of 1969-2001 and Quickbird imagery 2004 of the study area. The results showed that the built-up lands increased by 40.34% between 1969 and 1978, 5.63% between 1978 and 1988, and 111.45% between 1988 and 2001 and 0.16% between 2001 and 2004 at the expense of the agricultural land.

Muhammad, Abubakar, Shehu and Zainab (2013) in their study of Spatial Analysis of Urban Growth in Kazaure Local Government Area of Jigawa State, Nigeria utilized LandSat TM of 1988 and Landsat ETM imageries of 1999 and 2007. Findings revealed that built up area increased from 12.2% in 1988 to 29.7% in 2007. In addition, the bare surface has decreased tremendously over the years from 34.2% in the year 1988 to 4.1% in the year 2007. Water body and vegetation increased tremendously from 25.8% to 33.2% and 27.8% to 33.0% in 1988 and 2007 respectively.

Klett, Ahlbrandt, Schmoker and Dolton (2010) monitored land cover change in the landscapes area of Chile between 1975 and 2008. The result of the study using the Supervised (MLC) classification showed an average rate of deforestation to be -1.7% and shrub land -0.7%, however agriculture and timber plantations increased at an annual rate of 1.1% and 3.3% respectively. The study concludes that there has been a progressive land cover change in the region.

Rasuly, Rezvan and Mehdi (2010) in their study asserted that the use of GIS and remote sensing techniques to monitor the rate of forest alterations in the Arasbaran protected area using the supervised classification was an advantage. The result of the study showed that about 6146.9 hectares of the area has been deforested over the past 18 years. Furthermore, they were able to found out that the lost was due to physiographic factors and they suggest to distant settlements from the protected area.

Similarly, Changquan *et al*. (2010) in the assessment of Paraguay's land cover change using Landsat observation of high resolution images. The result showed that Atlantic forest ecosystem experienced the most loss with the 73.4% forest cover in the 1970's decreasing precipitously down to 40.4% by the 1990s and further down to 24.9% by the year 2000. This shows that there is great change in land cover in the study area which is a thing of concern to all as asserted by the researchers.

In addition, Mapedza, Wright and Fawcett (2003) investigates land cover change of the forest reserve area of Mafungautsi Zimbabwe, the study showed that whilst forest cover within the reserve remain the same, there was steadily decline around its boundaries as a result of agricultural expansions, the collection of fuel wood and building materials demand.

Ifatimehin, Musa and Adeyemi (2009) in their study of an analysis of the changing land use and its effect on the environment of Anyigba town used land use map of 1995 and Nigeria sat1 imagery of 2006 of the study area. The study revealed that there have been tremendous transformations in the various land uses, with the built-up area expanding more than other land uses with 398.4% within the period of the study.

Sunday and Umar (2013) in their study of spatio-temporal Analyses of Land Use and Land Cover Changes in Suleja Local Government Area, Niger State, Nigeria using Remote Sensing and Geographic Information System between 1987 and 2012. The results obtained show that the proportion of area covered by built up land, farm land and bare soil is on the increase, whilst there is decline in vegetation. Built up land increased from 7.0 km2 (or 5.2%) in 1987 to 17.9 km2 (or 12.5%) in 2012, farmland from 50.1 km2 (or 36.7%) to 63.0 km2 (or 46.2%) and a decline in vegetation from 68.7 km2 (or 50.4%) in 1987 to 43.1 km2 (or 31.6%) in 2012.

Jajere, Muhammad and Musa (2014) in their study of Analysis of Land use/Land cover change in Damaturu Town of Yobe State, Nigeria used Remote Sensing and Geographic information System techniques between 1991 and 2009. Their results revealed that built-up area increased from 3.02% in 1991 to 23.42% in 2009, bare surface and shrub land decreased from 81.47% to 23.13% and 41.63% to 9.10% in 1991 and 2009 respectively while cultivation increased from 95.99% to 117.63% within the study period.

Abbas and Arigbede (2011) in their study of Sustainable land management in Zaria used Landsat, Spot and Digital Globe imageries for 1985, 1995 and 2005 respectively for the land use/land cover analysis. The result shows 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 1985 to 40% in 2005 sending a bad signal of imminent food crisis if not checked.

2.4.3: Human activities causing land use/cover changes

Deforestation is one of the oldest and continuous ways in which man modifies the environment. It is the act of destroying or removing forest vegetation with little or no effort of replacement that eventually results into ecological imbalance or degradation (Maigari, 2002). This is apparent, because of the fundamental roles of vegetation to ecosystem including man.

Land use change, especially in developing countries, induces deforestation through clearance of the surrounding woody biomass for the creation of new settlements or expansion of the existing ones. In Abuja, the Federal Capital Territory (FCT) of Nigeria, for example, about 200ha of forest land was destroyed between 1980 and 1990 for settlement while resettlement of people from FCT has claimed about 27,330 ha of forest reserve in Niger State (Maigari, 2002).

Another urban related activity that seriously causes deforestation is fuel wood exploitation. In most of the developing nations, the conventional sources of energy, fossil fuels and electricity, are very expensive for both the urban and rural poor. Coupled with increasing population growth, fuel wood exploitation, inevitably, becomes the most attractive and therefore an alternative source of energy for this category of people (Maigari, 2002).

Infrastructural development such as roads rail lines, pipelines, industrial layouts, military bases, educational institutions and airports among others, claim large areas of forest. For example, in Nigeria about 7420 hectares of forest in Kaduna was cleared for military and paramilitary bases, 18,390 hectares of Ajaokuta forest reserve was cleared for the steel Development Company and about 1,140 hectares of forest reserve was taken over for airport at Ilorin, Kwara State (NEST,1991a: 163).

The implication of this rapid change in land use/land cover is the change in thermal properties of built-up land surfaces that would result in more solar energy being stored and converted to sensible heat and the removal of vegetation cover that reduces those natural cooling (effects of shading and evapotranspiration). The average ambient temperature in urban areas is generally 2-3 degrees higher than in non urban area (Nowak, Crane, Stevens & Ibarra 2002), which can cause discomfort and even health risks in the study area as it has in locations such as Shanghai in China (Zhang *et al*., 2006).

In the end, despite the fact that change in land use/land cover to urban growth cannot be totally halted, but sustainable planning and management will go a long way towards reliable and sustainable way of protecting the environment which always serves as the ecosystem service provider to the urban centres and its immediate surroundings.

CHAPTER THREE

STUDY AREA AND RESEARCH METHODOLOGY

3.1: INTRODUCTION

This chapter describes the study area, the data used and method used to collect and analyze the data. The chapter contains components of the location, population, geology and relief, climate, soil, vegetation and land uses of the study area. Others are the procedure of methods employed in achieving the set objectives such as data acquisition, image pre-processing, classification and change detection analysis.

3.2: THE STUDY AREA

Dutse town is the Administrative Headquarters of Jigawa State created on Tuesday 27, August, 1991 from the old Kano State.

3.2.1: Location and Extent

Dutse is located between Latitudes 11^o $38^'$ 31"N and $11^o46^'$ $16^{''}$N and longitudes 9^o $18^'$ $33^{''}$E and $9^o24^'$ $24^{''}$E. Dutse Local Government Area is bordered by Ringim and Jahun Local Government Area to the North, Birnin Kudu Local Government Area to the South, Kiyawa and Gaya Local Government Areas to the East and West respectively (Aliyu, 2005). (See Fig. 3.1).

The old location of Dutse formally known as a “Garu” is full of hills and inselbergs, before it was later move to its present location. Though, there were political agitation as of when Dutse was made the state capital of Jigawa State in 1991 by some influential individuals and powerful emirates such as Hadejia, Ringim, Kazaure, Gumel among others questioning the suitability of awarding Dutse the state capital.

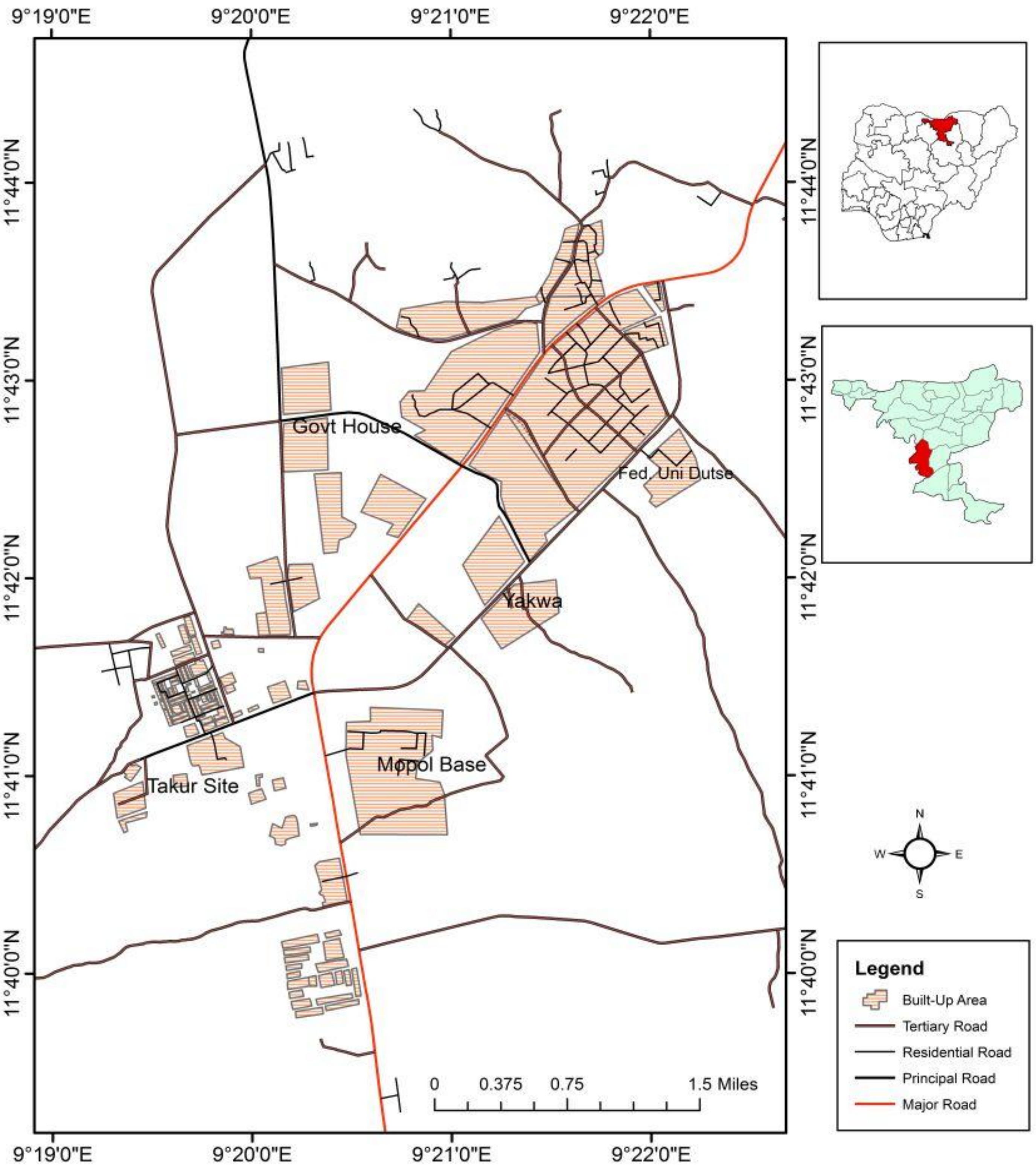

Fig. 3.1: Dutse Town (Study Area)

Source: Min. of Land, Housing and Urban Dev. Jigawa State (2011)

3.2.2: Climate

The climate of Dutse corresponds to that of Kano region since it is considered to be part of Kano region. The climate is tropical wet dry climate (Koppen AW) classification and the temperature is warm to hot throughout the year, even though there is slightly cool period around November through February. The mean annual temperature is 26^0c but, mean monthly value ranges between 21^0c in the coldest months (December/February) and 31^0c in the hottest months (April/May) (Olofin, 1987).

Rainfall is a very critical element in Dutse, because of its deficiency during the dry season. Rainfall starts in April and ends in October with about 800mm recorded annually (Olofin, 1987). Great temporal variation occurs in the amount of rainfall received in the area. No two consecutive years record the same amount of rainfall and the average calculated for any two periods are never the same. For example, calculation based on the period 1965-1974 gives an average of 720mm while the next five years 1957-1979 recorded an average of 748mm (Garba, 1998).

The general effect of climate control and the temporal variation in rainfall and temperature condition gives Dutse not just a dry and wet season as commonly believed but rather four seasons as identified by Olofin (1987).

1) The dry and cool season, this starts around November through February, which is referred to as *Kaka* in the area.

2) The dry and hot season known as *Bazara*, this is a transitional period between Harmattan and wet season. It is the hottest season in the area.

3) The wet and warm season referred to as *Damina* begins in June through September. Nevertheless, the first rain comes late in May and cropping starts immediately.

4) The dry and warm season *Rani* starts at the end of the rainy season that is around November, with the onset of Harmattan.

3.2.3: Vegetation

Most parts of the study area lie within the Sudan Savannah with elements of Guinea Savannah in the southern part. Total forest cover in the State is very much below national average of 14.8% (Garba, 1998). Due to both natural and human factors, forest cover is being depleted, making it vulnerable to desert encroachment. The Study area enjoys vast fertile arable land to which almost all tropical crops could adapt, thus constituting one of its highly prized natural resources. The Sudan Savannah vegetation zone is also made up of vast grazing lands suitable for livestock production.

3.2.4: Population

The rocky nature of Dutse old settlement (Garu) prevented the expansion of the town for quite a long time and this has affected the population of Dutse before it moves to its present location now. Dutse is predominantly populated by Hausa/Fulani tribe with Bare-Bare minority group whose proportion is very minimal. The estimated population of Dutse in 1991 was 138,451people in the area. This comprises of 68,975 males and 69,476 females (NPC, 1991). Based on the 2006 census, Dutse has a population of 251,135, people living in the area, with 125,773 male and 125,362 females (NPC, 2006). The main occupation of the inhabitants is farming and trading. Following the creation of Jiagawa State in 1991 and subsequent nomination of Dutse as the capital, it has experienced comparatively rapid population growth. This population growth was attributed to the mass movement of people particularly the public servants, who were re-deployed from Kano State to Jigawa State for administrative purposes. In addition, it has attracted many people from different parts of the state and the country at large for various economic activities, especially in the areas of commerce and service provision. The increase in population led to increasing demand for residential, commercial, industrial and governmental land for developmental purposes.

3.2.5: Geology and Relief

Dutse occupies a relatively high plains surface that occurs within the younger sediment of the Chad formation area of Kano Region. The rocks are Precambrian in origin with the granitic outcrops there are presence of isolated hills of plutonic rocks in the area (Olofin, 1987).

The relief of Dutse comprises of high plains and highland known as the high plains of Hausa land. The highest elevations are associated with igneous structure and the lowest with the chad formation. The study area has an undulating terrain with the uplands used for rainfed agricultural practices. The general elevation of Kano Region above mean sea level ranges from above 400meters in the northern margin to over 1200meters in the southern tip (Olofin, 1987).

3.2.6: Soils

The nature of the soils occurring in this basement complex region is mainly from wind drift materials that have covered the regolith of the ancient rocks in some meters deep (Olofin, 1987). In some areas the materials have been removed by exposing the real regolith as a result of erosion and there is presence of soil of the chad plains in the area.

The soil of the area is very fertile which makes the inhabitants engage in rainfed agriculture. Several crops are grown in the study area.

3.2.7: Land use types in Dutse

Land use is a primary indicator of the extent and degree to which man has an impression on the earth surface. This reflects political, social and economic aspect of human culture and this provides an index of the intensity of human lifestyle (Mortimore, 1966) in (Garba, 1998).

Furthermore, urban and emerging urban centres represent a complex association of population concentration, intensive economic activities, diverse land uses and lifestyle. These are microcosm of human activities and frequently express rapid change in land use that need be understood (Garba, 1998). Mortimore (1966) in Garba (1998) asserted that the pattern of land use in Kano Region is a reflection of a chain of decision by public authorities concerning the zoning of the different urban activities. The major urban land use in the study area includes agricultural land use, residential, commercial and industrial use.

3.2.7.1: Agricultural Land Use

Agriculture is one most important land use types in the study area. The vast majority of the population of the area engaged in agricultural activities and a substantial percentage of the land area is under agricultural uses. However, the fertility of the soil tends to decrease as one moves from the northern part (Chamo and Balaga area) to southern part (Sakawa area) (Bello, 1991) in (Garba, 1998). Both rainfed and irrigated agriculture are practiced in the study area with rainfed being the major agricultural land uses for both subsistence and commercial purposes. The crops produced under this system include millet, guinea corn, maize and groundnuts. Other crops cultivated under irrigated agriculture which includes onion, tomato, e. t. c.

3.2.7.2: Residential Land Use

Residential problem is one of the first problems encountered by the new government of Jigawa State in Dutse when it was created in 1991. The period of 1979-1983 witnessed an increase in the residential land use in Dutse. This coincided with the time when the government decided to resettle the people of Dutse old settlement (Garu) outside the rocky area (Garba, 1998). Furthermore, the appointment of Dutse as the State capital in 1991escalated the demand for residential land, for this reason a vast area of agricultural land in Yadi and Takur was converted to residential use. In these two areas the government constructed one thousand low cost houses in order to accommodate the public officers who were re-deployed from Kano State and other Federal Government parasatals to Jigawa State for administrative purposes (Garba, 1998).

3.2.7.3: Commercial Land Use

Commercial land use in Dutse is relatively small in proportion due to the limited commercial activities taking place in the area. The commercial center houses the Jigawa line (a transport company), Dutse main market which was expanded recently, Dutse motor park, Cooperative Consumer shop, e. t. c. In order to increase the commercial land use, commercial layouts have been marked and allocated to people to develop and establish their commercial activities. In this regard, various banks and departmental stores are now evident in the state capital.

3.2.7.4: Industrial Land Use

This type of land use is very much limited in Dutse but with the presence of very few blocks and light industries scattered in the capital. Although, the government designated industrial layouts, the recent turn out for this land is relatively encouraging and very promising.

3.3: RESEARCH METHODOLOGY

This section entails type and sources of data, technique of data collection, equipment used, techniques of data analysis and procedures of data analysis.

3.3.1: Reconnaissance Survey

Reconnaissance survey was carried out so as to get acquainted with the study area and interacted with the people on the land use changes of the area.

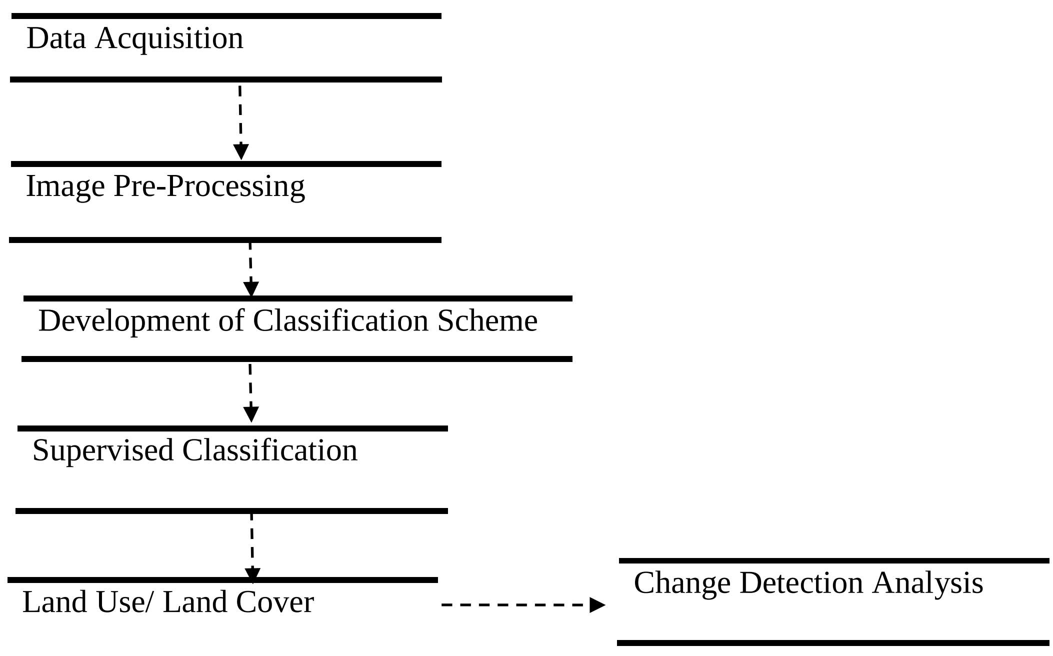

Figure 3.2: A flow chart specifically developed for this study describing the sequence of steps undertaken during the study.

Source: Field study, 2014

3.3.2: Types and Sources of Data

The types of data used for this research are landsat imageries of 1986, 2000 and 2014. Each Landsat scene covered 185x185 square kilometers area. The satellite imageries were obtained from the Global Land Cover Facility, university of Maryland. Dutse town lies on Path 188 Row 52 on World Referencing System. Landsat images are geo-referenced to Universal Transverse Mercator (UTM) map projection and coordinate system.

3.3.2.1: The Primary Data

I. Landsat TM (Thematic Mapper) image of 7th November, 1986 with 30meter spatial resolution which has 7 bands. This was used to determine the extent of urban and other land use/land cover coverage in the area in 1986.

II. Landsat ETM$^+$ (Enhanced Thematic Mapper) image of 11th August, 2000 which possess 8 spectral bands, where bands 1-7 has spatial resolution of 30meters and band 8 (panchromatic band) with a higher spatial resolution of 15meters was used to examine the extent of urban land use and other land use/land cover coverage in 2000.

III. Landsat ETM+ (Enhanced Thematic Mapper) image of 11th March, 2014 with 30meter spatial resolution where band 8 of the spectral bands has a spatial resolution of 15meter was used to determine the area extent of urban and other land use/land cover coverage in 2014.

IV. Ground Control points (GCPs) were obtained using Global Positioning System (GPS) to validate the coordinates of the classified imageries.

3.3.2.2: The Secondary Sources of Data

The secondary source of data includes Map, existing literature from journals, text books, conference proceedings, seminar papers, theses, reports and web references were used for literature review.

3.3.3: Data Processing

Since the satellite images were digitally processed within, they were ortho-rectified there was no need for any geometric and radiometric corrections. The images were obtained in different layers and the layer were stacked together using ERDAS imagine 9.2 software; A subset of the study area was obtained using the ERDAS imagine software subset tool. In addition, the images were geo-referenced using ERDAS imagine 9.2 software geo-referencing tool.

3.3.4: Digital Image Classification

IDRISSI 17.1 Selva Edition software was used for the pixel-based classification. Supervised classification was performed using maximum likelihood classifier since it is a land use/land cover classification which produced the output raster layer. The three images were classified into different land cover types. Supervised classification allowed natural spectral clusters to be distinct with high degree of objectivity. This method of classification involves the procedure of identifying pixels possessing the same spectral features. IDRISSI software was used in digitally processing and identifying the spectral clusters on the Landsat images. By carrying out this classification, the signature editor was used via the classifier icon of the IDRISSI Selva Edition Software to identify the spectral signature of different features. Maximum likelihood algorithm was used to classify the images and the digital numbers of the pixels were grouped with pixels arranged and organized into land cover classes of built-up area, vegetation, bare surface, rock outcrops, cultivated land and water bodies.

3.3.4.1: Classification Scheme

To extract valuable information from the images, development of a land cover classification system was done in order to get the classes of interest. The images were classified as shown in Table 3.1.

Table 3.1: Land Use/ Land Cover Classification Scheme

Classes	Description
Built-up	Residential, Commercial, Industrial, villages
Bare soil/landfill	Exposed soils, landfill, and areas of active excavation and production
Cultivated land	Cleared forest lands and deforested area, Farm lands
Vegetation	Any species of plants (flora), forest
Water bodies	River, lakes and reservoirs
Rock Outcrops	Any type of rock identified

Source: Jensen (2005)

3.3.5: Ground Truthing

Ground truthing of the study area was carried out so as identify different land use/ cover types in the area in relation to the land use/ cover types on the images for accurate and efficient assessment.

3.3.6: Procedure of Analysis

To analyze the extent of land use/land cover coverage in 1986, 2000 and 2014.

The images were classified into various classes based on the classification scheme presented in Table 3.1. The classification gave substantial information needed on the extent of land use/land cover coverage of the study area. The aerial extent land use/land cover were automatically calculated. To compare these sets of data, the resulting values were converted to percentages and used as absolute data for the presentation of urban and land use/land cover coverage.

To determine the rate and magnitude of land use/land cover changes in the area between 1986-2000, 2000-2014 and 1986-2014.

Statistical analysis was used to show the rate and magnitude of the land use/cover changes using the resulting values generated from satellite imagery. To compare these sets of data for 1986, 2000 and 2014, the resulting values were converted to percentage and used as absolute data.

The magnitude of the change was calculated as: C = B-A

Where:

C = is the magnitude of change

B = Base year (1986 and 2000)

A = Reference year

Percentage of changes (E)

$$E = \frac{C}{\text{base year} \times 100}$$

Where

C = magnitude of change

$$\text{Annual rate of change (D)} = \frac{C}{\text{number of years between the period}}$$

Where:

C= magnitude of change of each urban land use divided by the number of years between the periods i.e. 14 years for 1986 and 2000, and 14 years for 2000 and 2014, 1986-2014 for 28 years.

To detect the changes in the land use/cover at different years, post classification comparison of the change detection techniques was used. Singh (1989) stated that the main drawback is that the accuracy of the change maps depends on the accuracy of individual classifications and subject to error propagation (Yuan, Sawaya, Loeffelholz & Bauer, 2005). However, the authors argued that change detection is the most common approach used to compare data from different sources and dates. The advantage of post classification techniques is that it bypasses the associated difficulties with the analysis of images acquired at different times. Also, the post classification answers the amount, location, and nature of change (Howarth & Wickware, 1981). A comparison between the classified maps was carried out subsequently on a pixel-by-pixel basis (Jensen & Ramsey, 1987). Furthermore, the percentage change was identified and the proportion represented by that area for each year (1986, 2000 and 2014). Then to determine the percentage change, it is calculated by dividing the change in area by the initial area multiplied by 100.

To analyze extent to which urban expansion influences land use/land cover change in the area.

The extent to which urban expansion influences land use/land cover change in the area was determined by Land Change Modeller (LCM) change analysis through transition map which shows all the transition that is, the change and spatial trend from all other land use/cover into built-up between classified imageries of 1986-2000 and 2000-2014 and identify how much urban land has increased over the years at the expense of other land use/land cover during the study period.

3.3.7: Software and Hardware

The satellite imageries were digitally analyzed using ERDAS IMAGINE 9.2 software and IDRISSI 17.1 Selva Edition software for the purpose of extracting more information about the study area on changes that have occurred over the period of time under focus. The classified maps were imported into IDRISSI 17.1 software for transition map analysis. The hardware used in this study includes; a printer, scanner, and a system.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1: INTRODUCTION

This chapter looks at the various land use/cover in Dutse urban area. The land use/cover change analysis is based on the satellite imageries of Landsat TM of 1986, Landsat ETM$^+$ of 2000 and 2014. The results of the analysis are presented in the form of maps, tables and bar graphs which formed the basis of discussion.

4.2: LAND USE AND LAND COVER OF DUTSE

The land use land cover of the study area is as presented in Table 4.1 and Figures 4.1 to 4.4. The categories of land use/cover identified in the study area are; bare surfaces, built-up areas, cultivated land, vegetation, rock outcrops and water bodies. Land use/cover in the area was observed to vary among classes. Table 4.1 shows the tabulated land use/cover coverage and the percentages of the various years (1986, 2000 and 2014).

Table 4.1: Land use/cover of Dutse town for 1986, 2000 and 2014

Land use/cover categories	**1986**		**2000**		**2014**	
	Areas in Hectares	***%***	***Areas in Hectares***	***%***	***Areas in Hectares***	***%***
Bare Surface	1958.74	23.3	1577.10	18.8	1679.00	20.0
Built-up	1713.44	20.4	2388.07	28.4	3208.07	38.2
Cultivated Land	2440.17	29.0	2620.24	31.2	2200.09	26.2
Rock Outcrops	823.70	10.0	820.25	9.8	821.28	9.8
Vegetation	1438.36	17.1	960.66	11.4	465.96	5.5
Water Bodies	21.87	0.2	29.96	0.4	21.88	0.3
Total	**8396.28**	**100.0**	**8396.28**	**100.0**	**8396.28**	**100.0**

Source: Author's GIS Analysis, 2014

4.3: LAND USE LAND COVER CHANGE OF DUTSE

It can be observed from Tables and Figures 4.1, 4.2 and 4.3 that the growth rate of Dutse urban area varied with time and class of land use, while in 1986 and 2000 the growth rate is significant, it become higher between 2000 and 2014 due to the population increase and development brought about by becoming the state capital in 1991 and due to urban development usher in by the new government from 2007 to date.

Table 4.2: Magnitude of land use/Cover Change of Dutse

	1986 (Ha)	2000 (Ha)	2014 (Ha)	Magnitude of change 1986-2000 Ha	%	2000-2014 Ha	%	1986-2014 Ha	%
Bare Surfaces	1958.74	1577.10	1679.00	-381.64	-19.5	101.9	6.9	-279.74	-14.3
Built-up	1713.44	2388.07	3208.07	674.63	39.4	820	24.3	1494.63	87.2
Cultivated Land	2440.17	2620.24	2200.09	180.07	7.4	-420.15	-16.0	-240.08	-9.8
Rock Outcrops	823.70	820.25	821.28	-3.45	-0.4	1.03	0.1	-2.42	-0.3
Vegetation	1438.36	960.66	465.96	-477.7	-33.2	-494.7	-51.5	-972.4	-67.6
Water Bodies	21.87	29.96	21.88	8.09	36.90	-8.08	-26.90	0.01	0.05

Source: Author's GIS Analysis, 2014

Table 4.3: Annual rate of Change of Land Use/Cover

Land use/cover Categories	Magnitude of change			Annual rate of change					
	(1986-2000) (Ha)	(2000-2014) (Ha)	(1986-2014) (Ha)	(1986-2000)		(2000-2014)		(1986-2014)	
				Ha	%	Ha	%	Ha	%
Bare Surfaces	-381.64	101.9	-279.74	-27.3	-22.1	7.3	3.53	-9.90	-9.27
Built-up	674.63	820.0	1494.63	48.2	39.1	58.6	44.44	53.4	50.04
Cultivated Land	180.07	-420.15	-240.08	12.9	10.5	-30.0	-22.74	-8.6	-8.05
Rock Outcrops	-3.45	1.03	-2.42	-0.25	-0.2	0.1	0.076	-0.1	-0.09
Vegetation	-477.7	-494.7	-972.4	-34.1	-27.6	-35.3	-26.76	-34.7	-32.53
Water Bodies	8.09	-8.08	0.01	0.58	0.5	-0.6	0.454	0.00	0.00

Source: Author's GIS Analysis, 2014

Built up areas comprises of residential, transportational, recreational, commercial land uses e.t.c. found in the study area. Built up areas increases from 1713.44 hectares (20.4%) to 2388.07 hectares (28.4%) between 1986 and 2000, with magnitude change of 674.63 hectares. The annual rate of change is 48.2 hectares respectively. Further increase from 2388.07 hectares (28.4%) to 3208.07 (38.2%) hectares were witnessed between 2000 and 2014, with magnitudes changes 820 hectares and annual change rate of 58.6 hectares, this is in line with the recent urban development taking place in the area. This is one of the major contributing factors in changing the land use/cover of Dutse town.

The period of twenty eight (28) years from 1986 to 2014 witnessed considerable increase in population in the study area, this can be inferred from the fact that the land area covered by built-up area, comprising of residential, commercial, industrial, recreational and institutional land uses are on the increase, there by affecting other land use/cover categories. For instance, built up areas increases from 20.4% to 28.4% from 1986 and 2000. Further increase from 28.4% to 38.2% was witnessed from 2000 to 2014.

The most dramatic increase and the continuous expansion experienced in built-up area are shown between 2000 and 2014, which coincide with Dutse being the state capital of Jigawa State after its creation from the old Kano in 1991. This results to rapid population growth because of its affordable accommodation for low and middle income workers, low land prices, e.t.c.. The upsurge in population of the area was further enhanced in recent time (i.e from 2007) by the desire of the Jigawa State Government to restore Dutse to its master plan by erecting all forms of new structures within its territory.

Bare surface refers to areas that are exposed and of active excavation and production. They include; institutions play grounds for the use of students, open spaces between buildings and vacant land. Bare surfaces witness a decrease from 1958.74 hectares (23.3%) to 1577.10 hectares (18.8%) between 1986 and 2000 with magnitude changes of -381.64 hectares and annual change rate of -27.3 hectares, this is due to the fact that that the latter imagery was taken during a rainy season which led to the increase in cultivation, and increase in built-up witnessed between the periods. An increase from 1577.10 hectares (18.8%) to 1679.00 hectares (20%) was observed between 2000 and 2014, with magnitude change of 101.9 hectares and annual change rate of 7.3 hectares, due to the fact that built-up area was increasing and bare surface happens to be a component of urban expansion and also due to the drastic decrease in vegetation in the area which pave way for urban development.

Vegetation includes forest, shrubs and tall grasses found in any part of the study area, especially at the fringes of the urban area where cultivation and settlements have not occurred. Result from the analysis shows that vegetation covered a substantial part of the study area in 1986. This has drastically decline from 1438.36 hectares (17.1%) to 960.66 hectares (11.4%) between 1986 and 2000 with magnitude change of -477.7 hectares and annual change rate of -34.1 hectares. It further decline from 960.66 hectares (11.4%) to 465.96 hectares (5.5%) between 2000 and 2014 with magnitude changes of -494.7 hectares and annual change rate of -35.3 hectares, this is attributed to the fact that there was increase in built-up area, bare surfaces and cultivation between the periods and could also be attributed to the time the imagery was taken and this led to exaggeration due to the classification. Aliyu (2005) in an assessment of land use changes in Dutse between 1976 and 2000 revealed that there was vegetation loss of about 37% in the study area between the study periods which coincides with the drastic loss of vegetation as asserted by this study.

Vegetation is fast disappearing due to the effect of human activities and increase in built up area. This result is inferred on the fact that increase in population due to the influx movement of people to Dutse result to increase in demand for shelter as such natural vegetation is been cleared for built up area. Also, fuel wood represents the traditional energy source in use especially by the indigenous people and the low income in general. It is used as the main source for cooking at homes and in the catering industry, bakeries and restaurant. Access to fuel wood is either by cutting trees directly from the nearby vegetation or from the cleared vegetation for construction sites and agricultural development. This further enhanced or led to the decrease in natural vegetation in the area.

Cultivated land includes farm lands and all agricultural practices found in the study area. Cultivated land witnesses an increase from 2440.17 hectares (29%) to 2620.24 hectares (31.2%) between 1986 and 2000, with magnitude changes of 180.07 hectares and annual change rate of 12.9 hectares. This is due to the fact that the latter imagery was taking during a rainy season where there is all likelihood of increase in cultivation. Thereafter, it decreases from 2620.24 hectares (31.2%) to 2200.09 hectares (26.2%) between 2000 and 2014 with magnitude changes of -420.15 hectares and annual change rate of -30.0 hectares respectively, this attributed to the slight increase in bare surfaces and increase in built-up area witnessed between the periods. The conversion of cultivated land to build up area is rapid. Cultivated land witnesses an increase from 29% to 31.2% between 1986 and 2000, with annual change rate of 12.9 hectares. Thereafter, decreases from 31% to 26.2% between 2000 and 2014 with annual change rate of -30.0 hectares respectively. This is a thing of concern because the vast majority of the people of the area engaged in agricultural activities and there is need for a solution in order to do away with the issue of food security that is making the waves all over Sub-Saharan Africa.

This result implies that between the period of 2000 and 2014, there is a decrease in agricultural activities likely due to the changes in the occupation of the work force of the area. The people are taking advantage of the state capital for employment opportunity. The creation of Jigawa State and Dutse as its capital from the old Kano state in 1991 creates employment opportunities due to the massive construction work, wide spread commercialization of local economy and rapid urban expansion, as such the youths of this area and other migrants move to the city in search for a greener pasture, there by abandoning agricultural activities for women and old people. Aliyu (2005) in his assessment of land use changes in Dutse between 1976 and 2000 revealed that there was agricultural land loss of about 7% between the study period which is in line with this study that revealed a decrease in agricultural production of about 5% between 2000 and 2014.

The rock outcrops form part of the numerous hills and granite Inselbergs that can be seen in the study area. Rock out crops slightly decreases from 823.70 hectares (10%) to 820.25 hectares (9.8%) between 1986 and 2000 with magnitude changes of -3.45 hectares and annual change rate of -0.25 hectares; this could be due to quarrying for urban expansion and effect of weathering between the periods. Furthermore, slight increase was experienced from 820.25 hectares (9.8%) to 821.28 hectares (9.8%) between 2000 and 2014 with magnitude changes of 1.03 hectares and annual change rate of 0.1 hectares respectively; this could be attributed to the fact that erosion might have exposed the rocks over the years.

Water bodies comprises of rivers, ponds, lakes, reservoirs and marshy areas. Water bodies cover 21.87 hectares (0.2%) of the study area in 1986. It then increases and by 2000 it covered 29.96 hectares (0.4%) indicating a magnitude change of 8.09 hectares and annual change rate of 0.58 hectares, this could be attributed to the fact that, the time the latter imagery was taken which was a rainy season led to the seasonal erosion or flooding experienced by water bodies. It later decreases to 21.88 hectares (0.3%) in 2014 with magnitude changes of -8.08 hectares and annual change rate of -0.6 hectares respectively. This could also be attributed to climate fluctuation and the increase demand of water by the fast growing population of the area for irrigation and other uses. Most of the streams are decreasing or are seasonal while the size of the rivers and other water bodies are changing.

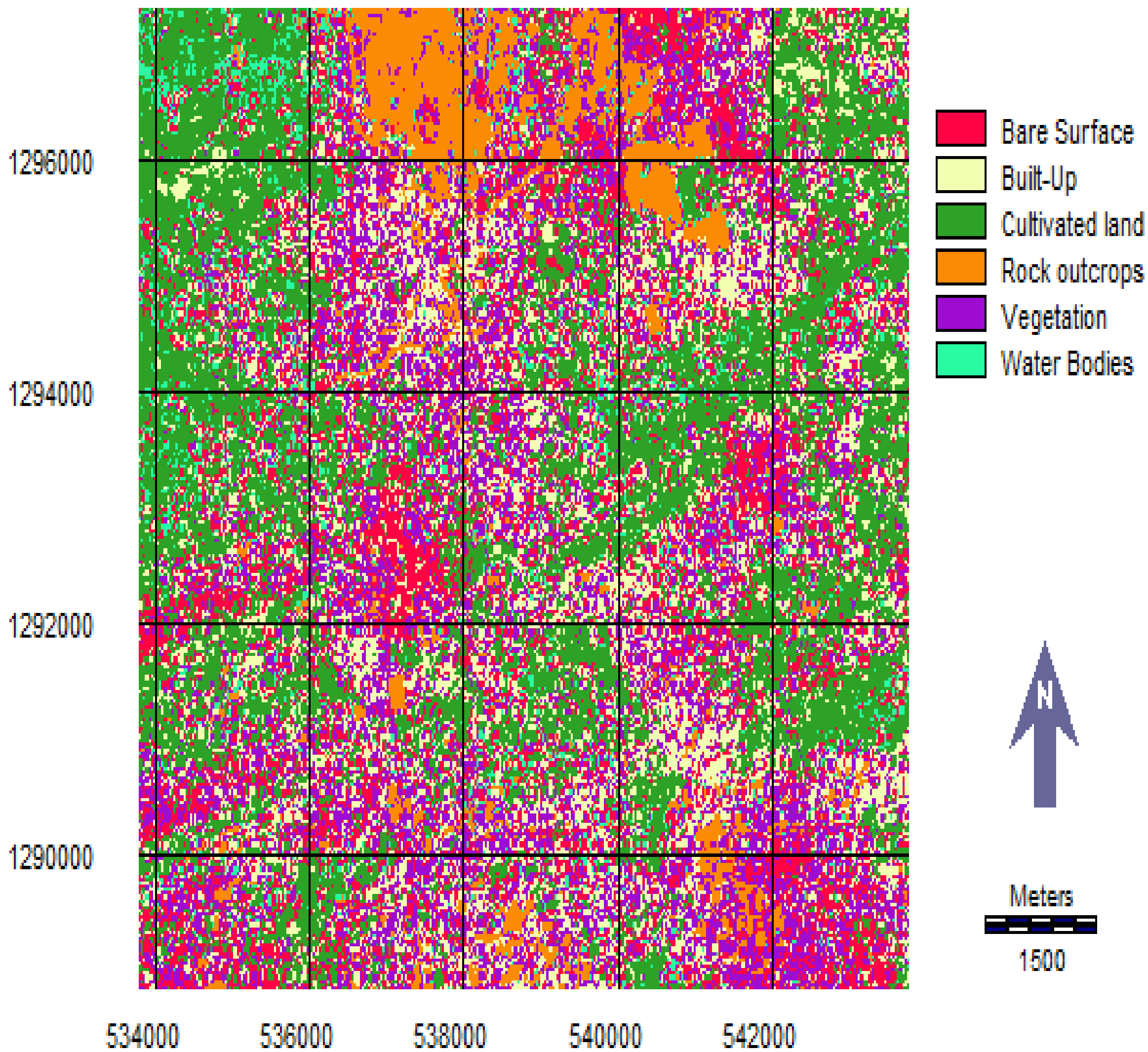

Figure 4.1: Land Use Land Cover Map of Dutse 1986

Source: Author's GIS Analysis, 2014

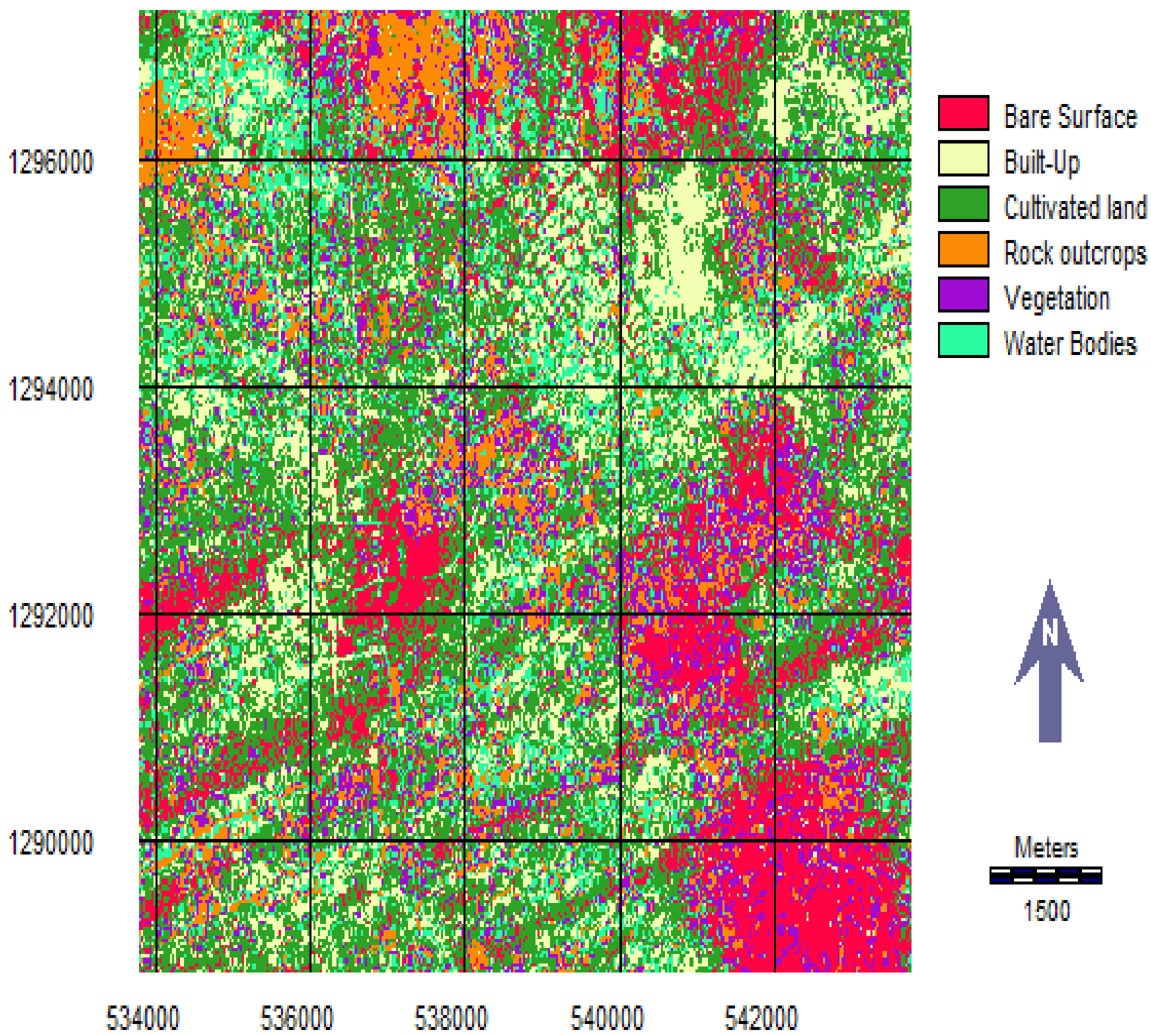

Figure 4.2: Land Use Land Cover Map of Dutse 2000

Source: Author's GIS Analysis, 2014

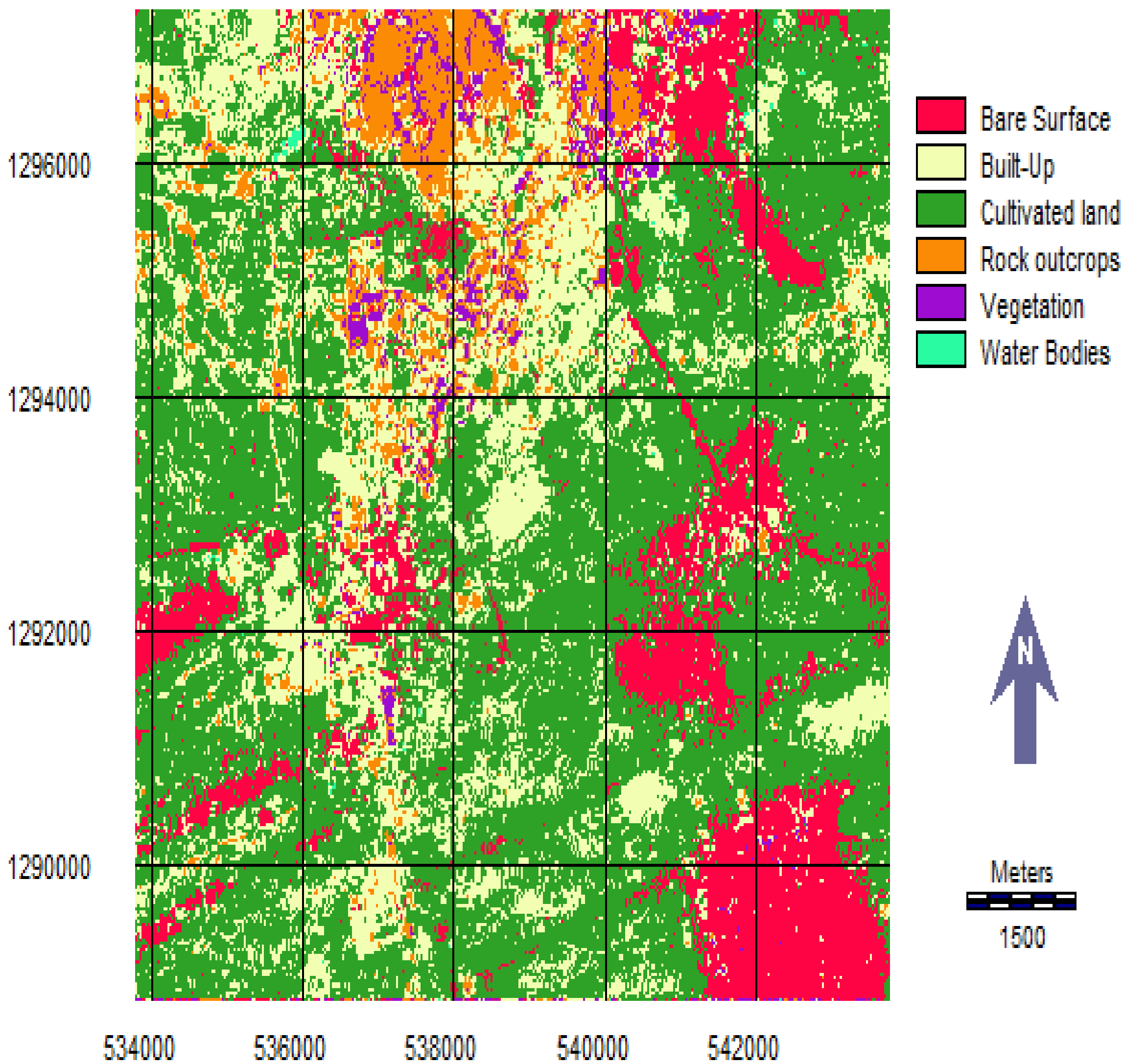

Figure 4.3: Land Use Land Cover Map of Dutse 2014

Source: Author's GIS Analysis, 2014

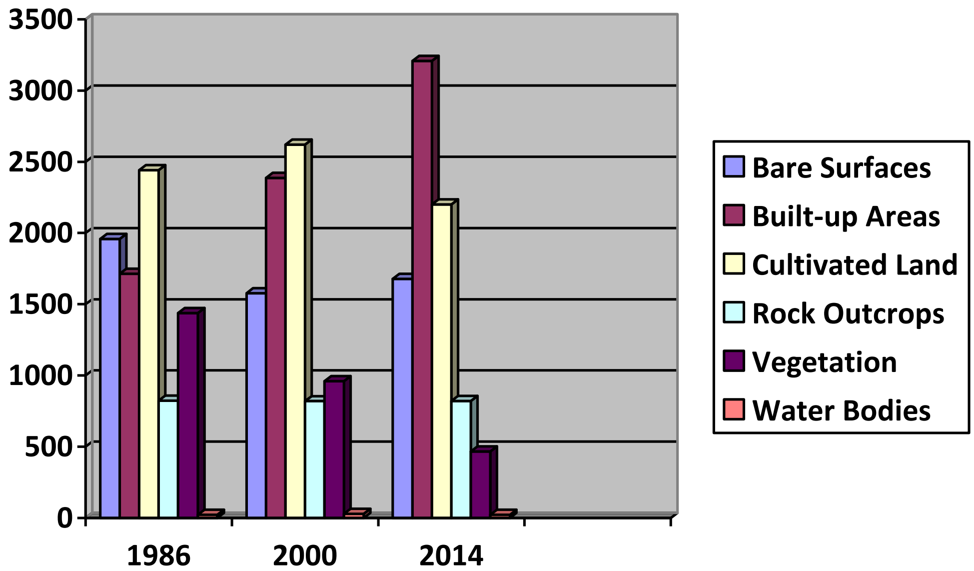

Figure 4.4: Land Use/land Cover Change From 1986 to 2014
Source: Author's GIS Analysis, 2014

4.4: TRANSITION FROM LAND USE/COVER INTO BUILT-UP

This is one of the unique capabilities of IDRISSI 17.1 Selva Edition that is of analyzing the transition that takes place from one form of land use/cover into built-up within the study period. This will go a long way in showing the extent to which urban growth influences other land use/cover within the study period. Table 4.4 shows the tabulated transition from other land use/cover coverage into built-up.

Table 4.4: Transition of Land use/cover into Built-up area of Dutse town between 1986-2000, 2000-2014 and 1986-2014

Land use/cover Categories	1986-2000		2000-2014		1986-2014	
	Areas in Hectares	%	Areas in Hectares	%	Areas in Hectares	%
No data	7292.41	86.9	7117.53	84.8	6049.06	72.0
Bare/S	273.06	3.3	364.00	4.3	601.66	7.2
Cultivated/L	591.30	7.0	653.58	7.8	1244.88	14.8
Rock /O	58.50	0.7	57.63	0.7	116.13	1.4
Vegetation	178.78	2.1	202.14	2.4	380.92	4.5
Water/B	2.23	0.0	1.40	0.0	3.63	0.1

Source: Author's GIS Analysis, 2014

From the results obtained, it shows a category that represents "No Data", this category entails other land use/cover that remained the same and changed into other land uses other than built-up and the built-up coverage within the study period, this covers 7292.41 hectares (86.9%) from 1986-2000, 7117.53 hectares (84.8%) from 2000-2014 and 6049.06 hectares (72.2%), as shown in Table 4.5 and Figures 4.5, 4.6 and 4.7.

The result revealed that bare surfaces changed into built-up of about 273.06 hectares (3.3%) from 1986-2000, 364.00 hectares (4.3%) from 2000-2014 and 601 hectares (7.2%) from 1986-2014, as shown in Table 4.5 and Figures 4.5, 4.6 and 4.7.

Cultivated land as obtained from the result shows that about 591.30 hectares (7.0%) from 1986-2000, 653.58 hectares (7.8%) from 2000-2014 and 1244.88 hectares (14.8%) from 1986-2014 changed into built-up, as shown in table 4.5 and figures 4.5, 4.6 and 4.7.

Rock outcrops changed into built-up of about 58.50 hectares (0.7%), 57.63 hectares (0.7%) and 116.13 hectares (1.4%) from 1986-2000, 2000-2014 and 1986-2014 respectively, as shown in Table 4.5 and Figures 4.5, 4.6 and 4.7.

The satellite imagery results revealed that vegetation changed into built-up of about 178.78 hectares (2.1%), 202.14 hectares (2.4%) and 380.92 hectares (4.5%) from 1986-2000, 2000-2014 and 1986-2014 respectively, as shown in table 4.5 and figures 4.5, 4.6 and 4.7.

Water bodies results as obtained from the imagery shows that about 2.23 hectares (0.0%) from 1986-2000, 1.40 hectares (0.0%) and 3.63 hectares (0.1%) from 2000-2014 and 1986-2014 changed into built-up respectively, as shown in table 4.5 and figures 4.5, 4.6 and 4.7.

This change analysis uses the Land Change Modeller (LCM) which shows the spatial trend of the change between 1986-2000, 2000-2014 and 1986-2014 from the classified maps and bar chart graph, as shown in figure 4.5, 4.6, 4.7 and 4.8.

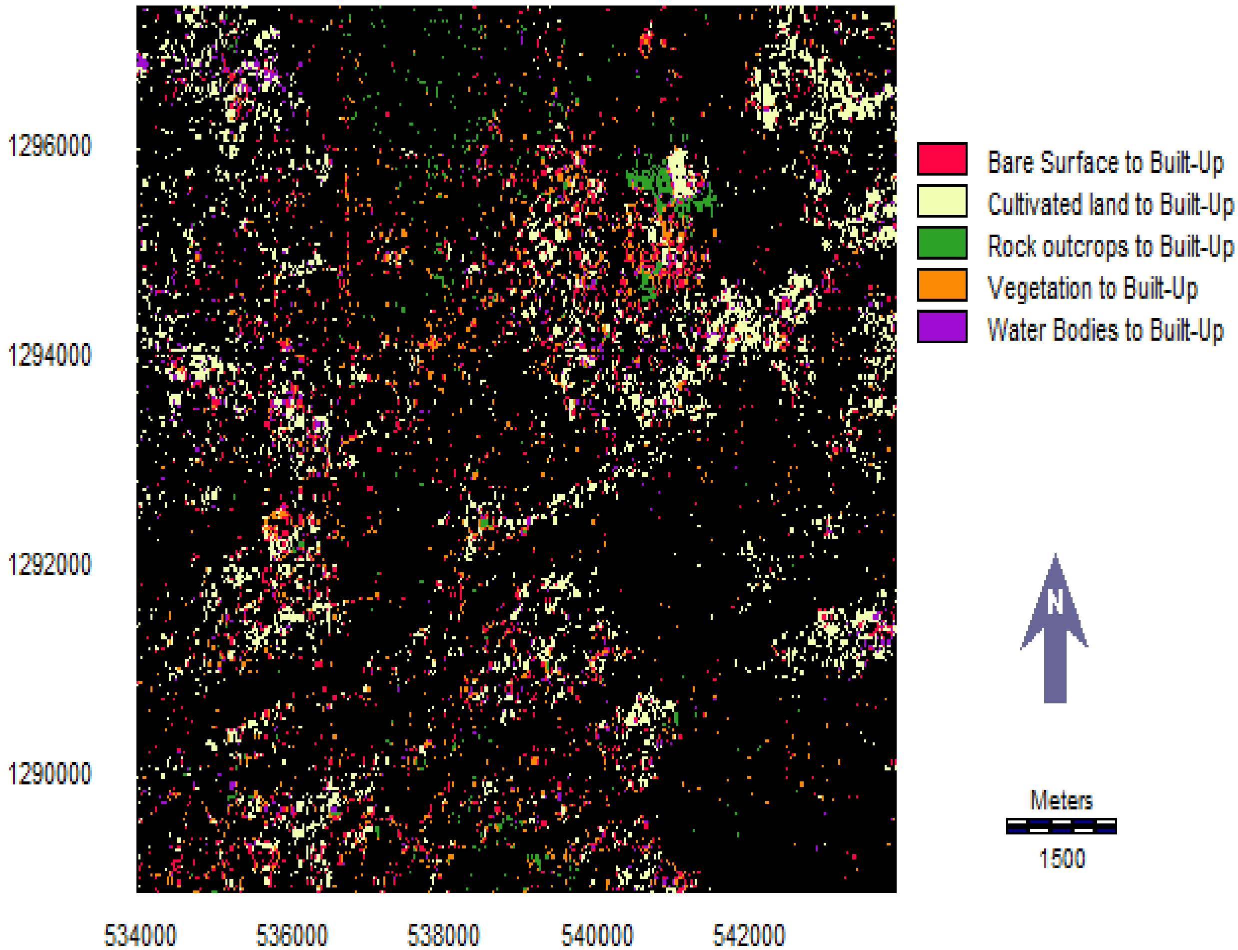

Figure 4.5: Transition from Classified Land Use/Cover map to built-up of Dutse for 1986-2000

Source: Author's GIS Analysis, 2014

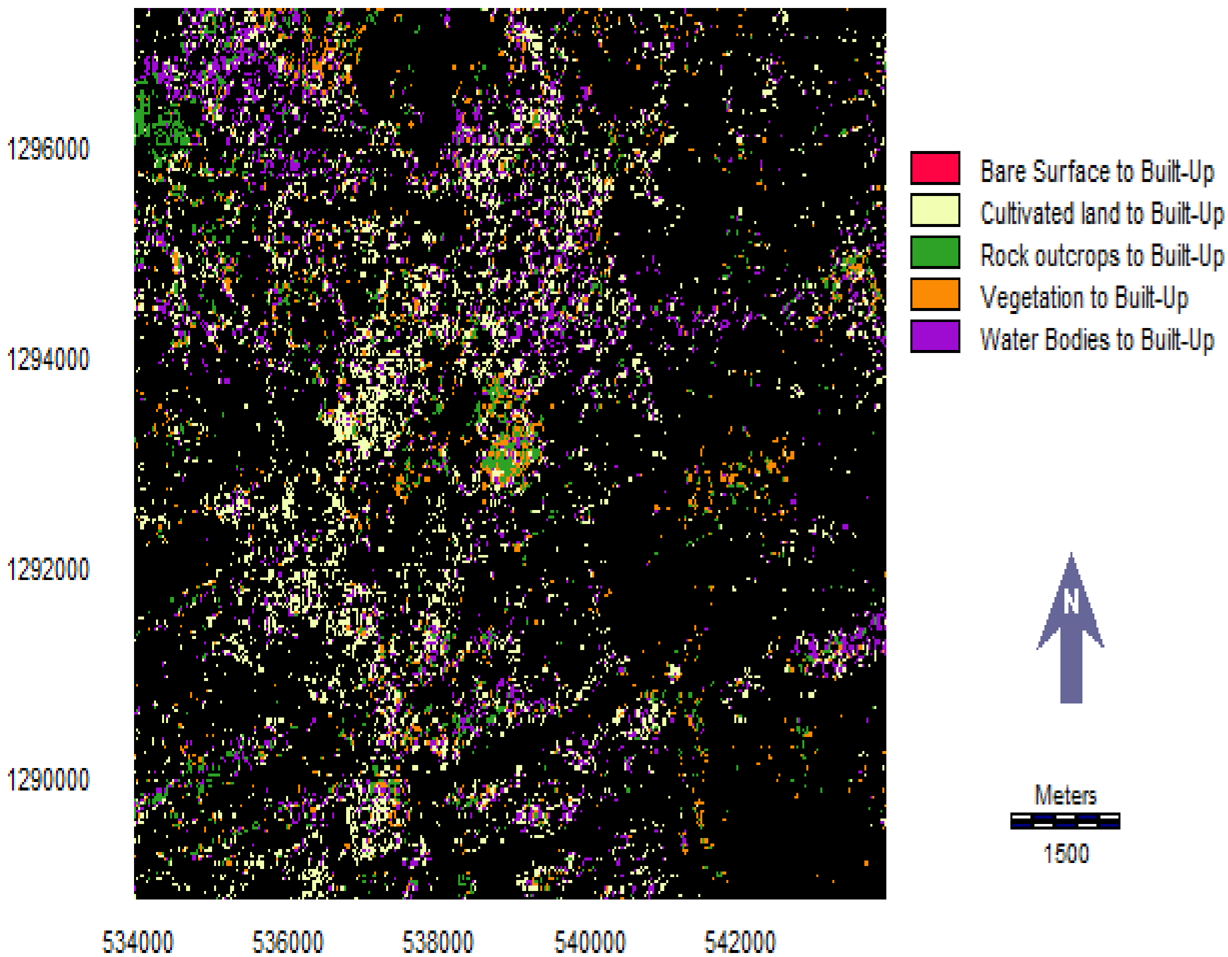

Figure 4.6: Transition from Classified Land Use/Cover map to built-up of Dutse for 2000-2014

Source: Author's GIS Analysis, 2014

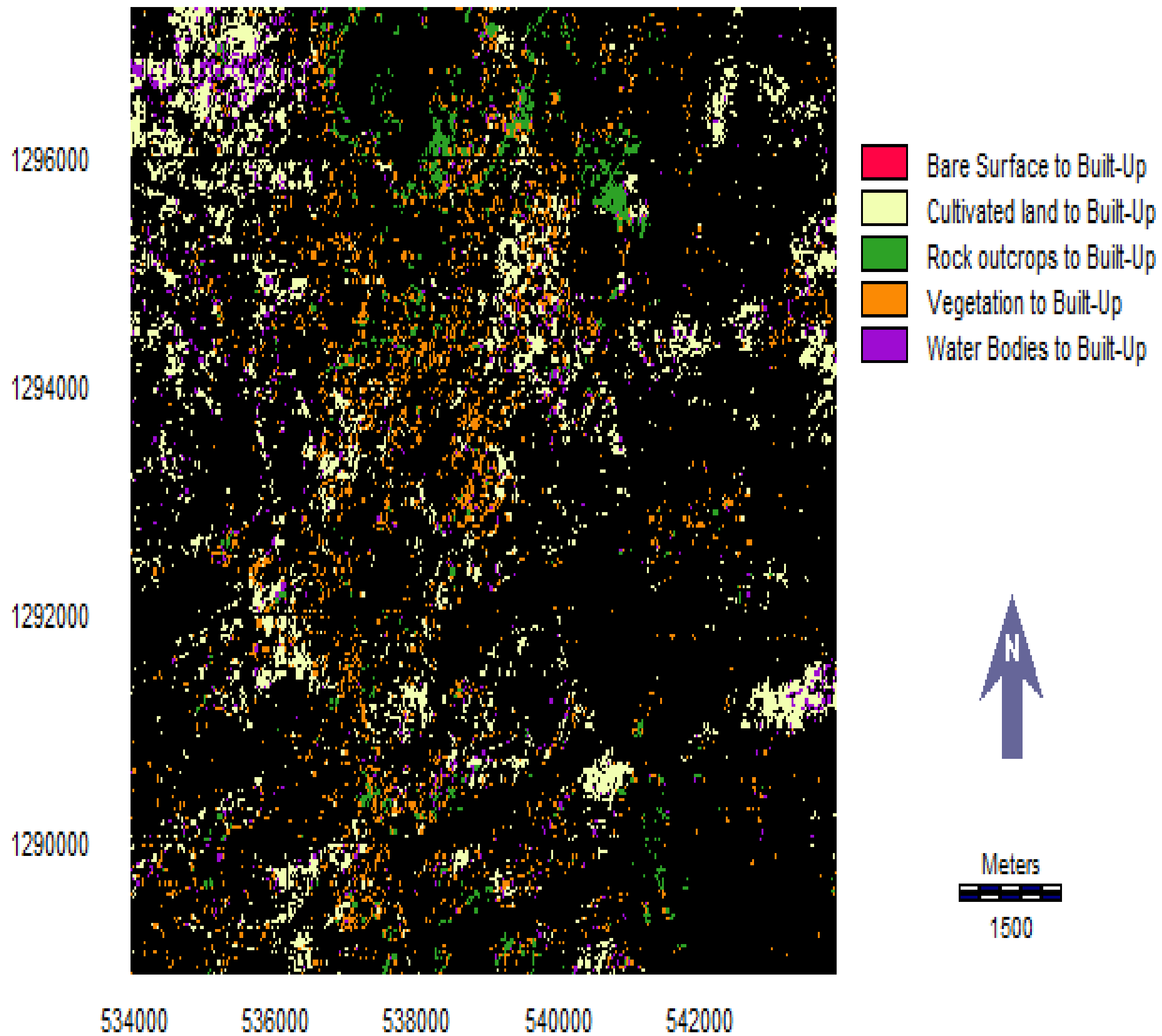

Figure 4.7: Transition from Classified Land Use/Cover map to built-up of Dutse for 1986-2014

Source: Author's GIS Analysis, 2014

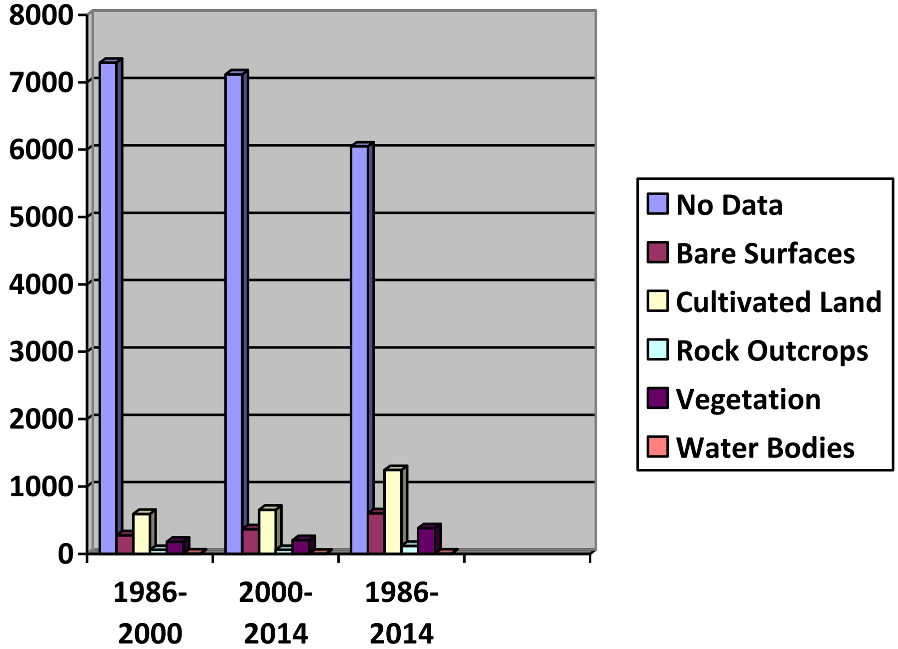

Figure 4.8: Transition from Land Use/Cover Change to built-up from 1986 to 2014
Source: Author's GIS Analysis, 2014

It is seen from the foregoing results obtained as shown in the transition maps that other land use/cover classes changed into built-up which led to urban land use changes experienced within the study period. It is observed that bare surfaces changed into built-up of about 273.06 hectares from 1986-2000, 364.00 hectares from 2000-2014 and 601 hectares from 1986-2014, this shows that bare surfaces have been fluctuating over the span of the study period which led to its reduction at expense of increase in built up area.

Cultivated land as obtained from the result shows that about 591.30 hectares (7.0%) from 1986-2000, 653.58 hectares (7.8%) from 2000-2014 and 1244.88 hectares (14.8%) from 1986-2014 changed into built-up and this is attributed to the fact that urban expansion was experienced within the study period at the expense of the cultivated land. This led to the reduction in cultivated land except in year 2000 that a slight increase was experienced due to the time the imagery was obtained and the economic activity engaged by the people of the area.

Rock outcrops changed into built-up of about 58.50 hectares (0.7%), 57.63 hectares (0.7%) and 116.13 hectares (1.4%) from 1986-2000, 2000-2014 and 1986-2014 respectively. This is due to the fact that quarrying for urban expansion is taking place in the area and the effect of weathering might have taken its cause within the study period. Though, the decrease experienced is minimal which solely represent urban expansion that is taken place at the expense of rock outcrops in the study area.

As revealed by the results obtained from the analysis vegetation changed into built-up of about 178.78 hectares, 202.14 hectares and 380.92 hectares from 1986-2000, 2000-2014 and 1986-2014 respectively. This is attributed to the fact that vegetation is cleared due to urban expansion for developmental purposes and it also affirms the fact that vegetation is decreasing throughout the study period at the expense of built-up areas.

The transition maps revealed that water bodies of about 2.23 hectares (0.0%) from 1986-2000, 1.40 hectares (0.0%) and 3.63 hectares (0.1%) from 2000-2014 and 1986-2014 changed into built-up respectively. This is minimal because of the fact that it is unlikely for a substantial amount of water bodies to change into built-up but rather into bare surfaces when it dries up, cultivated land or vegetation as confirmed by the results.

Based on the foregoing results and discussion it is very clear that the objectives of the study have been achieved as the extent of land use/cover coverage, rate and magnitude of land use/cover and the extent to which urban spatial growth influences other land use/cover in the study area have been known and established using geospatial analysis.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMMENDATIONS

5.1: INTRODUCTION

This chapter presents the summary of the study and conclusion. Recommendations of the study were also presented.

5.2: SUMMARY OF THE STUDY

This study established the capabilities and usefulness of Remote Sensing and GIS in the study of land use/cover change of Dutse town, Jigawa State, Nigeria. The study make use of Landsat TM satellite image of 1986, Landsat ETM$^+$ satellite image of 2000 and 2014 respectively to determine the changes on land use/cover of the study area that have occurred over the years. The study also makes use of Global Positioning System to acquired data in order to validate the data collected from the imageries. ERDAS IMAGINE 9.2 and IDRISSI 17.0 the Selva Edition software were used for data analysis using digital image processing algorithm and spatial analyst tool of the above mentioned software packages. Post classification comparison and Land Change Modeller (LCM) change analysis were also used.

Findings from the results of this study revealed there were changes in land use land cover of the study area, transition from built-up areas into other land use/land cover categories. The most dramatic increase and the continuous changes experienced in built-up area are shown between 2000 and 2014. It coincides with Dutse being the headquarters of Jigawa State created in 1991 from the old Kano State. The town has affordable accommodation for low and middle income workers and low land prices which contributed to the land use/cover changes in the area. The resulted changes in land use/cover categories between 1986 and 2014 are as follows: bare surfaces witness a decrease from 23.3% to 18.8% between 1986 and 2000. An increase from 18.8% to 20% was observed between 2000 and 2014. Built-up areas from 20.4% to 28.4% between 1986 and 2000. Further increased from 28.4% to 38.2% were witnessed between 2000 and 2014. Cultivated land witnesses an increase from 29% to 31.2% between 1986 and 2000. Thereafter, it declined from 31.2% to 26.2% between 2000 and 2014. Rock out crops slightly decreases from 823.70 hectares (10%) to 820.25 hectares (9.8%) between 1986 and 2000. Furthermore, slight increase was experienced from 820.25 hectares (9.8%) to 821.28 hectares (9.8%) between 2000 and 2014. Vegetation has drastically declined from 17.1% to11.4% between 1986 and 2000. It further 11.4% to 5.5% between 2000 and 2014. Water bodies covered 0.2% in 1986. It then increases and by 2000 it covered 0.4%. It later decreases to 0.3% in 2014.

It is a general trend for land use/cover to change indiscriminately from one type to another type over a period of time. For example, the conversion of land use/cover into built-up that is evident in this study. Hence, this study has revealed the changes in land use/cover in Dutse town between 1986-2014 using geospatial analyses.

5.3: CONCLUSION

The use of geospatial analysis in this study revealed changes in land use land cover due to continuous expansion, construction work and urbanization of the area as a result of the creation of Jigawa State in 1991. This has imposed significant pressure on the environment and natural resources with serious implications on spatial organization within the area. The search for a way forward will therefore require a synthesis of present situation and the identification of options for feasible intervention. The aim is to cater for the present with the future in mind through approaches that are financially, technically and environmentally suitable. It is paramount that such approaches should reflect important considerations of the environmental effects and the use of locally available human and natural resources. Meanwhile, it is clearly evident that land use land cover changes have taken place in the area.

5.4: RECOMMENDATIONS

i)- There is need for Jigawa State Government to equip the planning authorities and other ministries involved in decision making with adequate spatial data to ensure broad based decisions. This can be achieved by investing in the acquisition and management of remotely sensed data and Geo-Information Technology in order to develop a data base which will enhance the management of land use/cover in the area.

ii)- More studies can be conducted in the study area using satellite imageries with higher spatial resolution.

iii)- Land use suitability analysis of the study area is also recommended.

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