MSC THESIS

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MONITORING CHANGE OF URBAN GROWTH USING REMOTE SENSING AND GIS TECHNIQUES A CASE STUDY OF KANO CITY, NORTHERN NIGERIA

BY

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Declaration

I declare that this dissertation is the result of my own independent work. Where I made reference to other people's work, I have indicated my acknowledgement to the sources.

Signed …………………………... (TANIMU ISAH)

Date ……………………………

Dedication

I dedicate this work to my beloved Mother, Hajiya Khadija Isah.

Acknowledgement

I am grateful to God for giving me health and the ability to complete this thesis. I would like to express my gratitude to my supervisor Dr David Kidner, who guided me at the study area during data collection and also during data analysis processes within GIS environments. I would also like to express my appreciation to my second supervisor Dr Mitch Langford. I am grateful to Professor Abba Abubakar Haladu and Dr Ahmad Ali Yakasai both Lecturers from Bayero University Kano for the assistance rendered during my studies.

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Abstract

Urban growth and expansion is among the major phenomena of study globally. This study examines the urban growth of Kano, which is the largest city in northern part of Nigeria and the second most populace city in the country according to the 2006 Nigerian National population Census. Two satellite imageries (ETM+1999 and ETM+2003) and demographic data were used for the study. Supervised and unsupervised image classification technique were applied to the two images and the after the image were spectrally and spatially enhanced. ERDAS imagine remotely sensed software was used for classification, and ArcGIS 10.1 was used to export the analysed images as maps. Google map, Historical map, and prior knowledge of the study area were used as referenced data for the classification. Four land use classes were used by the study, i.e. built up area, vegetation, bare surface and water body. The Digital Elevation Model (DEM) of the study area was prepared from the SRTM data using Arc-scene functions ArcGIS 10.1 software. The terrain elevation has connection with urbanisation and result displayed the topographic view and elevation of the study area, the study made a significant reference to historical map to trace the history of the city's growth, this study used the final change detection tools available in ERDAS imagine for the creation of change detection map

The study obtained good result of some increased area and some decreased area results from both images data of the two different dates, that is 1999 image and 2003 image was merged as an input to produce one image of change detection results. Post classification analysis was used in order quantify the changes that took place during the period of the study. The findings revealed that built-up areas had increased by 25.36% between 1999 and 2003, while the vegetation cover and bare land were decreased by 25.47% and 3.64% respectively. Both remote sensing and GIS techniques was fully demonstrated in this study, and the thesis had provides (from the analysis) a supporting data and good information that could be used for decision making in urban planning and general environmental studies.

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List of Abbreviations

LU	Land use
LC	Land Cover
GIS	Geographical Information Systems
ERDAS	Earth Resources Data Analysis System
ETM+	Enhanced Thematic Mapper Plus
PCA	Principal Component analysis
UNDESA	United Nations Department of Economic and Social Affairs
UNEP	United Nations Environmental Programme
UNDP	United Nations Development Programme
NDVI	Normalized Different Vegetation Index
SRTM	Shuttle Rader Topographic Mission
DEM	Digital Elevation Model
FAO-UN	Food and Agriculture Organization of the United Nations
UNESCO	United Nations Educational scientific and Cultural Development
GRA	Government Reserve Areas
NPC	National Population Commission
KASEPPA	Kano State Urban Planning and Development Board
USGS	United State Geological Survey
UNOOSA	United Nations Office for Outer Space
FAOUN	United Nations Food Agricultural Organisation
NASA	National Aeronautics and Space Administration
LANDSAT	United States Geological Survey
AVIRIS	Advance Visible/Infrared Imaging Spectrometer
MERIS	European Space Agency Medium Resolution Spectrometer
MODIS	Moderate Imaging Spectrum Radiometer
ASTER	Advanced Space borne Thermal Emission and Radiometer
UN-(Habitat)	United Nations Human Settlement Programme
UNCHS	United Nations Human Settlement Programme

EIA	Environmental Impact and Assessments
MDG	Millennium Development Goals
ISODATA	Interactive Self-organising Data Analysis
NDVI	Normalized Different Vegetation Index
NTR	near Infrared Band
RED	Red Band
PCA	Principal Components Analysis
DEM	Digital Elevation Model
LIDAR	Light Detection and Ranging
OSGB	Ordnance Survey of Great Britain
SRTM	Shuttle Radar Topography Mission
USGS	United States Geological Surveys
NGA	Geospatial intelligence Agency
DN	Digital Numbers
RGB	Red, Green, and Blue
IHS	Intensify –Hue- Saturation

CHAPTER 1: INTRODUCTION

1.0 Background

Urban growth is a global phenomenon that is caused by humans' action with current reduction of agricultural land (Lopez, et al. 2001), deforestation (Alphan, 2003), that reduces plants growth. This is as a result of population growth, cities expansion that results to the conversion of rural areas and agricultural lands to urban built up areas particularly in the developing countries of the world (UN-Habitat, 2003), it is clear evidence in China and other Asian countries. Nigeria is among the developing countries with rapid population and urbanisation growth, and some major cities like Kano are experiencing this urban growth and expansion. Kano is a commercial city in northern Nigeria with rapid urbanisation which is associated with urban problems like, unemployment, inadequate water supply, and traffic congestion.

Urban expansion requires development of Land Use and Land Cover Change (Musa, 1994).Very high urbanisation and towns expansion in most of developing countries has been discovered as the major causes of land use and land cover (LU/LC) changes (Odjo, 2007, Oyinloyye, and Adesina, 2006). As urbanisation is the major agent of land use and land cover (LU/LC) change detection of some important information that are needed in the process of monitoring cities using GIS and remote sensing application for analysis in the process of projecting the trends of future land use and land cover changes, and the causes of urbanisations in most of developing countries particularly in Africa. This is because of unawareness of data sources in government organisations and institutions of higher learning. There are serious limitations of remote sensing, and Geographical Information Systems (GIS), in developing countries particularly in the area of technical know-how on how to get a good data for GIS analysis which will be use for extracting meaningful information from the data, (Okpala, 1983, Adesina, 2005). However, according to Stren, (1994) there was a setback of economic resources in the academic institutions of higher learning particularly universities to conduct a research in remote sensing and Geographical Information Systems, (GIS). The second reason is political instabilities in some developing countries which hinder the successful development of Remote Sensing, GIS application and data sources as well as data collection, with main advantage of monitoring urban growth and the provision of thematic mapping so as to provide the bedrock of development with good information to policy makers, administrators which will be used for other development control, planning review of urban area. That is why the remote sensing (RS) and Geographical Information Systems (GIS) are needed. The data capture and analysis with the use of these powerful tools to achieve the objectives. Data capture, analysis and evaluation will be used to provide thematic maps and graphs of the study area. The result will serve as a useful information to policy makers and urban studies of both land use and land cover change (Geneletti, and Gorte, 2003). The use of land sat ETM+ of 1999 and land sat ETM+ of 2003 to assess the rate of changes in Kano metropolis with the change detection discovered at eastern bypass of the study area and some other changes within the study period. Some supporting data apart from images used as reference guide as well as data capture and data collections, the result of unplanned growth in Kano affect the spatial shape of the land use. This is because of the uncontrolled development and lack of information technology of data acquisition like Remote Sensing and GIS (Ikhuoria, 1995).

1.1 Remote sensing Application in land use and land cover change

Urban landscape change using remote sensing application and techniques is useful in environmental changes particularly in this study of urban land use and its infrastructure. The remote sensing application will be used for extracting changes that occur over period of time in the study area and may be use for global or regional studies such as global monitoring vegetation cover, global food change as well as regional resource management using change detection analysis in remote sensing application by the Global Monitoring Report 2013(MDG, 2013). Available at http://econ.worldbank.org/

Remote sensing techniques are very good in data capturing and analysis in the process of quantifying the nature of urbanization and rapid growth. An image resolution of both temporal and spatial are now an important methods of challenging urban problems by creating a thematic mapping for the general environment within the study periods by producing outcomes from the study and guides to policy makers, (Miller and Small, 2003).

Remote sensing has significant role in urban studies and its capable of monitoring changes in the general environment. Base on the image resolution, remote sensing images provide quality data particularly a very high resolution image which provides successful mapping of an urban area. Generally, the applications requires two different date images for comparison in the process of monitoring changes and bring out good result for decision making in solving some problems related to the urban growth and town plan against the uncontrolled development.

1.2 Change Detection

This refers to the way of identifying changes on the environment phenomenon and the physical features of the environment. Some remote sensing techniques tools are used in measuring changes when comparing two different date satellite images to extract meaningful information on the output images, (Green et al. 1994).

1.3 Image Transformation

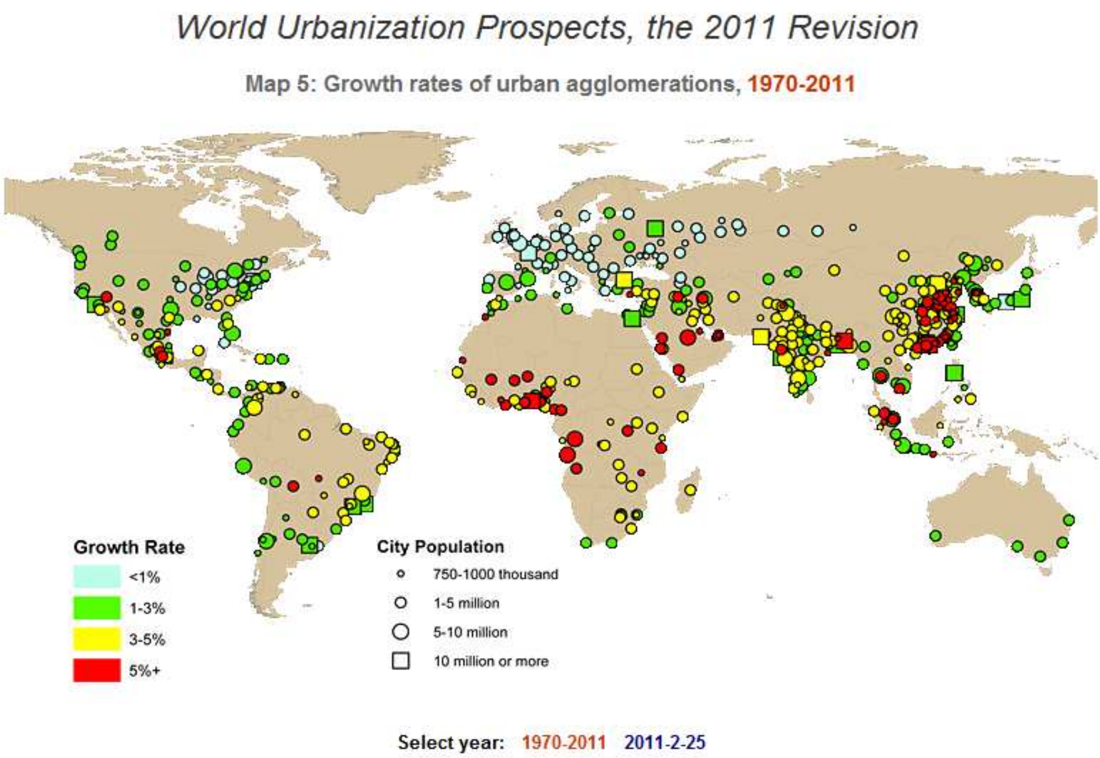
This is an important techniques in remote sensing that are very relevant and useful to land use and land cover studies when the principal component analysis, (PCA) has good advantage and capable of reduction of data redundancy that are usually within image bands in order to have component information. These famous techniques point out areas in the process of identifying changes on the two different date images. One of the short coming of principal component analysis is very difficult to interpret the change detection about the details information obtained and the information on the transform output images.

1.4 Geographical Information Systems (GIS), Application in LU/LC Change

The Geographical Information Systems (GIS) application, plays significant role in Urban change detection of land use and land cover studies that involves the use of GIS software of both remote sensing and GIS techniques with powerful tools that has the capacities of incorporating different data set particularly in this study. When historical map of the study area was collected during the data collection at the study area, the collected data was processed in GIS techniques as a source data in line with the objectives of this study of identifying the land use and land cover changes in the study area. This Geographical Information Systems (GIS) application has important advantage of using powerful function with good example of ArcGIS software that has good tools for multi-source data processing of the change detection studies to the Geographical Information Systems (GIS) .This analysis involves data accuracy and those formats that usually affect the change detection analysis results.

1.5 Urban Context

Urban studies in remote sensing is an old study and early application with evolution of aerial photograph which used in urbanisation up to date inventory of different satellite images of different sources from different nationalities. Discovering the up to date geographical features with modern technologies of computer application despite the complex of urban systems helps in urban management, control and planning, by the United Nation department of economic and social affairs, (UNDESA). Available at http://esa.un.org/unup/Maps/maps_1970_2011.htm



Figure; 1 showing World growth rate, (source; UNDESA, 2012)

1.6 The Research Problem

The recent growing volume of urban areas in Kano metropolis requires standard urban planning due to the high increase of unplanned growth is calling the attention of planning authorities than any other urban problems and is quite clear problems that affect that area within and outside the metropolitan city of Kano.

Urbanisation is usually associated with compounded environmental problems. The study area has this environmental problems which resulted into environmental degradation because of high urbanisation that usually affects the natural ecosystem of conservation programme of forest cover or game reserve that are usually converted into urban areas for residential and commercial purpose and other urban infrastructures for what they said is urban development which on the other hand affects the natural environment which results into environmental degradation(United Nation Environmental Programme, (UNEP). Available at http://www.unep.org/

1.7 Study Area

Kano is semiarid region in sub-Sahara West Africa. It is dominantly commercial centre in the whole in Nigeria (Sani, and Sulaiman,2011). Kano share common boundary with some Northern States in Nigeria at East with Jigawa state, West with Katsina state, North with Bauchi state and border with Kaduna state at the southern part with the coverage area of 20,760 KM^2 and 1,754,200 hectares. It is dominantly agricultural land use with total of 75,000 hectares area Forest cover and Animal grazing land (UNDP,2004). The Geographical location is between latitude 11^0 5N to 12^0 7N and the longitude of 8^0 23E to 8^0 5E with the elevation of 400m to 500m above the mean sea level of the terrain topography. The main climate of Kano is Wet and Dry seasons of 16^0C to 21^0C in the month of December and January as the lowest temperature and the highest temperature period of 30^0C to 40^0C in March to end of May (Olofin, 1987.The seasonal rainfall of tropical region According to Schoeniech,(1998), is 800mm to 1000mm that usually start in the beginning of May and stop in the month of October with natural vegetation cover of savannah type vegetation with the different characteristics of trees species with bold canopies. Usually, the vegetation cover of the study area is in extinction due to the act of deforestation of natural forest as the result of population growth which leads to the high demand of fire wood and the urban expansions in the area. Regarding to vegetation cover of the area, special recommendation should be made to government and other planning authorities to improve forestation programme in order to enhance the vegetation growth in this study area. In view of Normalized Different Vegetation Index (NDVI), It is important methods of change detection of vegetation cover.

1.8 Origin of growth in Kano

Kano was originated around Dala hill with the beginning of spatial development in the area. But after the post-independence from British colonial masters, the city started growing in with new urban shape. This is because of the socio-economic activities in the city that facilitate the physical planning and development which really transformed the physical appearance of the city. Also commercial activities and socio-economic development facilitate the rapid urban expansion of the growing city with a lot of infrastructural developments and this attracted migrants from surrounding villages and other towns and that was the causes of population growth.

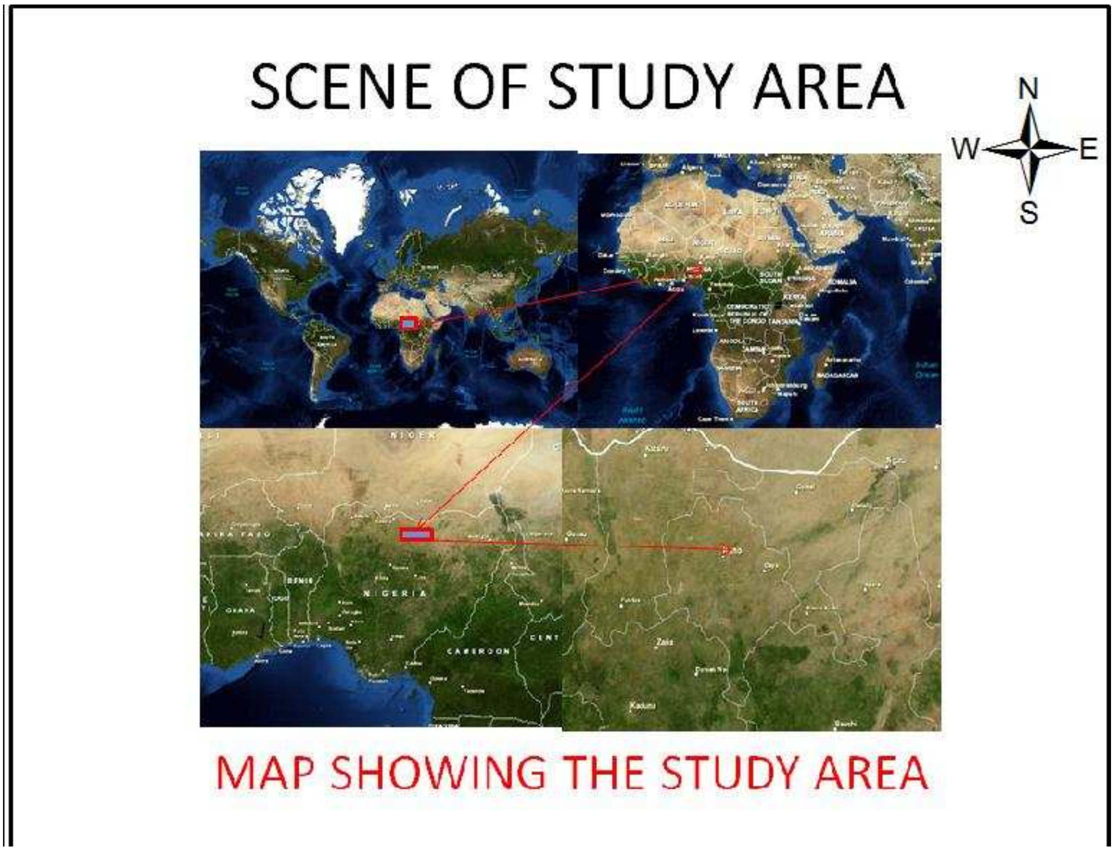


Figure 2: showing the scene of the study area (source; ESRI online)

Figure 3: Map of Nigeria showing the study area

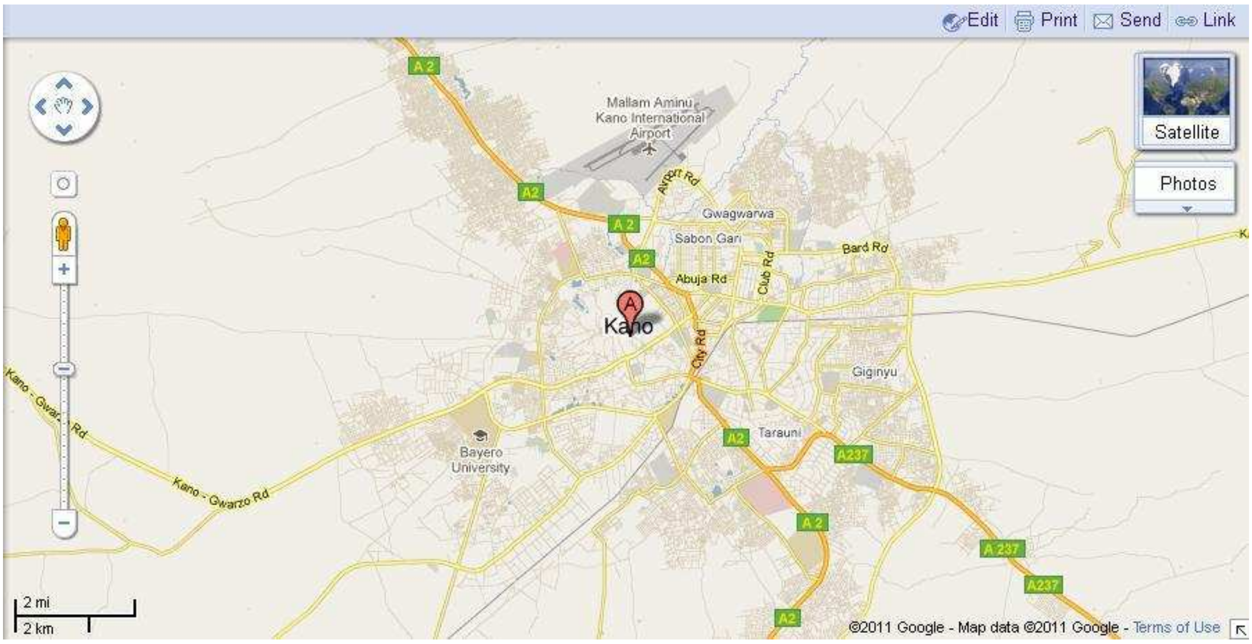


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Figure 4: showing the Scene of the study area (source; Google map)

1.9 SRTM Digital Elevation Model (DEM)

Shuttle Rader Topographic Mission (SRTM) provides digital elevation model (DEM) of the study area with 90m resolutions it's a digital representation of ground surface topography that expressed relief of the terrain

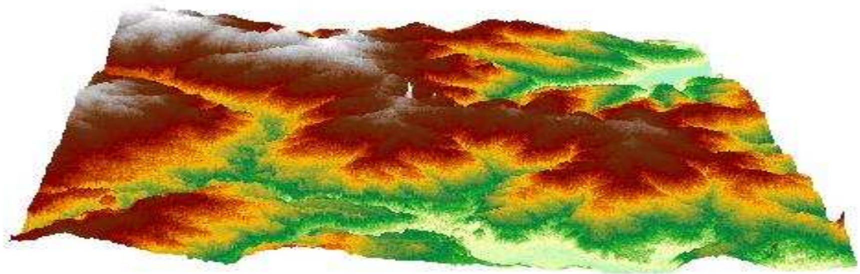


Figure 5: showing the study area in 3D perspective of SRTM 90m (DEM)

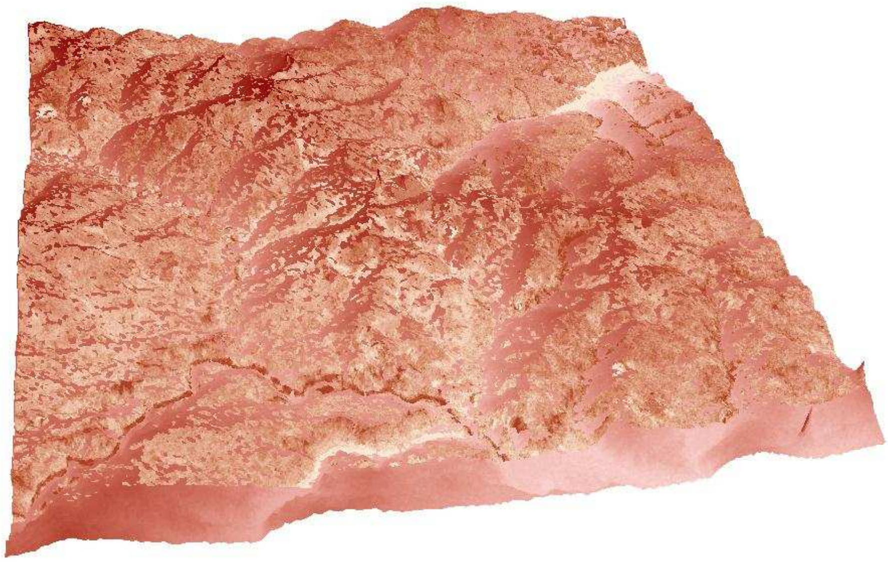


Figure 6: showing overlay with image and SRTM data in 3D perspectives

1.10 Geography and Physical Nature of the Study Area

1.10.1Climate

The Geography of Kano and the present climate is savannah type or tropical wet and dry climate with emphasis on the seasonality of rainfall received with an average temperature warm throughout the year at about 27°C± 7°C conversely. There are very hot months when mean temperatures (Olofin, 1987)

1.10.2 Temperature

Two different temperature of the study area are usually hot and dry season and warm and wet season that every year started from the month of May to early October and the Dry season start from the month of November to April with Temperature of 28 to 30^{0}C.The Temperature drops to 24 to 29^{0}C in warm and wet season with evaporate transpiration of the higher relative humidity in rainy season, (Olofin, 1987).

1.10.3 Geology

Kano region geology is based on three different geological formations: they are rock of basement complex of underlying rocks of both older and younger granite of the origin era of Precambrian period, as well as Crystalline igneous and metamorphic rocks (Aron, 1998).

- **Formation Of Basement Complex**; The Coverage of the most part of southern Kano region with younger and older granite are derived from metamorphism of clay sediments with usual free of intrusive structure of rocks to earth surface.
- **Chad Formation Of Unconsolidated Sediments;** The unconsolidated sediments of Chad formation covering north-eastern Kano where unconsolidated Aeolian sand form a drift plain starting from Jakara, Thomas, and Gari river systems. The terrain is sands and clay with high level of desert encroachment covering large area of macro planting of shelter belts.
- **Geological resources;** High concentration deposited mineral of granolith that attracted mining activities mostly from colonial periods with the present Tin located from the Riruwai area with granite ring complexes which currently has economic potentiality.

1.10.4 Land forms

The landforms of Kano with regards to geomorphologic history of the plane terrain, (Bawden et al, 1973), was originated during Gondwana land. The surface was in existence 135 million years ago. This resulted to a range of hills in southern Kano. And that was the origin of Kano river systems which becomes main source of water to Tiga Dam that provides water for irrigation activities at Kadawa and Kura axis which currently has significant and potential economic activities of the state.

1.10.5Rainfall

Kano region rainfall is seasonal rainfall system with rainfall variability between the northern part of the state and the southern part of the state which is related to latitudinal position with over 1000mm with the mean annual rainfall 823mm. That was recorded in the period of one decade: between 1998 to 1999.That was when the annual rainfall was intensive in the 1998, which resulted into flood. This caused the region had drought Hazards that affected the seasonal rural cultivation in the study area

1.10.6 Tropical soils.

Kano soil is nitro tropical soils with different soil horizons of different textural, structures and different colour horizon. Example of B horizon that reserves mineral resources arising from little rainfall usually brown and reddish soils (FAO, UNESCO) and Arid sols. This is due to the chemical weathering processes to form the parent material of tropical soils.

1.10.7 Vegetation cover

Kano is savannah type vegetation characterizes with different species of plant and trees with grass land. Usually savannah is open with shorter grasses of 1.5 to 3m tall and the trees height of 5 to 6m

Most of vegetation cover has been greatly deforested for intensive rural cultivation. Even within the protected areas of forest reserve has been tempered and converted to cultivation area. This made more than 75% of land coverage is cultivated land with density of trees of less than 25% among the identified vegetation. The region has some thick vegetation that are found along the river system flood plain. Other are wood land forest at the southern part of Kano of the hilly terrain of Falgore forest and game reserve with coverage of 370km$^{2.}$ Currently the forest reserve is reducing due to massive encroachment of rural cultivation.

1.10.8 Topography

The topography of Kano region and the location of the study area are located on a plain terrain with an elevation of 470m to 590m above mean sea level, and the two major hill located in the central city of Kano, Goron Dutse and Dala Hills with the elevation of 720m above mean sea level. There are two river systems located at southern part of the city known as Challawa River, and the other one is located at the northern part of the city known as Jakara River. Both the rivers drain to lake Chad Basin. Kano is the commercial centre in northern Nigeria with industrial Areas

Administration; Kano is the capital city of Kano State in Nigeria. It has an administrative activities of state government, headed by the state civilian Governor, Engr. Rabiu Musa Kwankwaso. It has local administration councils and traditional rulers from the majestic Emir Palace, all of them help in running the functionalities of administration and other formal activities in the state.

Educational Facilities; Kano in term of academics activities was not left behind. This is because the state has three universities, one of them from the federal government of Nigeria and the remaining two belong to the state government. There are other educational institutions of higher learning; among of them are Kano state polytechnics and three colleges of education. One of the belongs to federal government of Nigeria as institutions of higher learning, the others are the many secondary schools and primary schools that belong to the government and other private schools.

Commercial Centre; Kano is commercial centre in northern Nigeria. It is also a regional market covering all northern part and some other neighbouring countries. The socio-economic activities of the city attract migration that facilitate urban expansion and accelerate the population increase of the city.

Industries; Kano is an industrial location. And this was originated since the British colonial masters as results of intensive ground nuts production. It is the second largest industrial location in Nigeria apart from Lagos. Kano first industrial location was in the area around Bompai. These industries were designed by the British Colonial Government with substantive industrial facilities of road network and railway lines to each one of the industries in Bompai industrial area. The urban expansion began and led to another industrial extension at sharada industrial area between 1970 to 1980, Subsequently with urban expansions and rapid growth, a new industrial location was emerged at Challawa industrial estate; a very high industrial plant that including coca cola company and other textiles industries. It is located by 15km away from the metropolis. The city continued to growth leading to another industrial location at Tokarawa industrial layout at north-eastern part of the city. It is a linear industrial area along Hadejia Road. Currently there is growing along the road with about 15km coverage some plastic and rubber shoes manufacturing industries.

Tourism; Kano has historical monuments that attract tourists. this is because of some historical monuments including an old market in West Africa known as "KASUWAR KURMI". It was in existence at the beginning of 15 century. The city has historical majestic palace that always attract tourists for some historical festivals at emir palace.

Defence; Kano has important installation military barracks and Air Forces Training College; all of them belong to the Federal Government of Nigeria.

Settlement of urban area; Urbanisation was started since the British colonial masters. They modified some important areas. During the period of colonial rule, modern urban shape emerged. The construction of administrative buildings including the Government Reserve Areas (GRA) with up to date administrative headquarters and Governor Offices started at that period.

1.10.9 Demography

Kano has high rural urban migration that facilitates population growth. The population of urban Kano was put at 2,374,221 by the National Population Commission, (NPC, 1991), and compared with 2006 census was 2, 83,323 (NPC, 2006). This resulted into population growth and built-up areas in Kano metropolitan that change the shape and size of the existing city and resulted into several environmental degradations such as poor drainage, pollution and traffic congestion. Within the urban areas, these environmental problems affect the socio-economic activities that require attention. To reduce these problems of urban growth, the urban planners should provide good functions in their activities by improving spatial and temporal land use and land cover studies. These should be applied to these changes so as to attain meaningful development, socio-economic, and environmental protection.

1.10.10 Population

The study area has the second most populated area in Nigeria apart from Lagos. It is also one of the fastest in Africa in term of growth which facilitates the urban growth and population. By the 2006 census data of the study area, the male population was put 4,947,952 with the female population of 4,453,336 from National Population Commission (NPC) 2006 Census Available at http://www.population.gov.ng/

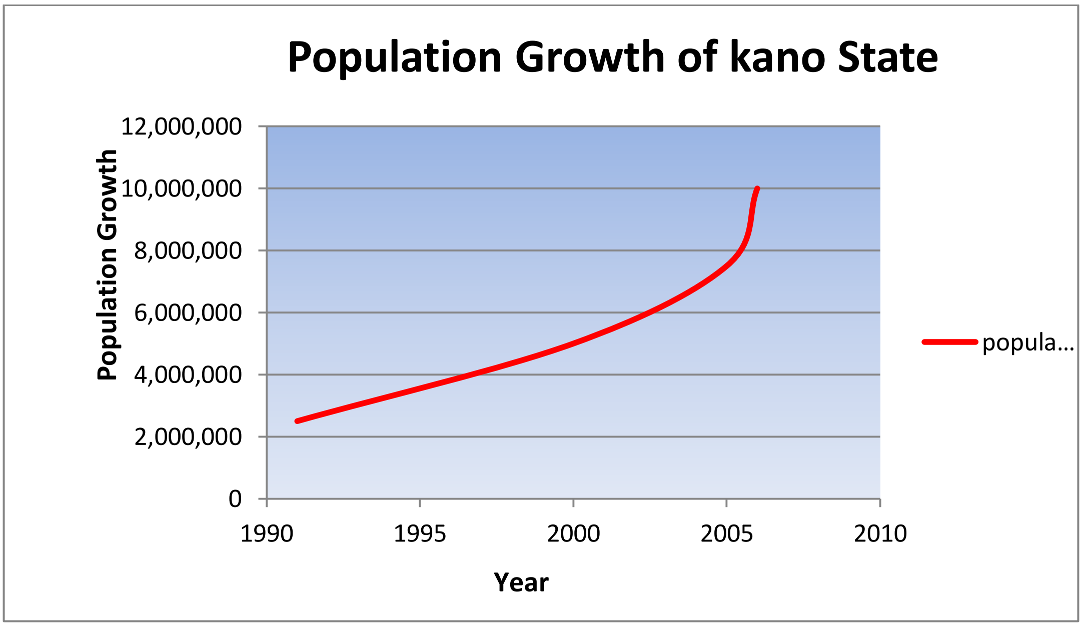


Figure 7: Showing the population growth of Kano

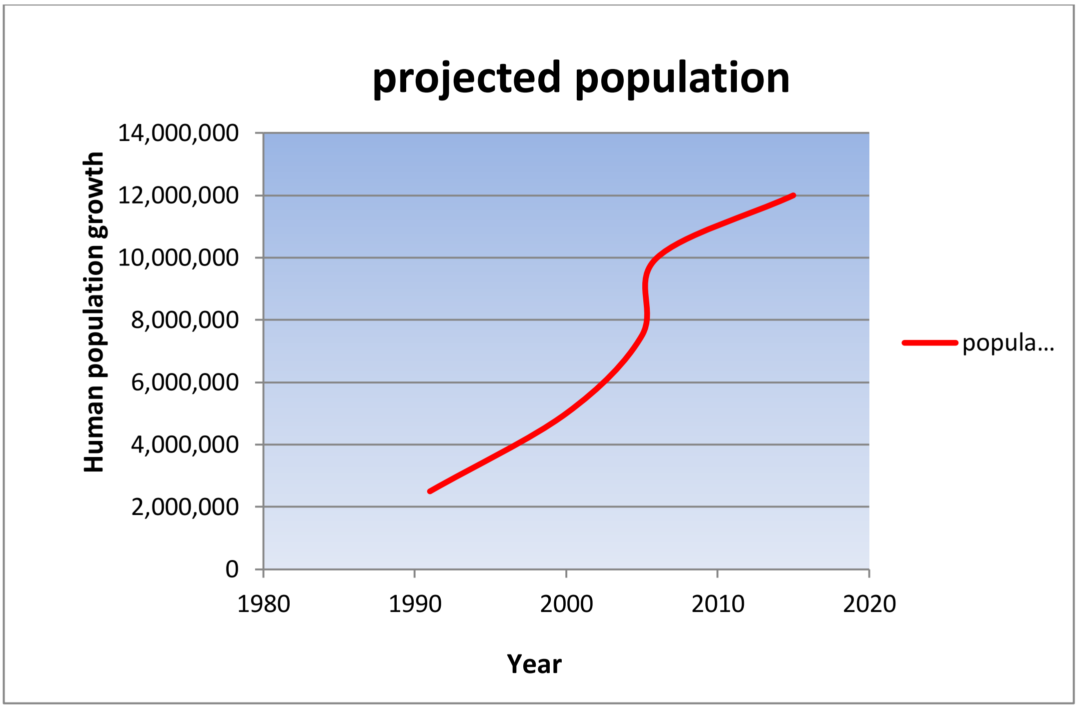


Figure 8: Showing the projected population of Kano

1.11 Aim and Objectives

Aim

The aim of this Study is to identify the rate of urban growth in Kano city, Nigeria, and suggest workable measures to enhance the physical environment of the area.

Objectives;

i. To produce Land Use and Land Cover classifications.

ii. To examine the trend of urban expansion in the Study area.

iii. To produce different output images, maps, graphs and symbols.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

For quite a long time, people have been tempering with land resources for many purposes which include settlements for building houses, commercial buildings, Industrial and others. However, the natural ecosystem has been tempered for agricultural purposes, this includes arable farming, cultivation of crops and shifting cultivation that cover large extent area on the earth surface over a long period of time (Houghton, 1994).It was discovered that currently most of forest cover, grassland, and agricultural land use were lost to settlements and urbanisation processes which is currently a global phenomenon that affect the natural ecosystem of environmental conservation as a results of land use and land cover changes, (Penner, 1994).

One good advantage of creation of thematic map of land use and land cover change detection using Remote Sensing and Geographical Information Systems (GIS) techniques is when comparing two different date images and captured images of the same study area in process of determine land use and land cover (LU/LC) changes over a period of the study years (Prakash and Gupta, 1998). Both Remote Sensing and GIS techniques are important fields of study particularly in the three major application which are in area of urban growth studies, area of land use change detection analysis, and vegetation studies (NDVI).This is another study of its own that involves Remote Sensing and GIS application which is currently a global studies in the process of monitoring global vegetation cover and its indices. Urban growth studies are one of the environmental studies globally that involves both developed and developing countries with strong issues of rural urban migration. This migration is one of the causes of urbanisation and the urban dynamics of land use that are needed for strategic planning, disaster management, and environmental impact assessment that require good planning, resources management and good guide to decision makers with updated information on urban extent and urban change detection (Grey, et al, 2003).

Rapid urban growth with high industrial activities facilitate the sub-region and increase the in-migration of urban which compound the problems of the planning policies as a result of unplanned settlement with key issues relating to illegal development which now becomes an issue by the Kano state government. This is because the city has uncontrolled urban development. The massive growth of the city began in the year 1980. The expansion moved towards Dorayi and Panshekara Road, (Keles, 1996). Kano has planning agency known as Kano State Urban Planning and Development Authority (KANUPDA).

This Organisation is the vital actor in matter of any legal development in the state. It engages into business between developers and urban planners with many urban problems. According to Lillesand et al, (2005),Remote Sensing play dominant role in the development of many environmental application which has advantages compared to photogrammetric and ground conventional land surveying methods. These advantages are:

- Remote sensing application provides data for use in much application about the physical surface of general environment for the purpose of environmental studies.
- It has powerful tools of measuring inaccessible areas that involves an areas that are difficult to access like hills and valleys. It is capable to penetrate and provide data for useful information.
- Its application is not time consuming; the application always saved time; a large coverage area can be visualised and analysed within short time.

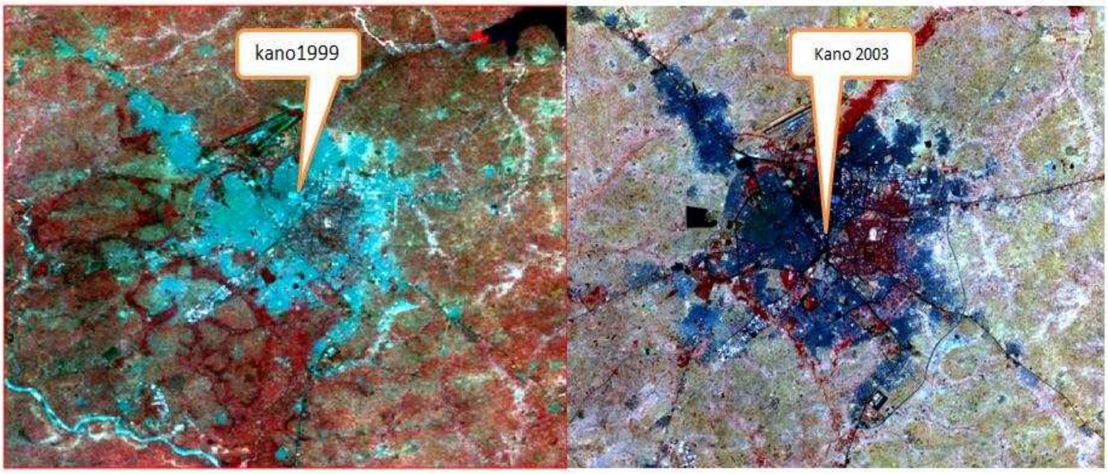


Figure 9: showing two different date images of the study area

The above images have different bands that records wavelength mostly used for many purposes .This will be described in the table below showing some basic characteristics of LANDSAT image in remote sensing.

Table 5: Characteristics of LANDSAT images (ETM+ Sensor)

	Band	Wavelength (µm)	Resolution (m)
Blue	1	1.45 – 0.52	30
Green	2	0.52 – 0.60	30
Red	3	0.63 – 0.69	30
Near IR	4	0.76 – 0.90	30
SWIR	5	1.55 – 1.75	30
Thermal IR	6	10.40 – 12.50	120 (TM) 60 (ETM+)
SWIR	7	2.08 – 2.35	30
Panchromatic		0.5 – 0.9	15

2. 1 Evolution of Remote Sensing

Remote Sensing was originated since 1783 for aerial reconnaissance and military purposes. The development of aerial photograph and photo interpretation become useful and important way of extracting meaningful information by the military application in beginning of World War I up to the end of World War II. And then later the technology becomes available to civilian for other applications. Remote Sensing is known as a science and art that contain large information about the physical object on surface of the earth been captured with a device without physical contact to that object on the environment (Campbell, 2002).

Remote sensing has very powerful functionalities that include many applications and processing satellite images for a specific operation in the process of producing substantives results from an input raster images (Cambell, 2002). Many airborne platforms in these centuries have been developing a good scientific progress of remote sensing application in term of earth observation with Balloon (Lillesand et al, 2004). Along with this evolution, there was a scientific development of remote sensing in term of digital cameras with sophisticated sensors in application area of cartographic field in the 1972. For the purpose of remote sensing satellite data for civilian purposes the application extends from cartographic work to other application of monitoring environment, forest cover, ecology, and land use and land cover (LU/LC) changes (Campbell, 1996).

Currently Kano state government has engaged into physical environmental programmes that involves flyovers at the city centre and infrastructural, estate and rural area development with good roads at all the local government areas. All these progress require a standard information technology of Geographical Information Systems (GIS) and Remote Sensing application. The remote sensing studies particularly urban change detection applications are needed in Nigeria particularly the study area. Kano needs Modern (GIS) as a source of data for decision making in term of urban planning. That is why this thesis is important to many applications including urban planning. The data source of remote sensing application is available at USGS that provide satellite data to United Nation. Because of global issues, the Land sat data with global coverage become important sources of data and physical terrain information to use and present changes on the environment for GIS analysis, (USGS/UNEP/UNOOSA, 2004).

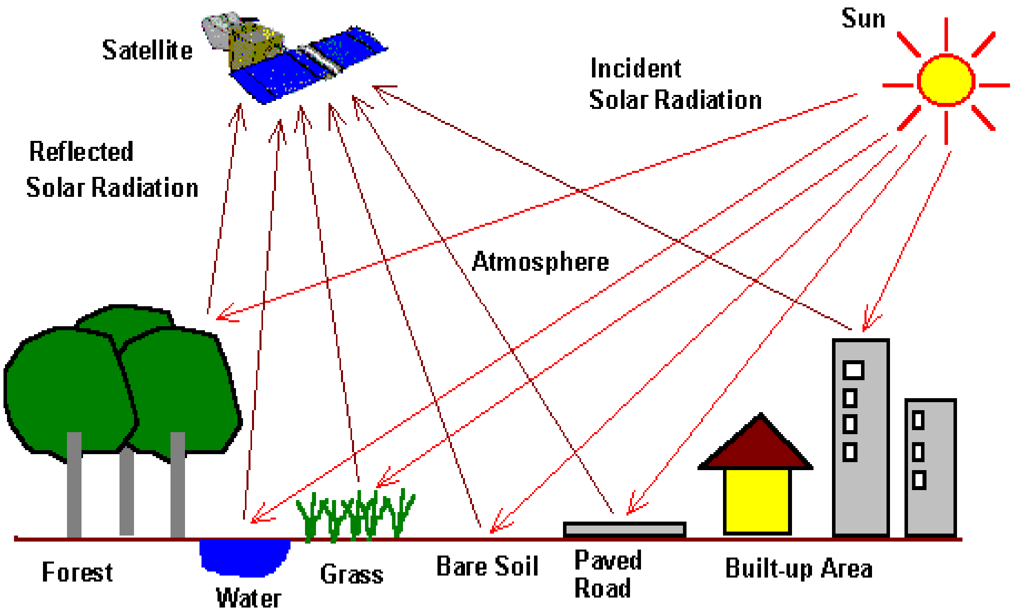


Figure 10: showing the remote sensing application and its processes from platform and incoming solar radiation to the earth surface, (source; UNOMAHA),

2. 2 Remote sensing and GIS application

The Technological development of computer systems and human skills help in processing large datasets for storage and processing in Geographical Information Systems (GIS).It facilitate the functions of remote sensing data as a good source of information in many field of applications particularly in the global context in a special issues like monitoring disaster management, and other areas like monitoring agricultural progress which is a global issues of food change by the United Nation Food Agricultural Organisation, (FAOUN). Others are issues of forest reserve conservations and environmental sustainability with remote sensing application particularly in the field of land use and land cover changes of global land cover classification systems of the United Nation programmes (Bergen et al, 1999.The remote sensing and Geographical Information Systems (GIS) are powerful tools in land use and land cover changes application in urban studies. With new information technology of Geographical Information Systems (GIS) the use of images data sources for remote sensing to visualise and classified the physical changes become easy (Lillesand et al, 2004).

2. 3 Remote Sensing as Sources of data

Remote sensing application now has different sources of data that are from different radio metric functions. This is a very sensitivity aspect of it in term of their spectral, spatial, and temporal resolutions and the current technological developments that provides a very high resolution digital images from different source as follows.

- QUICKBIRD (NASA)
- IKONOS (NASA)
- SPOT (Systeme Pour 1 Observation de la Terre)
- LANDSAT (NASA)
- AVIRIS (Advance Visible/InfRared Imagine Spectrometer)
- MERIS (European space agency MEdium Resolution Spectrometer)
- MODIS (Moderate Imagine Spectrum radiometer)
- ASTER (Advanced Spaceborne Thermal Emission and Radiometer)

2. 4 Geographical Information Systems (GIS)

Geographical Information systems (GIS), can be defined as powerful tools with combination of some data, hardware, software with analysis processes and human skills (Jarck, 1988). GIS is capable of processing different sets of data that involves both raster and vector formats as a sets of data programmes that are able to store analyse and visualise in spatial components (Richards, et al, 2010). GIS was developed in the year 1960 in Canada by a Canadian scientist Roger T. for the application of environmental studies using spatial data (ERDAS, 2003). It progressed in to further developments in the year 1972 when image interpretation of satellite data related with other geographical features as the beginning of digital image processing and image classifications.

Geographical Information Systems (GIS), are needed in developing countries particularly Nigeria with a new information technology that start to rise for the last 5-10 years. The application of GIS in some urban planning Agency and some planning ministries with basic computer applications and AutoCAD known as computer aided drawing, the new technology integrate data analysis from remote sensing and GIS techniques,(Gatrell and Loytones, 1998).

2.5 Radiometric control and image enhancements

This is where exact relationship between digital numbers and the colours representations for effectives display of satellite images.

- ❖ Spatial enhancement of image filtration and modification of spatial properties of an image and reduce image noise, (Mather, and Brandt, 2009) that the more the spatial resolution the number of image pixels will be low mostly land use (Sabins, 1997).
- ❖ Spectral enhancement is a complex process that involves all the three colour components more especially the multispectral images in the process of creation the colour separation of the spectral bands of the sensor usually in the process of classification of higher accuracy (schowengerdt, 2007).
- ❖ Temporal resolution where the temporal frequency of an area that sensed at arrangement by the sensor (Mather, 2004).

Spectral resolution; This means that different reflective from the physical ground objects with different spectral wavelength that has capable of measuring spectral bands of a sensor which is good in classifying higher accuracy (Schowagerdt, 2007).

Radiometric resolution; this is radiometric digital format quality of a data collection by the sensor of radiometric resolution with information from the sensor, (Mather, 2004).

Temporal resolution; This is another temporal resolution of a temporal frequency of image. It is when resolution is based on time factor and its equivalent that the image is based on geographical time of locations (Gao, 2009).

2. 6 Land Use and Land cover

Land use and land cover in urbanisation involves the activities of lands associated with both natural and anthropogenic factors of the physical environment within the cover and uses,(Mayer, and Tuner, 1994). At times land use and land cover are known as physical object on the surface of the earth that involves a lot of land cover; for examples forest cover grassland and water body while the land use means that, how human use the land as a resources of urban land use and animal grazing land (Wikipedia, 2008). Tempering of land use and land cover activities is environmental problems usually causes by man against environmental biodiversity conservation (George, 2005). It is good to conserve the environmental resources and that is the best way for sustainability of land and land cover. The population growth and urban expansion with availability of resources mostly results in land pressure leading to unplanned settlement and tempering land use and land cover changes, (Seto, 2002).

- ❖ Land cover: this involves both natural and Man Made features that can be seen on the ground or through remote sensing and with good example of natural features such as vegetation cover, forest reserve, water body, rocks, bare surface,(Gregorio, and Jensen, 1998),
- ❖ Land use: This is also involves main purpose of which land is being used, land use may be residential uses or agricultural uses, and it may be commercial uses that involve several uses on the same land use (Gregorio and Jensen, 1998).

2.7 Land use and land cover (LU/LC) change detection

The primitive way of land use mapping requires a lot of times to do and very hard to do it (Harold, et al, 2003). This is because of dynamics of physical environments, old methods of map making, which is primitive and out dated compared to current remote sensing and GIS techniques with standard tools for digital mapping with higher accuracy particularly land use and land cover maps for change detection analysis (George, 2005). Earth spectral radiometric of incoming solar radiation and image interpreter use some basic elements remote sensing data shape, sizes ,shadow, pattern, texture, and other elements that are important in extracting meaningful information of physical environment. However, according to Williams et al.(1991), highlighted that details on land use and cover change which was to extract meaningful information from digital satellite imagery of remote sensing data is very good data to update land use and land cover maps particularly the resource control and others (Moshen, 1999). The land cover of one hectare must have land use for animal grazing land, arable agricultural field and urban development. The other categories of land cover are of forest cover, cropland, urban areas and the rest (Mayer, 1995). Landsat images provide a parameter result of thematic map for the possible monitoring change detection. This analysis according to Tardie and Congalton (2005), has describe the change detection as a methods in remote sensing application of detecting changes in a specific area or zones of interest for the purpose of environmental and urban monitoring.

Within period of a time remote sensing data can be used to discover changes on a physical environment for the purpose of land use and land cover change detection. The technique is to compare two different date images for image interpretation in the process of creating a thematic map as useful information for change detection processes, and the result map are related to the image resolution such as spectral, spatial, temporal and radiometric resolutions (Gupta, 2007). According to Clawson and Stewart (1965) land use is regarded as what man made on the land and the surface of earth that how man use terrain for his personal uses and different purposes. This may be agricultural land use or whatever. However, Efiong-Fuller,(2008) described land use as human interactions with the surface of different purposes.

2.8 Urban Growth

The physical and spatial extent of the growing cities form the historical view and the evolution of urban context that was written 100 years ago According to (Dendrinos and Mullaly, 1985) urban evolution of the growing city can be a dynamics as a complex systems particularly with advent of modern technology of Geographical Information Systems (GIS) and environment methods of urban studies with computer application that extends the idea of examine urban growth and other phenomenon as dynamic studies.

Urban planning provides cities with infrastructural facilities and different activities in term of development. It change the shape and size of growing cities that happens from bare surface to residential, industrial purpose with other development activities within the axis of urban area (Shenge and Sylvia, 2002). Urban design view of are planned in accordance with building line regulation of effectives urban planning systems together with economic that facilitate urbanisation and population increase which usually resulted in uncontrolled development in the absence of information technology of remote sensing and Geographical Information Systems, GIS (Ikhuoria, 1995).

2.9 Historical origin of urbanisation

The evolution of urbanization and rapid growth of periphery of cities and town extension indicate the spatial growth of urban system or urban sprawl by both the population growth up to metropolitan area, that rationally known as Suburbs that covers large extents area Cheng, 2003). And the spatial interaction of cities input and output data (Leontief, 1970).This progress was made by the powerful tools of remote sensing and Geographical Information Systems with the systems theories in the 21 century with both application of remote sensing and GIS that provides the user with powerful tool to manipulate those complicated data on various spatial and temporal information of urban centres and city planning by the planners to have some challenges a head like enhancement of data and improve the their decisions making (Cheng, 2003). The land use and land cover changes can be easily detected now by the use of powerful computer machines and the supporting GIS software to visualize GIS environments.

2.10 Urban Growth in Africa

Urban cities in Africa are continued to growth and is associated with the growing population that are currently taken place in developing countries particularly Nigeria. This is as a result of dynamics of demographic trend and economic activities in those developing countries that facilitate urban growth. Largest cities are growing because of rural to urban migration which is associated with urban problems (UNCHS, 1996).

Most of the people worldwide are living in urban areas. Urban growth is now global issues regard to geographical areas, natural population growth, rural urban migration, and infrastructural facilities and activities in accordance with the national policies and strategic development with other issues regarding political and socio-economic reasons of globalisations, (UN-HABITAT, 2008). In Africa urbanisation become serious issues because of the current global climate change and political instability in Africa, (Lemonde, 2009).

The social factors in Africa is going hand in hand with rapid urbanisation growth and the current population growth of the urban centres with more additional cities and towns compared to few cities in those days of 1950th. Examples Egypt had more than one million inhabitants, South African city of Johannesburg with the population of 915,000 inhabitants and Ibadan in Nigeria (Rakodi, 1997).In the beginning of 1960 urban growth in Africa increased by 18.3% when southern part of Africa had the highest urbanisation growth of 42% compared to the eastern part of Africa which had very little growth rate of 7.4%. and in the beginning of 1980 about 23% are living in urban centres and that was one of the highest period of urbanisation and the second period is in 1990 to 2000 records with the highest growth of 340 million inhabitants that are located in urban areas. This is up to 43% of the total African population (UN-HABITAT, 2002). Usually high growing urban areas in developing countries affect the development programmes with good examples of industrialization processes as the main causes of rural urban migration. This is because of loss of agricultural as results of the industrial revolution in the developing countries. This facilitates the growth of urban areas with low mortality rate.

2.11 Urban Growth in Nigeria

The normal population growth as a result of high birth rate over death and the frequent rural urban migration facilitate the urban growth, and the expansion of urban area in terms of shape and size in Nigerian major cities including Kano, the study area that usually experience relocation from various part of the country base on search for greener posture and job opportunities that are located in the urban areas (Agboola, 2009). Because of the dynamic changes for a period of time urban land has been experiencing new building and constructions of different development and other growing infrastructures with facilities in the urban centres (Ago, 2001). In Nigeria, land resources are dynamics from the national level context with ecosystems preservation that people tempered with (Oyiloye, 2010). Urban growth is now urgent issues for organisation, this is because of rapid expansion of urban population that usually results in environmental problems (Mandel, 2000).It was observed that urban growth are the causative agents of changes on land use ,(Singh and kumar,2012). Urbanisation in developing countries is usually caused by rural urban migration that facilitate the high increase in urban area population that was within the period of 1990. With the increase rate of 2.5% in a year and that was when the population of Africa almost double in the year 1993, by (UN, 1993). That was when the urban population increased at high rate as compared with increase rate in the rural areas in most part of the developing countries particularly the sub-Sahara countries including Nigeria.

2.12 Demography of Urban Kano

The population growth of Kano city started in the year 1931 when the population was just 96,805 and then before the year 1952 population of Kano rose to 130,170 by that time with the subsequent growing of people in the city rose again in the year 1963, when the population rose up to 295,432 (Maiwada, 2000). Then the federal government of Nigeria conducted an official census in the year 1991 when Kano state has the official population of 5,810,340 people (Bala, 2000). With rapid growth of population dynamics of the growing city by the year 2006 census, when the population of Kano rose up to 9,383,683 as the current official population data by the National Population Commission of Nigeria. Urban growth has some advantages and disadvantages which usually results in to some urban problems and other difficulties based on socio-economic activities in the area. One of historical overview on the origin of cities was originated millions years ago before the civilisation of eight thousands years back (Sjoberg, 1985). In most of developing countries in Africa particularly Nigeria urban growth has to do with socio-economic problems in the areas (Gulgter, 1997) Some amenities of infrastructure located in Kano facilitate the growing population that usually result in exploiting the natural environment (Akinbami et al, 1996), in developing countries like Nigeria Kano urban growth is caused by rural urban migration seeking for greener posture (ishaya et al, 2008), and that usually result into environmental degradation as a result of growing population that affect the vegetation cover and other agricultural land lost to built-up areas and industrial activities on natural ecosystem (Akinbami et al, 1996).

2.13 Environmental Control in urban areas

The urban planning involves the development control of a city to prevent environmental impact and assessments (EIA) to always present the environmental degradation, (Barrow, 1997). The government agency usually requires environmental reports of some improvements and the assessments of urban areas that will be good guide in protecting the environmental changes and issues as progress report in urban study.

2.14 Urban development

The urban development refers to physical changes by the shapes and sizes of urban landscape usually with rapid development as a result of urbanisation of the exiting town expansion by either residential or other developments purpose of built-up areas. As the result of population growth in most of developing countries particularly in Africa, usually urban infrastructure development like roads and other physical development affect the natural environment, like vegetation cover and climate in terms of socio-economic development. The current Millennium Development Goals. (MDG), and United Nation Development Programmes, (UNDP), along with the important history of urbanisation and developments rise from 1950, when the world megacity, that is New York in the United States of America emerged in the year 1975 with number of inhabitants from 10million in 1950 rose to 12.3million in 1975, and currently with global development about 19 mega cities was emerged, and they will increase to 22 megacities by the end of 2015. And this is due global development activities (UN, 2006), despite the high increase in population in the developing countries, there is new development of modern cities in Africa, the figure below is an illustration of some major African developing cities including Nigeria. This development from 2007 to the projected growth of the year 2025, and this is a global history in terms of developments and dynamics, (Bronger, 1989).

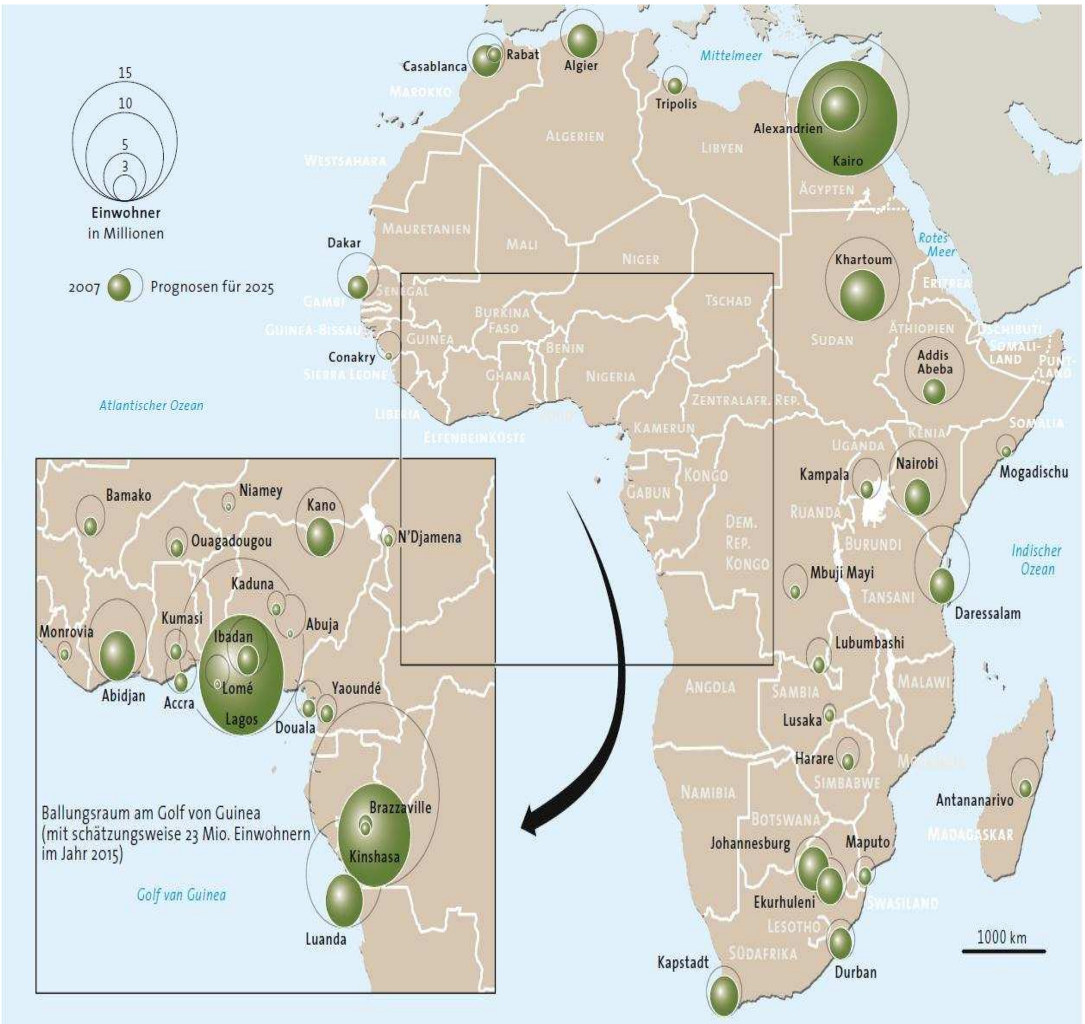


Figure 11: showing the megacities in Africa (Source: Le Monde Diplomatique, 2009: 139)

2.15 Urban planning

The urban planning is important area of urban development especially in developing countries particularly Africa. Whenever urban development take place without substantive urban design by the town planners, serious urban problems for example traffic congestion, crime, pollution, poverty, and outbreaks of spread diseases may result in negative consequences to both environment and socio-economic activities of the urban area (Neal et al., 2008). This activities in most cases result to unplanned settlement whereby you find that very poor people are not able to possess the regular housing programme or formal housing estate done by the planning authority or government organisation in some countries like Nigeria. Private estate development are fully participated in housing programmes, this has indicated that most of the population growth are located within this unplanned settlement or irregular settlement with full concentration of poor people (World Bank, 2002). Those irregular settlements have poor in fractural facilities which are contrary to urban and regional planning in the developing countries which stipulated rules and regulation in terms of development controls to urban development and planning processes. But due to sensitive issues of corruption in the civil service that hinder the successful activities of those organisational enforcement of those regulation from those authorities failed to control those illegal activities of those unplanned development, at the same time is becoming the dominant issues of urban slumps.

Slums are unplanned areas of development with a lot of inconsistence and a lot of irregularities with no physical facilities and infrastructures that most of urban poor accommodate those slumps and all the dwellers are obviously poor people (UN-HABITAT, 2003). Despite the fact, that slumps are the areas that require physical and regional planning as well as formal regular design. Improper planning results into problem of inaccessible road network. The slumps and the building quality are very poor structures which may easily destroy and kill people because of poor quality of building in those slumps. This is because densely populated area that is associated with high crime rate and other social offences due to lack of accessibility by the security agent to control the environment. The area has poor security systems within and surrounding and most of residential are not secured (UN-HABITAT, 2003). The planning view of those slums are very irregular and the spatial area tempered with a lot of irregularities, lack of good drainage systems, bad roads poor sewage systems leading to spread of diseases as a results of bad environments. Basically this kind of settlements can be described in two ways just to distinct them and discussed on them in details.

- Unauthorised Buildings
- Irregular Settlements

Most of unauthorised developments usually happens by informal developers that they create plots and sub-divided them into very small size as a plot and sale to the people illegally. Those developers always violate all the building planning regulation and one of the worst activities of them is that they convert the agricultural lands into plots for residential purposes without comply with rules and regulation for them to seek for permissions of formal layout and land acquisitions that possess all the proffer planning view including the title of ownership and the provisions of all requires layout design that provides basic infrastructure facilities of that formal layout designed. This is contrary to the informal plots with no planning view and they are not applying any guideline and good process of formal methods. They just jump all those steps without formal land registration and land title ownership of the inhabitant of those unplanned areas.

Table 2: Showing the two categories of urban settlement in the study area

	Formal Settlement	Informal Settlement
1	Formal procedure of settlement	Informal procedure of settlement (slums)
2	Land title of ownership	Acquiring direct without title of ownership
3	Provision of physical planning	Lack of planning view and services
4	Substantive records transaction	No records of ownership among dwellers
5	Building plan approval	Indiscriminate buildings and settlement
6	Bureaucratic process	No bureaucracy

2.16 Land Clearing

The study area Kano is experiencing land clearing for urbanisation as a result of two strong reasons which are deforestation for urban areas and deforestation for fuel fire wood that cause serious land clearing in the study area. Some plantation areas are converted to residential areas, the vegetation covers are facing destruction that are seen as nuisance as they are cut down for fire wood as a result of population growth that leads to the high demand of fire wood, fuel for cooking (Neal, et al, 2008).

2.17 Change detection

The change detection refer to comparing two different date images in the process of detecting changes out of the two different date satellite images. The change detection can be used at the same time to compare Historical Map and the remote sensing images. The Geographical information Systems (GIS) and Remote Sensing are important tools in mapping using image analysis to detect changes that have been taken place in the area of physical environment by comparison between two different date images through image interpretation that involves processes of atmospheric correction of the two different date images and the sensor differences between them. Another important image correction is radio metric normalisation and reduction in image pre-processing analysis towards the achievement of good result from land use and land cover change detection (LU/LC), (Singh et al., 1992).

2.18 Change detection at study area

The change detection requires use of powerful tools of both Geographical Information Systems (GIS), and Remote Sensing applications. The analysis process is to provide good information and changes of both land use and land cover due to urbanisation processes. The data analysis produces substantive information on land resources management, and the remote sensing data that facilitate the discovering output images of the study period (Wilkie and Finn., 1996). Kano experience this changes in both land use and land cover features which reflect on population growth and causes urban expansion and at the same time result into reduction of natural resources particularly vegetation cover that are converted into residential land use of uncontrolled growth of urban development that seriously affect Kano ecosystem and the climate (Balogun et al., 2009).

2.19 Remote sensing of urban areas

Urban areas remote sensing was began with the air photo interpretation in the history of remote sensing in urban areas for the purpose of monitoring urban change of land use and land cover for creation of thematic map with aerial photo image. As remote sensing data for interpretation and analysis is difficult the data source and comparison with historical remote sensing is depend on the image resolution of those aerial photograph (Weber, 2001), and it was explained by (Herold et al., 2003) that urban areas extent become a challenge between built-up and other rural areas with regards to image resolution of aerial photos as a result of complex nature of urban land use that requires high resolution image for spatial analysis and image classification of different classes of urban areas compared to satellite images that provides a very high spatial resolution for image interpretation. Examples of those are commercial remote sensing data like IKONOS and QUICKBIRDS which are very good data for urban studies, (Herold et al., 2002). Different views remote sensing data have its limitations in terms of visualisation of physical phenomena particularly the social environment that can be visible using remote sensing application. But the social scientists did not consider the remote sensing data as useful information for socio-economic uses (Rindfuss and Stern 1998). On the other hand, remote sensing is capable of producing data and good result for meaningful information particularly in urban change detection analysis. It also has some advantages of covering large extent areas and provides good information of different geographical features especially for monitoring urban land use and urban planning (Longlay et al., 2001).

2.20 Image classification

Image classification has two approach which are supervised classification and unsupervised classification techniques. Both of them play role in land use and land cover classification analysis in remote sensing and GIS application. This study requires historical information of the geographical area for supervised classification. The analysis process require time consuming in order to obtain accurate result by selecting many samples as training sites and knowledge of study area is important with good remote sensing software. For better classification techniques and remote sensing data, a good spatial resolution and the objectives of good training site are to identify high density of particular classes when the image pixels select the classes based on probability of the pixels location. This is usually associated with the information of the pixels, and the pixels associated problems that usually happen in the pixels location. The methods of determine the pixel does not belong to particular group or region. However, supervised classification has common approach known as maximum likelihood procedure and is known as statistical approach of pattern identification in order to recognise the image pixels. This is the probability of pixels that belong to set of classes that has been calculated by assigning class based on the highest probability of maximum likelihood approach of supervised classification methods (Mather, and Bandt, 2009), and (MCL) will consider that the pixels has highest probability of belonging to the particular class (Lillesand, et al, 2008).

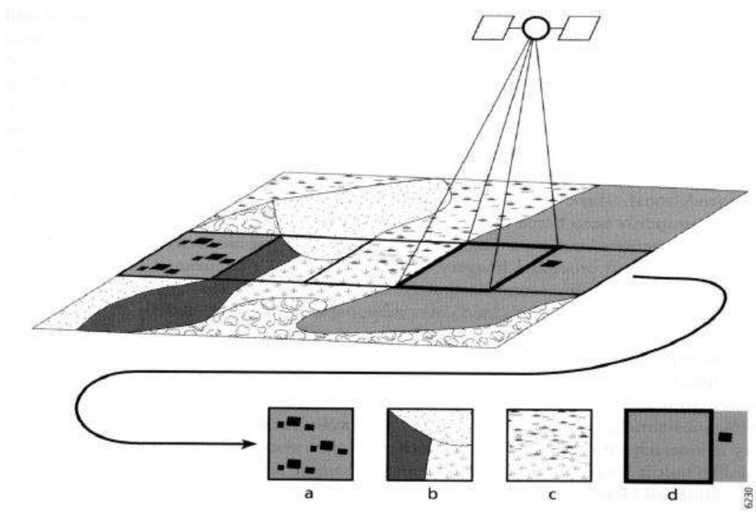


Figure 12: showing the mixed pixel problems (source; Foody, 2004)

2.21 Supervised Classification

Supervised classification is the best approach compared to unsupervised classification methods. The training site is important and the approach requires a lot of time. In the analysis process with good suitable selection of training sites and the knowledge of Geographical area include human skills are needed for physical object identifications (Lille sand, 1994).

2.22 Unsupervised Classification

Unsupervised Classification approach is the software functionalities that perform the operation with Interactive, self-organising data analysis (ISODATA) in clustering algorithms. And in the process, the analyst did not select any training site for the classes,(Thomas et al, 2007).

2.23 Normalized Different Vegetation Index, (NDVI)

The Normalized different vegetation index (NDVI), is a remote sensing area of application in the process of determine the rate of changes in vegetation cover. It is a very important study particularly in the global context. NDVI is used to determine the vegetation indices of near infrared radiance which depend on reflectance (Tucker, 1979). In remote sensing, NDVI is the study of its own; the application is very complex and the analysis is usually associated with photosynthesis of the surface chlorophyll available by the time of data acquisition in order to have good NDVI result (Myeni et al., 1995), and the visible red parts is from the electromagnetic spectrum as from indicated equation of NDVI values here:

Equation; NDVI = (NIR-RED)/(NIR+RED)

Where NTR is the near infrared band response

RED is the red band response for given pixels

The NDVI pixel values always range from (-1) to (+1). This values indicated that close to +1 that is (0.8-0.9) is showing the highest concentrations of vegetation cover and those at 0.1 means with no vegetation cover while grass land will indicate values like 0.2 to 0.3 that is grass cover (weir and Herring,1999).

2.24 Principal components analysis

The principal components analysis is known as statistical processes of data compression of different data images. PCA is the application of multi temporal data of change information to determine in new components analysis (LU et al, 2004). One of the main functions of PCA is capable of merging two images of two different date as a single data file of image change detection. PCA is important application in the image data transformation and change detection analysis (Aldakheel and Al-Hussaini, 2005). The PCA application has the advantage of reducing the data redundancy, especially when determine changes in the physical environments. According to Ingles-smith (2006) the detect changes on land use and land cover in urban development application using PCA provide better basis for classifications of change detection analysis (Rogon and Chen, 2004).

2.25 Digital Elevation Model (DEM)

Digital elevation has many important application in urban change detections analysis (Borrough and Mc donnell, 1998), the application has automatic way of using remote sensing data to create elevation models which refers to as digital surface model and this application of digital elevation model (DEM), in urban and environmental studies it is useful, however, the topographical map can be transforms into digital elevation model, (DEM), by digitising existing topographical map of the study area into 3D view, (Gao, 1995) then other surface data are Airborne light detection and ranging (LIDAR), this the most high resolution technology application in comparison with photogrammetric, (Baltsavias, 1999), the application of LIDAR should be the faster process in terms of measuring urban growth and other urban features like buildings edges and the like this mostly in land use change detection using LIDAR data that provides finer ground surface resolution currently a LIDAR products is now becoming important source of data to environmental agencies with good examples of ordnance survey of great Britain (OSGB), with spatial resolution of 1-2m (Haaalla and Brenner,1997).

Table 3: The summary of literature review and characteristics of urban change detection from some five journals in related areas

Project/Study	Year of Study	Research objectives	Research Method	Analysis	Quality assurance
Developing Urban growth Predictions From Spatial Indicators Based on Multi – temporal Images (Liu and Zhon 2005)	2005	Detect the extent of Urban Change in Chaoyang District of Beijing China	Remote Sensing, GIS and Multivariate Mathematical Model	The trajectory analysis, spatial proximity analysis and the multivariate spatial model	Published Journal Article on Science Direct website
Urban Sprawl: Metrics, dynamics and Modeling using GIS (Sudhira et al 2004).	2004	To Model the extent and pattern of unplanned urbanization.	Remote Sensing and GIS	Supervised classification, the Gaussian MLC and field observation using GPS.	Published Journal Article on Elsevier website.
Analysis of Landuse and Landcover changes of Aba Urban Using medium Resolution Satellite images	2011	To detect the extent of Urban change in Aba Nigeria between 1991 – 2005.	GIS and Remote Sensing	Both Supervised and Unsupervised Image classification with the Minimum Distance Algorithm	Peer – reviewed Journal Paper. FIG working week 2011.s

(Chigbu et al. 2011).					
Change Detection of Land Use Changes in Naein City Using Satellite Data of Landsat (Gohari et al. 2012).	2012	Detection of Land use Changes in Chengdu Between 1990 to 2002.	Remote Sensing and GIS	Unsupervised and Supervised Classification, Image processing and Land use Multiplication Matrix	Published Journal Article. Middle – East Journal of Scientific Research
Modeling Urban land Cover growth dynamic using multi Temporal images (Ahmed and Raquib Ahmed,2012).	2012	To Ascertain the extent of urban development with aid satellite images.	Remote sensing and GIS techniques	Is based on supervised classification data interpretation of change detection with high resolution images.	Published ISPRS International journal of Geo-information.

CHAPTER 3: METHODOLOGY

3.1 Introduction

The study used two set of landsat images captured in different periods from 1999 to 2003 to produce Land use / Land cover changes of Kano city in northern Nigeria. Supervised and unsupervised classification technique were used in image processing and guide from the historic map of the study area ground truthing was done to identify some valid training sites. The objectives of this is to monitor and examine the trend of urban expansion in Kano city using powerful tools of both remote sensing and GIS application.

3.1.1 Data description

This section described the data used in this study and conditions when the data were selected are of the same Geographical area and the different date of acquisition when the data was selected.

3.1.2 Data Selection

- Land sat Enhanced Thematic Map per Plus (ETM+) of two different dates captured with free cloud cover as shown in the figure 1.
- Shuttle Radar Topography Mission (SRTM), data of Digital Elevation Model (DEM), acquired with 90m resolution was duly processed.
- Historical Map of the study area as an Ancillary data
- Topographical Map of the study area as an Ancillary data
- Shape file data of Nigeria and the study area

3.2 Data capture and sources

The land use and land cover of the study area were used and examined from satellite images obtained from the United State Geological Surveys (USGS). Two land sat images of the same area with different acquisition dates were used for this study; the land sat images of ETM+ 1999 and ETM+ 2003. This was downloaded from the USGS website and the land sat data was added in to Erdas imagine from pre-process to processing image and then the data analysis of the study area in line with the objectives. The land used and land cover analysis was done using supervised and unsupervised classification methods with tools in erdas imagine to obtain the change detection map of the study area. The topographic map of Kano and its historical map for image interpretation and data analysis of the supervised classification was done using erdas imagine software version 2011.

One of the good advantages of supervised classification is that the approach has made similar spectral classes from the acquired image with signature file of the land cover likelihood as identified the training samples of the two different date images. Prior knowledge of the study area was used in selecting the training samples with reference data from topographical map and the historical map of the study area and physical visit to the field during data collection periods.

The supervised classification was achieved based on the training define classes in the future space approach bands combination of [R4, G5, B3]. This bands combination was used and extracted by using information physical data that provided good results. All this was done with the use of ground truth physical visit to those areas to meet the objectives of this thesis with good results available at http://glovis.usgs.gov/

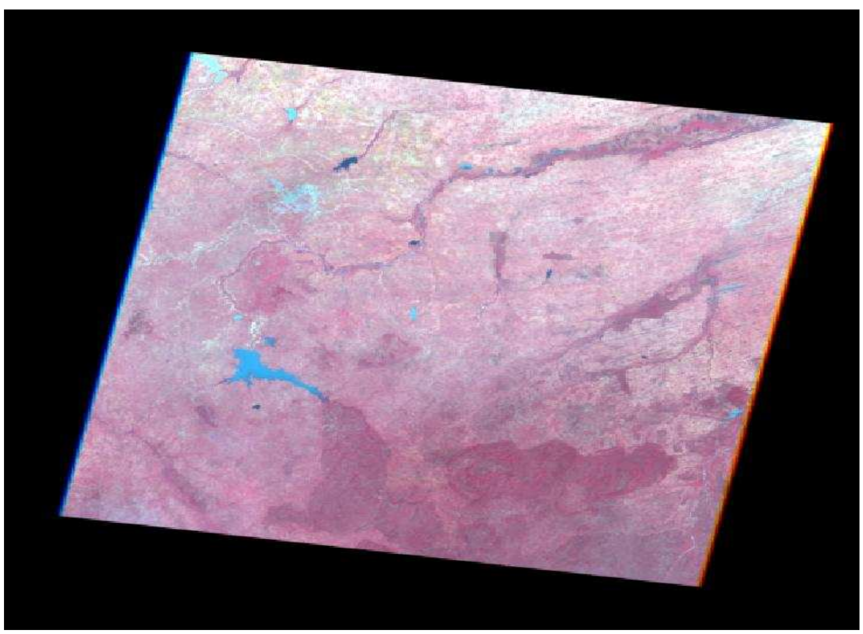


Figure 13: Layer stacking of 1999 image

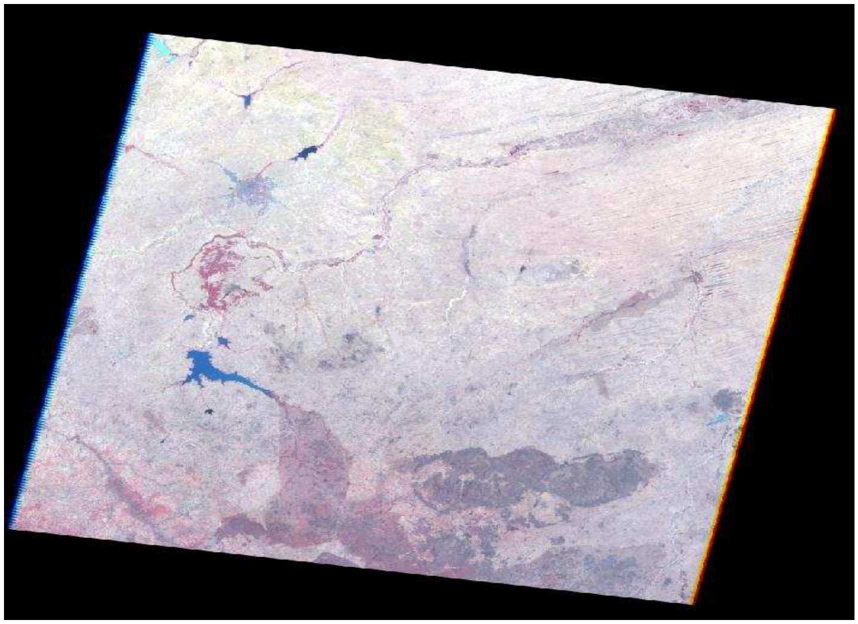


Fig 14: Layer staking of 2003 image

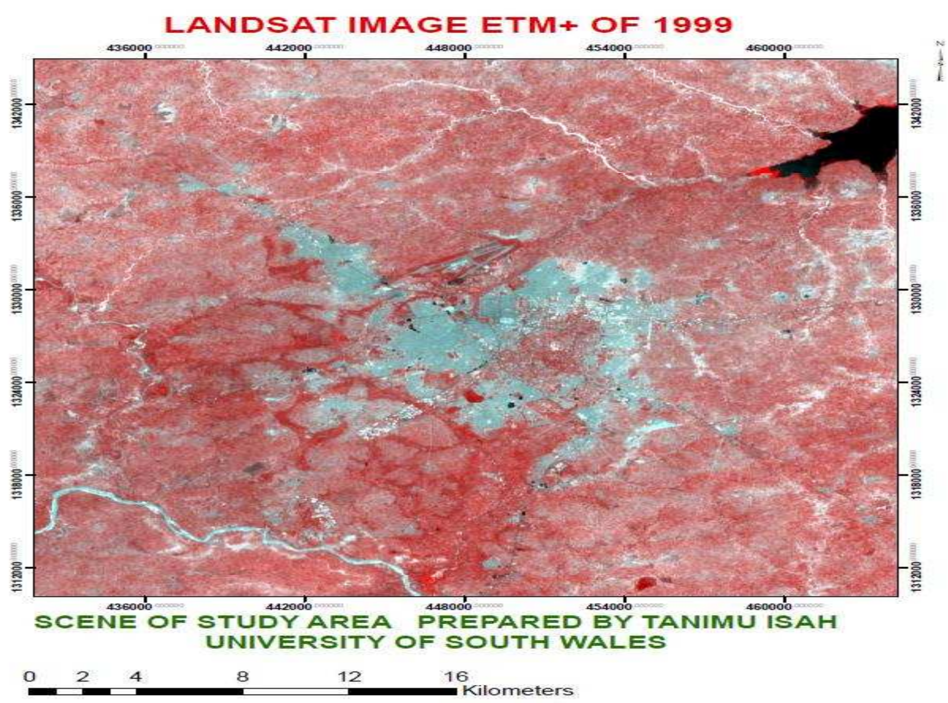


Fig 15: Sub-set image of 1999

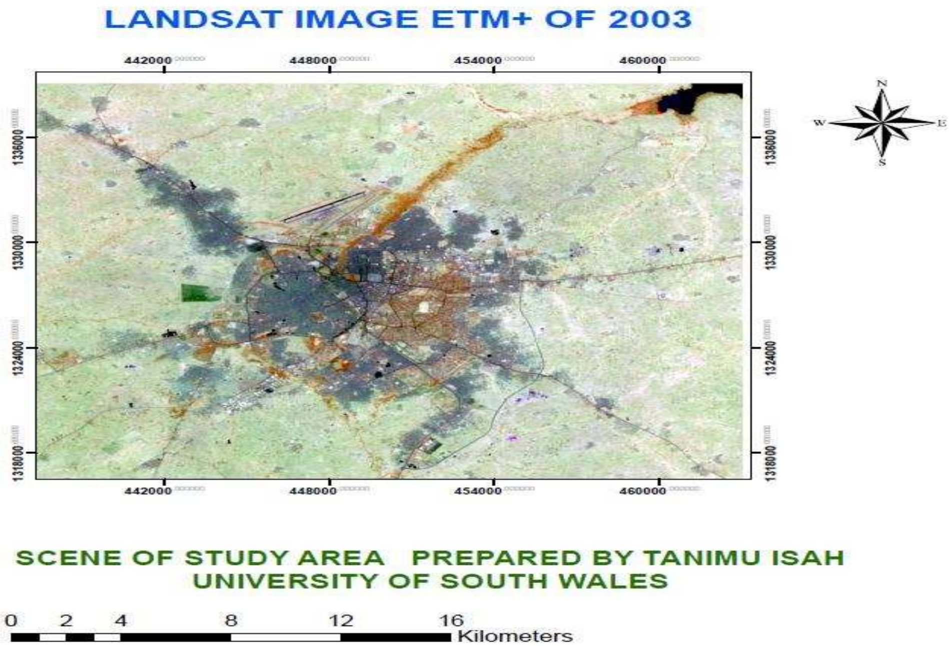


Fig 16: Sub-set image of 2003

Table 4: The data source and the acquisition dates of the images used

DATA TYPE	ACQUISITION DATE	SOURCE	CLOUD COVER
Land sat ETM+	28-OCT-1999	Earth Explorer	0 %
Land sat ETM+	29-MARCH-2003	Earth Explorer	0.02 %

Table 5: Characteristics of LANDSAT IMAGES (ETM+ Sensor)

	Band	Wavelength (µm)	Resolution (m)
Blue	**1**	1.45 – 0.52	30
Green	**2**	0.52 – 0.60	30
Red	**3**	0.63 – 0.69	30
Near IR	**4**	0.76 – 0.90	30
SWIR	**5**	1.55 – 1.75	30
Thermal IR	**6**	10.40 – 12.50	120 (TM) 60 (ETM+)
SWIR	**7**	2.08 – 2.35	30
Panchromatic		0.5 – 0.9	15

3.2.1 Visiting city planners at Ministry of Land

The visiting was done in the process of data collection at the study area when the historical map data was collected. At my visit to the Ministry of Land and Physical Planning Kano state for the purpose of identifying other physical features and some information that are not clearly identified on the satellite image. This is in order to relate the both datasets for geo-referencing as a good guide to image classification of land use and land cover data analysis. Four important classes were selected in this study in the process of providing the land cover maps of this study which include water body, built-up area, vegetation cover, and bare surface area (Jensen et al, 1999).

Table 6: land use and land cover classification class distributions

S/N	Land use and Land cover classes	Class description in details
1	Built-up Areas	Commercial, industrial, and residential
2	Vegetation	Scatted trees and grass land
3	Water body	Dam, river, and ponds

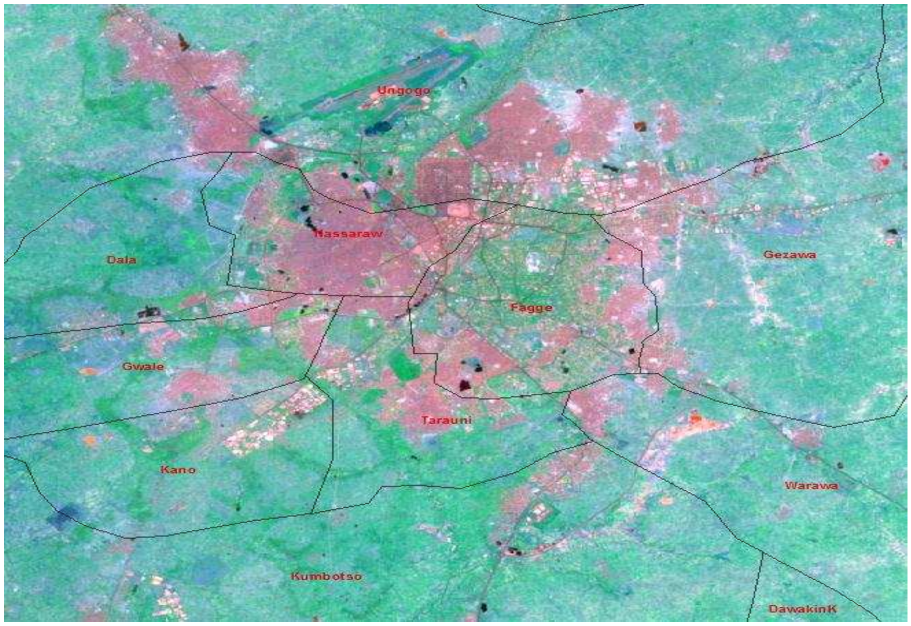


Figure 17: The 1999 image overlay on a districts boundary map of the study and the boundary data are in the same coordinate projections with the images

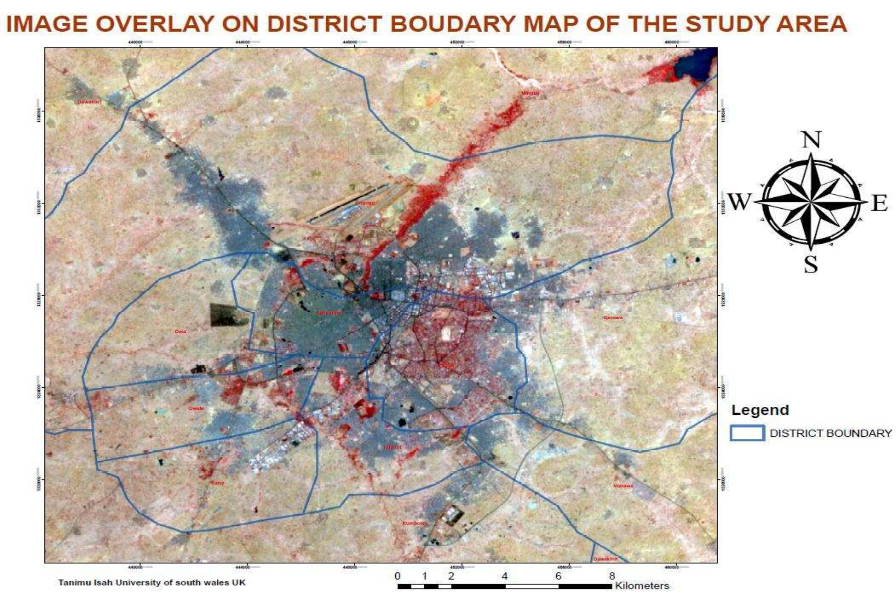


Figure 18: The 2003 image overlay on a districts boundary map of the study and the boundary data are in the same coordinate projections with the images

3.3 Shuttle Rader Topography Mission (SRTM), data

Shuttle Rader Topographic Mission (SRTM) was launched in February 2000 as one of the major geospatial project in the world. It was a joint project with National Geospatial intelligence Agency (NGA) of the United State of America and the second organisation is National Aeronautics and Space Administration (NASA) with main objectives to provides elevation data of terrain with the high resolution digital topographic data of about 90m equivalent to 295 feet. It was usually provided in mosaic datasets of 5 by 5 degree to the study area, and the digital elevation model (DEM) that was downloaded to obtain the digital elevation model data from the website that is available at http://www.viewfinderpanoramas.org/Coverage%20map%20viewfinderpanoramas_org3.htm

Then, the normal extracting procedure of zip folder was done and then added in to Arc map with the aid of added data and then merge grids with the arc map extension tools that was used with the function of clip tool to extract the subset of the area of interest. It was added into scene for the digital elevation model analysis (DEM), and then the data was also converted to contour line to create the contour line of the study area.

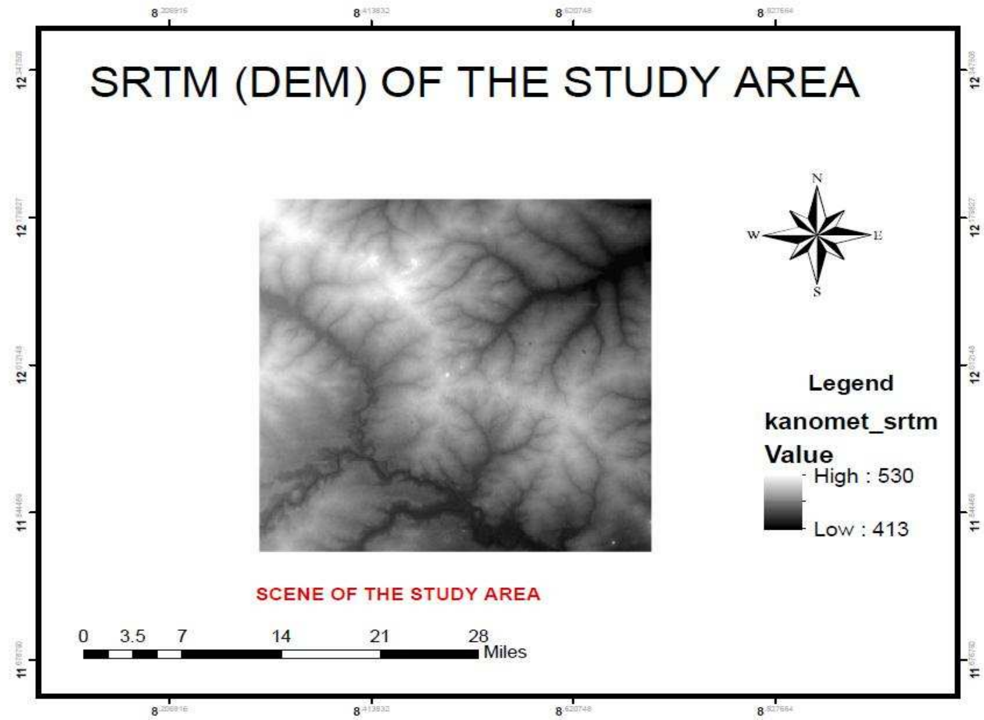


Figure 19: The SRTM (DEM) in Arc Map with the elevation value above mean sea level of the study area from 413m to 530m elevation after merge grids

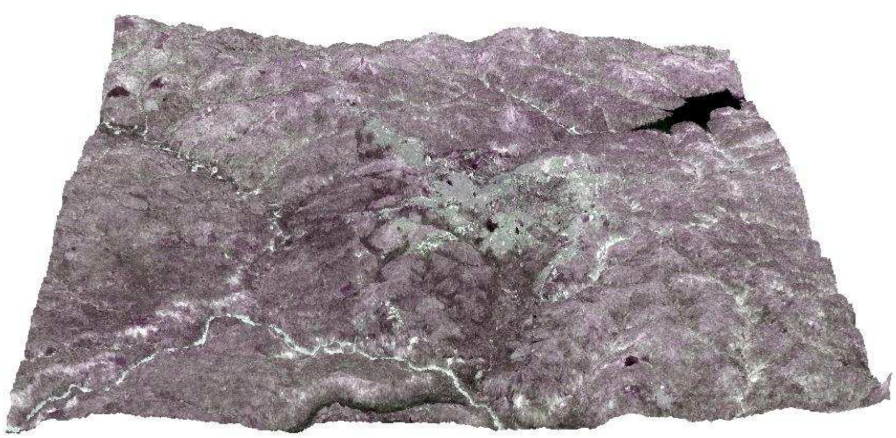


Figure 20: The land sat image of study area in 3D perspective

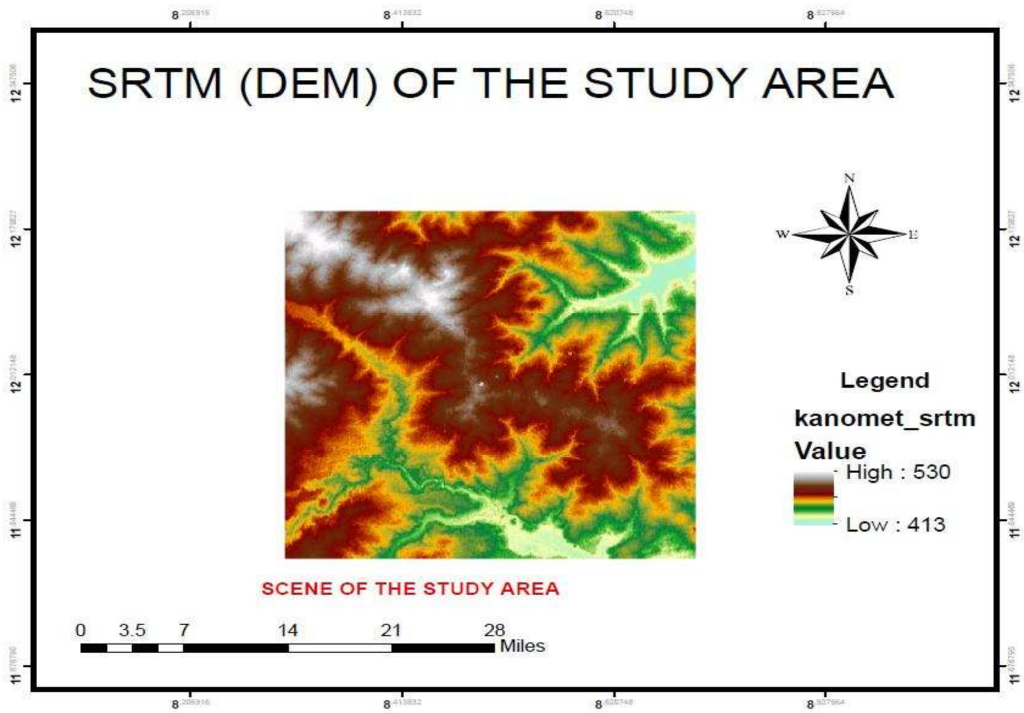


Figure 21: merge grids SRTM

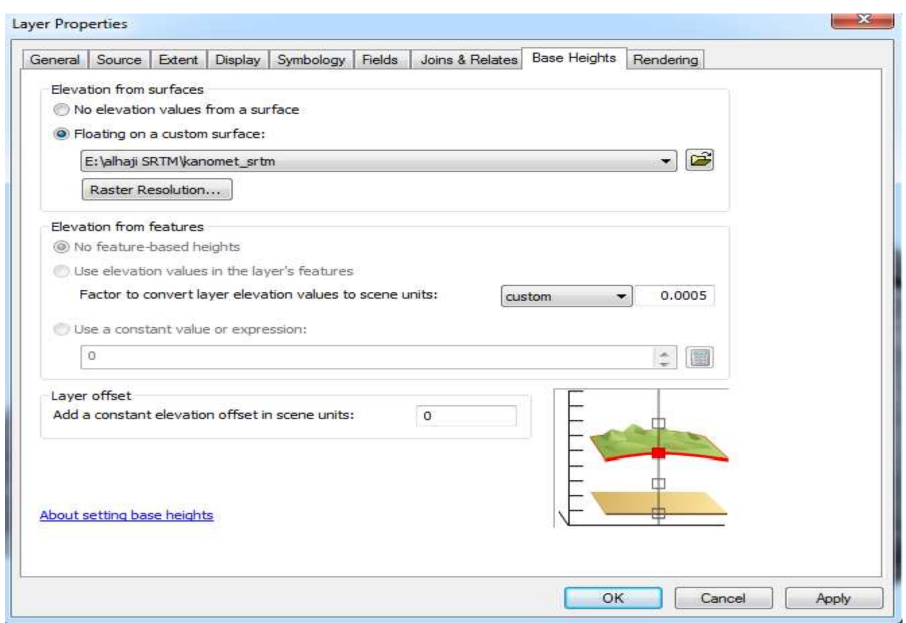


Figure 22: The SRTM data layer properties of base Heights the floating on a custom surface is 0.0005 this is because of the topographical nature of the terrain of high elevation of 530m above mean sea level.

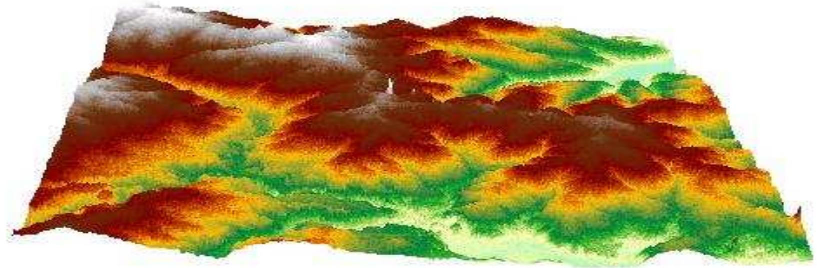


Figure 23: The study area in 3D view

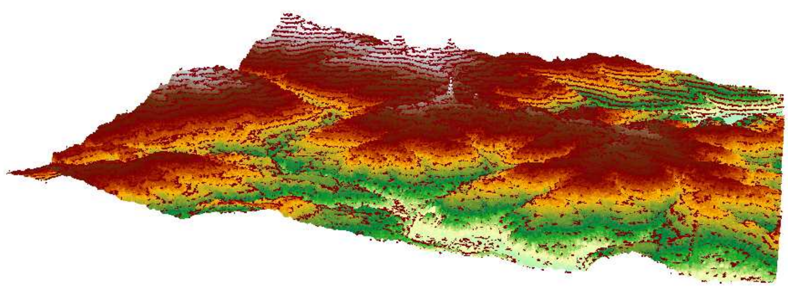


Figure 24: DEM and overlay with contour lines of the study area

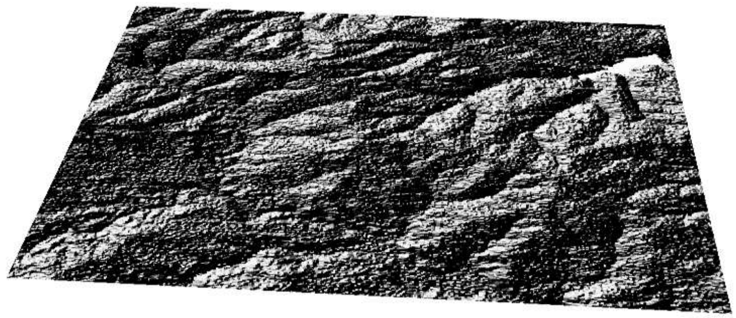


Figure 25: The hill shade of study area

3.4 Nigerian boundary data shape file of the study area from DIVA-GIS

The boundary data shape file was downloaded from DIVA-GIS website and processed the data in Arc GIS for the purpose of study area presentations and description of the scene of study available at http://www.diva-gis.org/

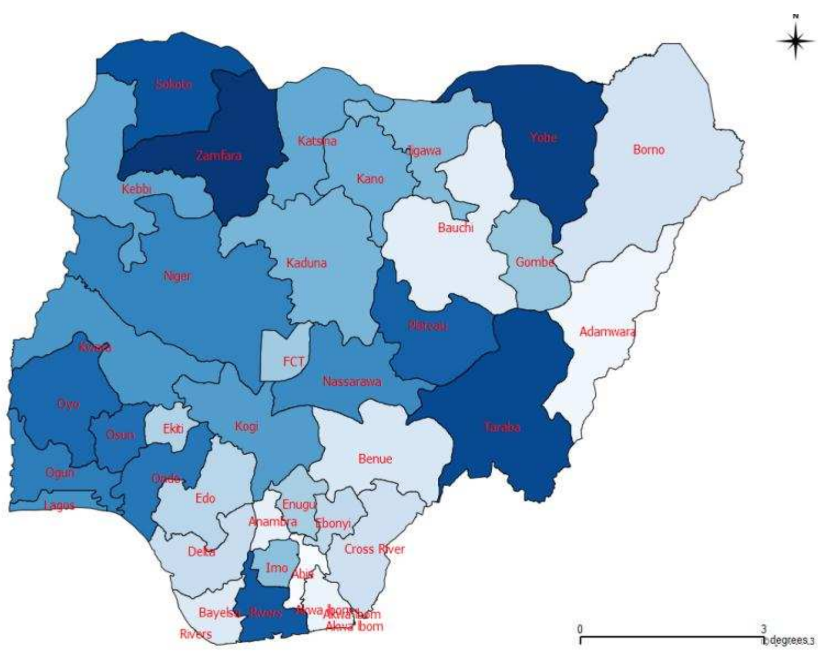


Figure 26: Map of Nigeria in QGIS

3.5 Historical Map of the study area

Historical map of the study area was prepared by the department of surveys and Geo informatics in Ministry of Lands and Physical Planning Kano state, northern Nigeria. The base map of the study area is a good guide and good starting in the analysis of land use and land cover. Many permanent features like built up areas and road network were identified and good guide to image interpretation of the available satellite data that was used in preliminary image interpretation and good guide for field ground trotting of valid training site in supervised classification methods. Arc map was used to geo-reference image of the study area and the available historic map to tie some selected control point to determine the shape and size with image of the study area.

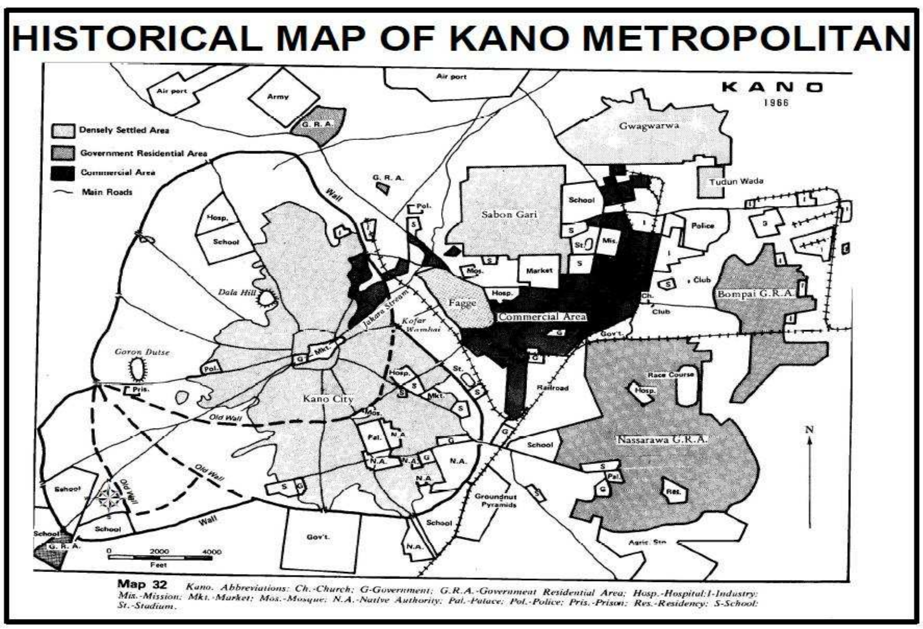


Figure 27: Historical map Kano

3.6 Topographical Map of the study area

. Kano is mostly plane terrain of semiarid sub-Sahara Africa with the elevation 479m above mean sea level. The topographical map was obtained from the survey department of Ministry of Land and Physical Planning Kano state, and was used to justify the downloaded SRTM data of the same area to compare the elevation model digitally with some catchment of river systems from the southern part and the north eastern Madelia River that drain to Lake Chad.

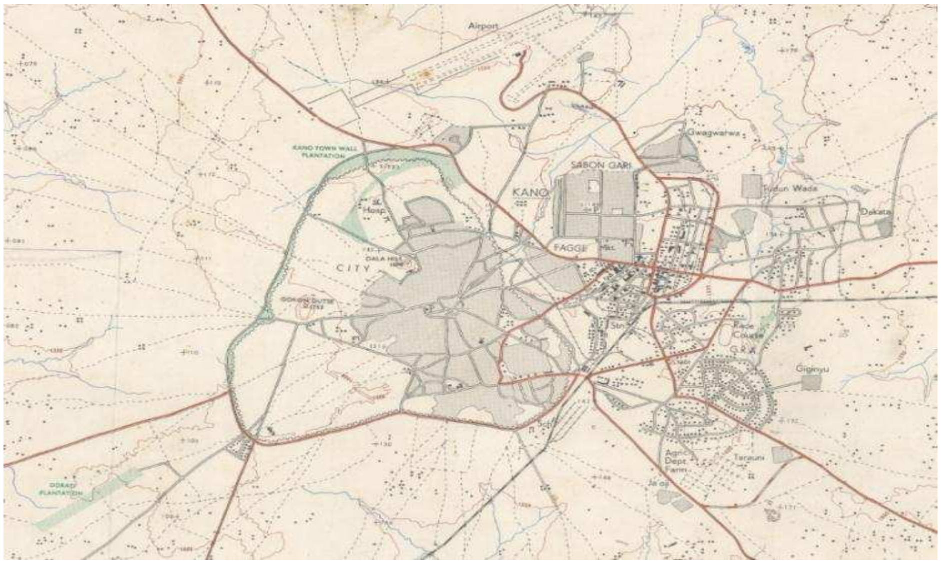


Figure 28: Topographical map of Kano

3.7 Software and Platforms

Satellite image pre-processing and processing was done by using ERDAS Imagine ver.2011 and Arc GIS ver. The10 methods used include the standard way of digital image processing and image classification and change detection map with Eras imagine that play specific sole in remote sensing analysis with high performance tools to process the land sat images particularly in this study. The data was visualised in analysis processes. A details about the software is available at http://www.erdas.com/default.aspx

Arc software play vital role in Geographical Information System (GIS). It has the capability of incorporating different data set with function of an extension tools that process them. Information about this software is available at http://www.esri.com/

SRTM was added into arc map and digital elevation model (DEM) of the study area. Microsoft word was used for research presentation and Microsoft Excel for Graphs and results, and QGIS version 1.7.4 was used to visualised and display Nigerian shape file map

- Erdas Imagine version 2011
- Arc GIS version 10.1
- Quantum GIS version 1.7.4

3.8 Geo-reference

Historical map was geo-reference with the image, Arc map tool was used by activating the geo-reference tool to tie-points as control points with the image. The information of data transformation with orientation using scale, shift, bottom for transformation of both data, shows three dimensional or two dimensional plane of a map or image to avoid image distortion of shape and size of distance orientation with map projection that provides the same distance for the projection of equal areas.

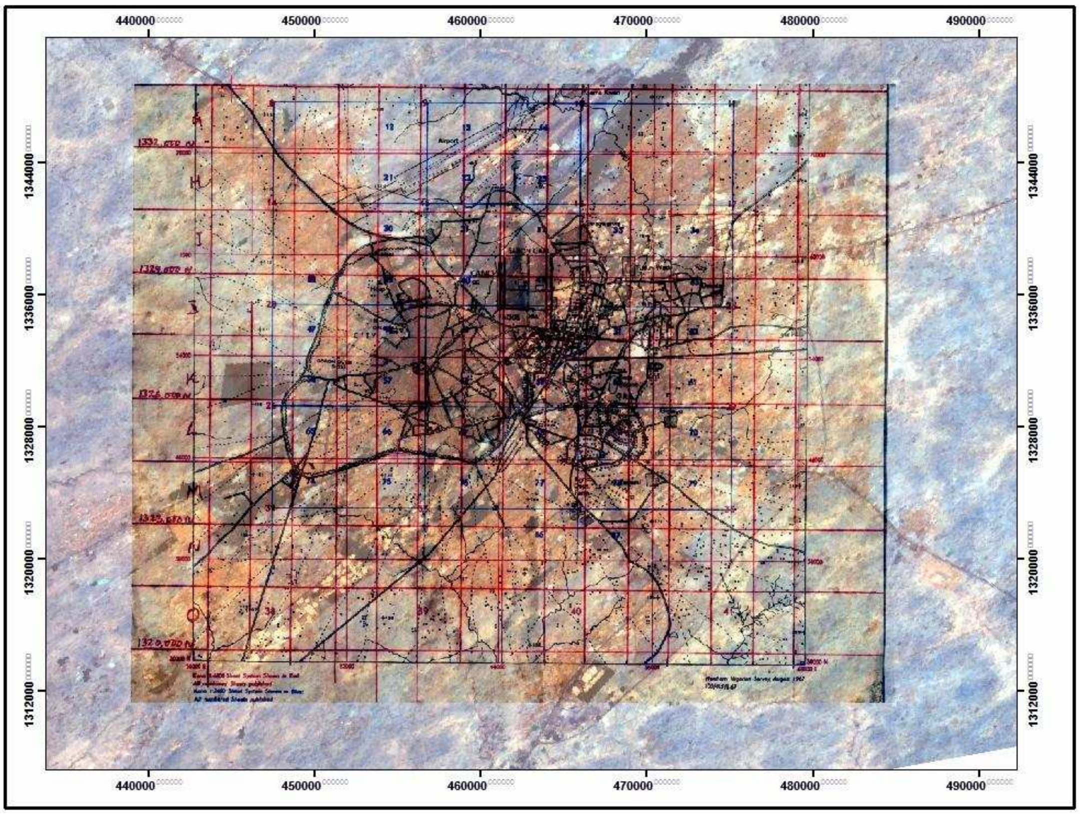


Figure 29: The geo-referencing land sat 7 ETM+ with historical map.

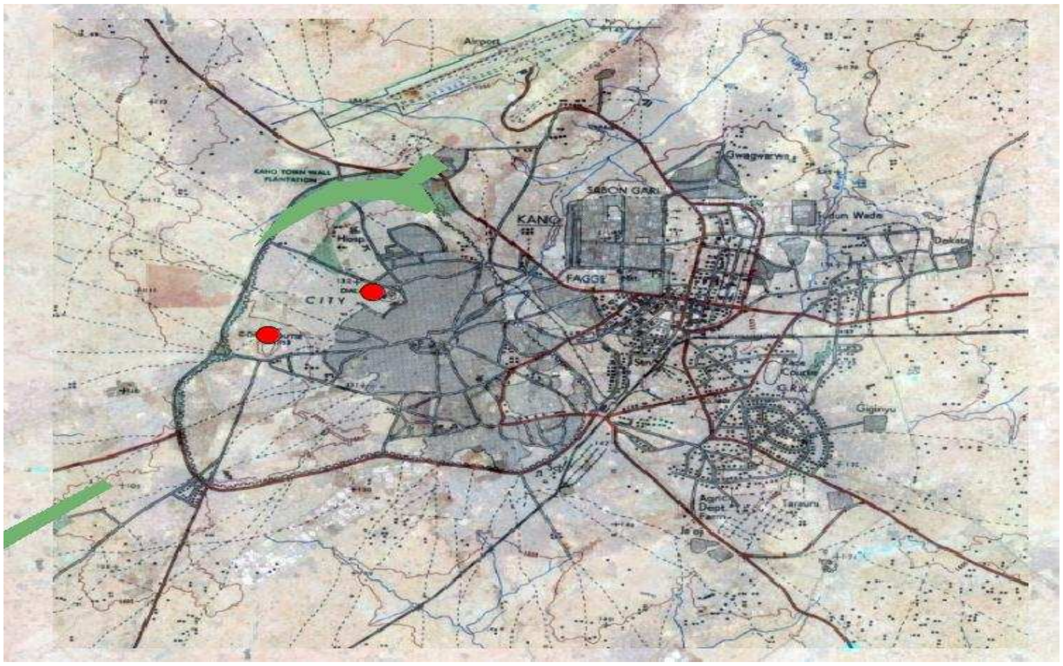


Figure 30: The geo-referencing of topographical map and image

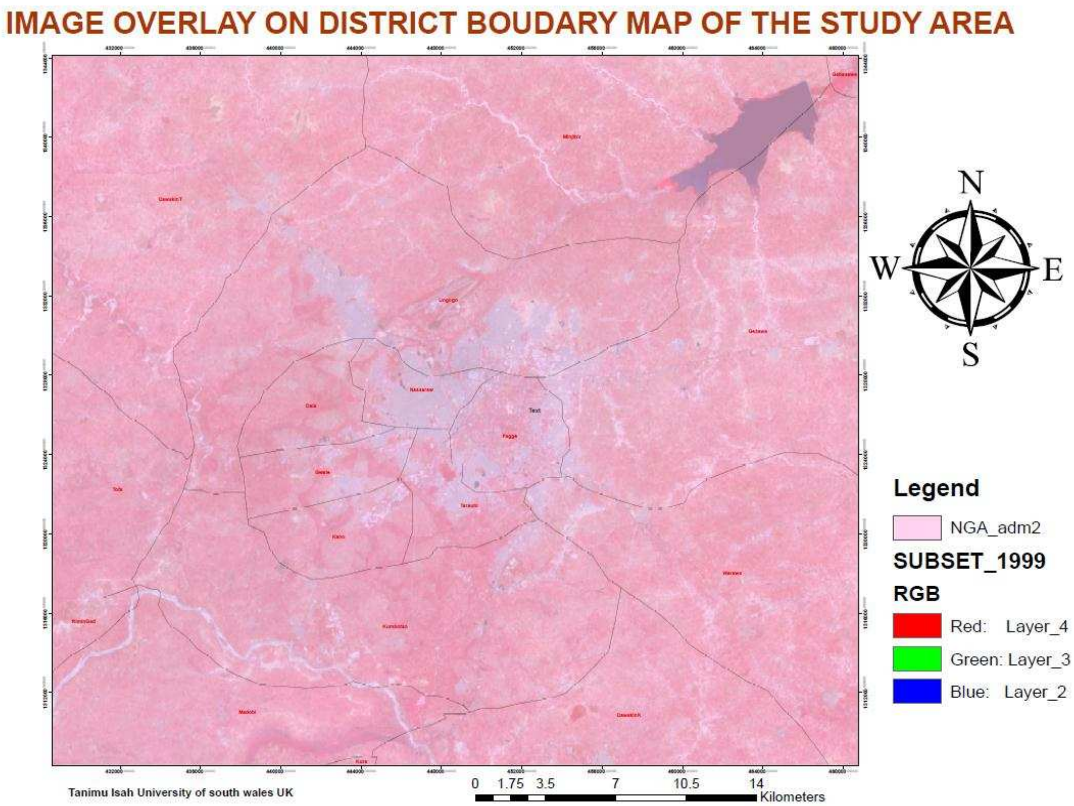


Figure 31: The 1999 image after overlay on district map of the study area with trance parent of 30% to determine the boundaries with image colour combinations

3.9 Scene of the study area

These are subset images showing the scene of study area before the radio metric corrections on both different days' satellite images.

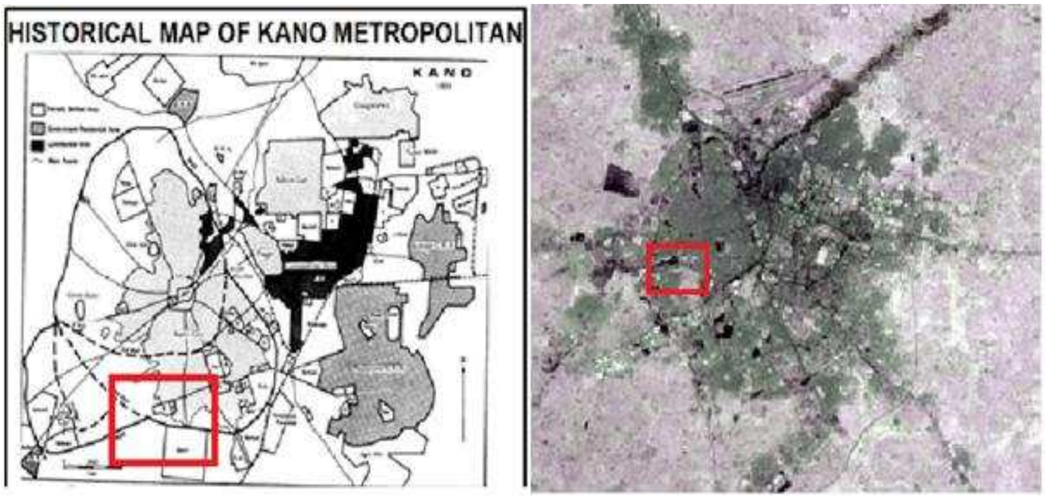


Figure 32: The historical and the land sat image in the process of identifying some areas on the images

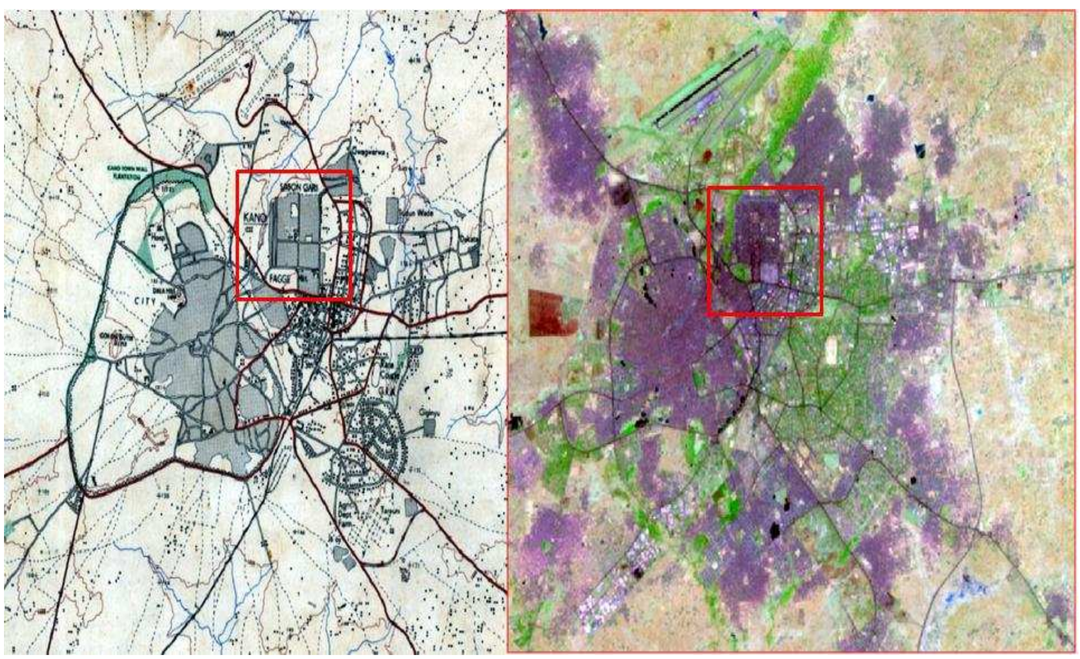


Figure 33: Image location identification with topographic map

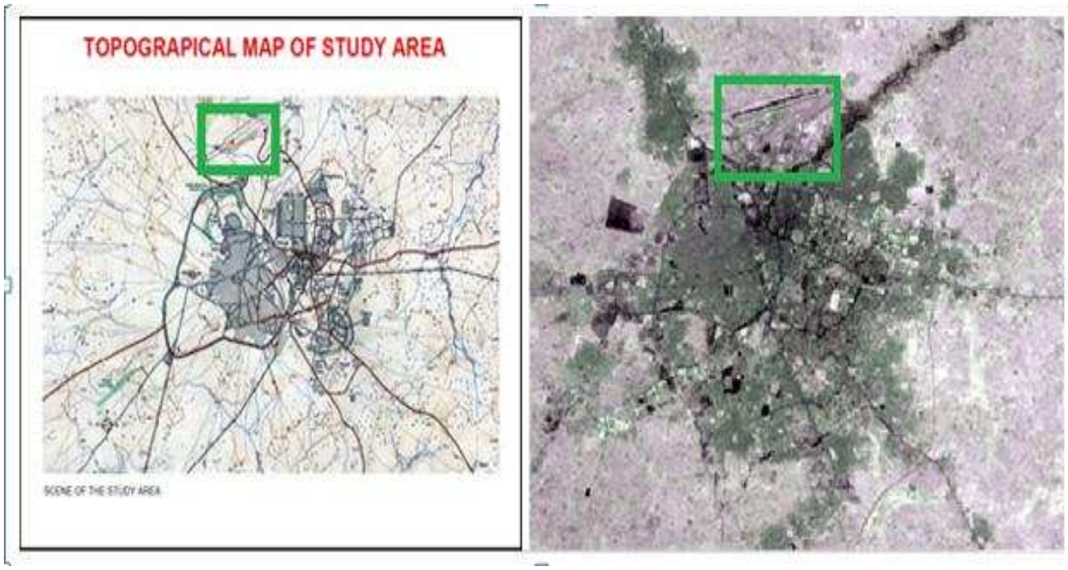


Figure 34: The topographical and the image identification process when airport was detected at both

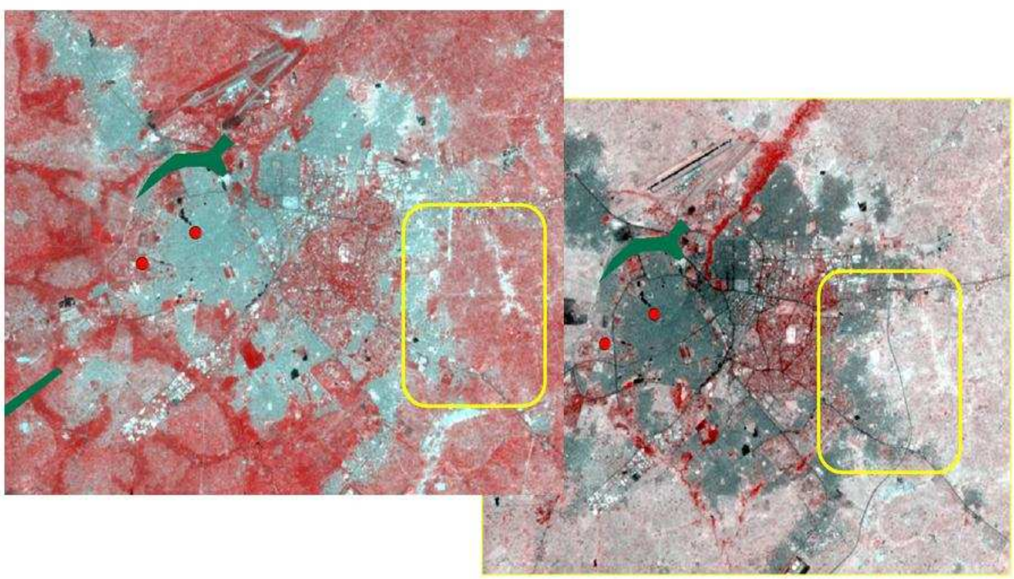


Figure 35: Two different date images of ETM+1999 and ETM+2003 visualise and change detection discover above at the eastern bypass with clear changes

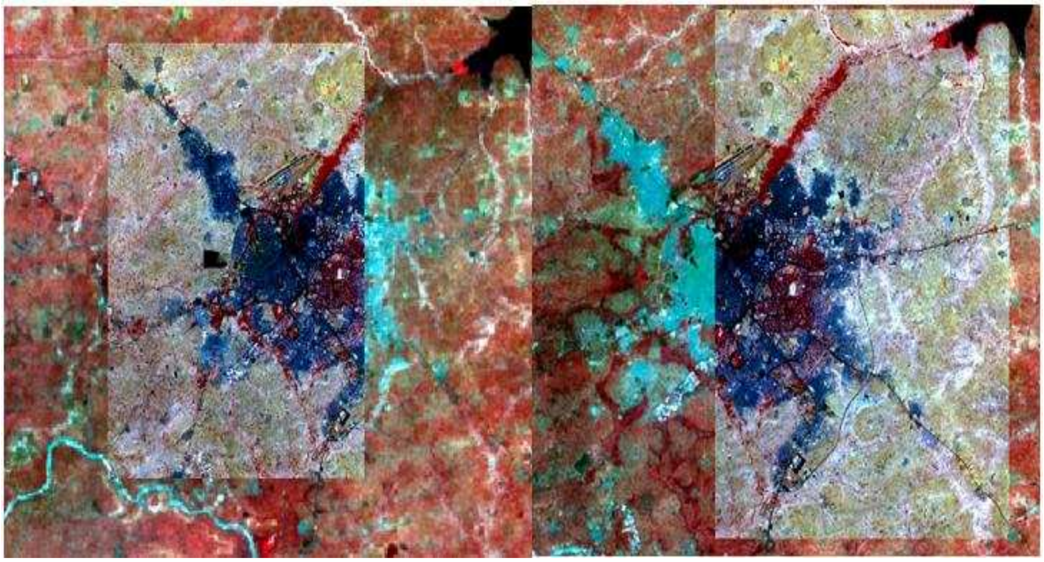
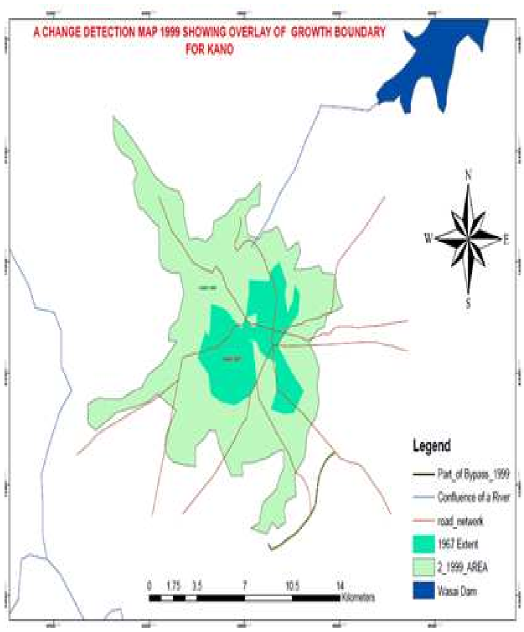


Figure 36: Swipe tool for identifying changes in erdas



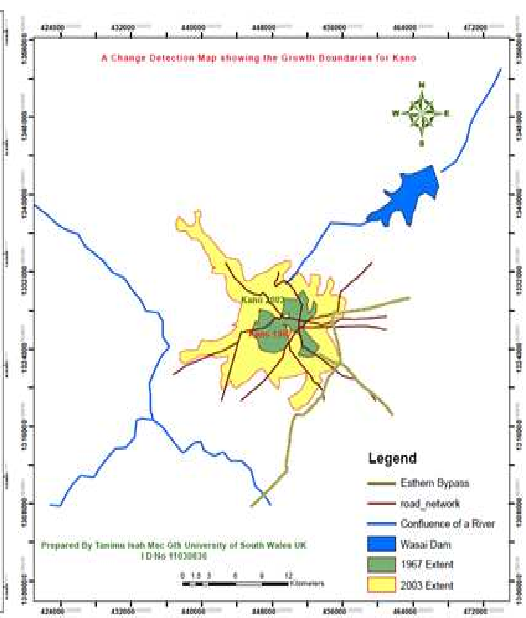


Figure 37: growth boundary 1999

Figure 38 growth boundary 2003

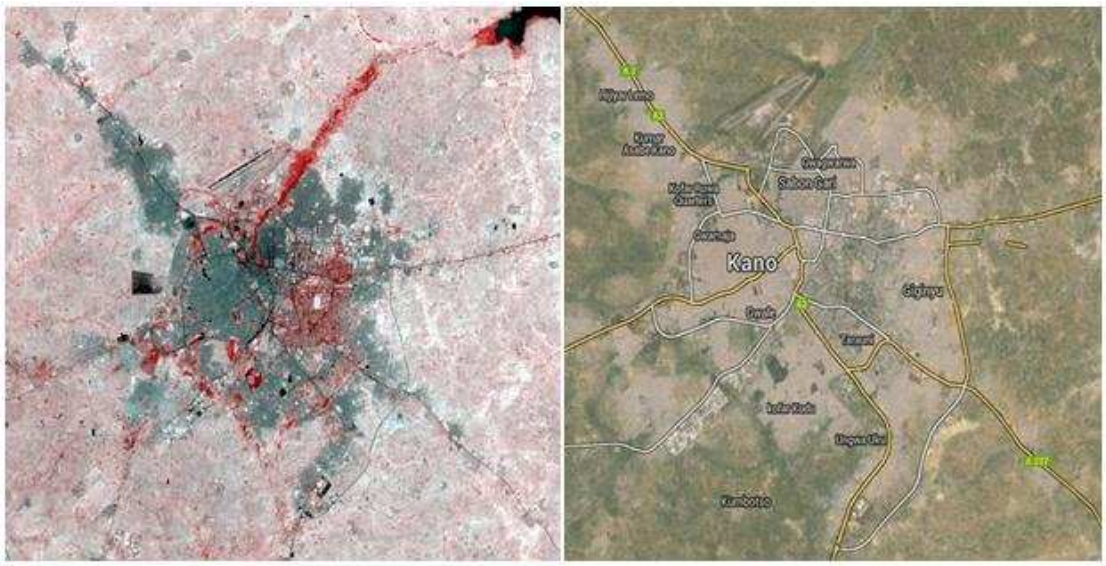


Figure 39: The land sat image of 2003 and the satellite image of Google maps

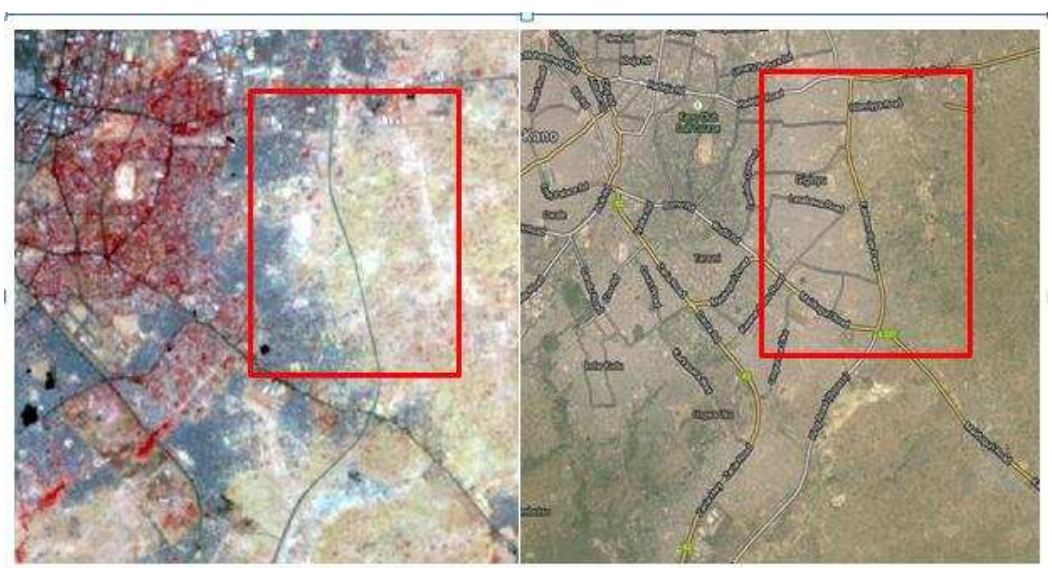


Figure 40: The link view of land sat images and the Google map with identification of change detections areas as comparison with Google map

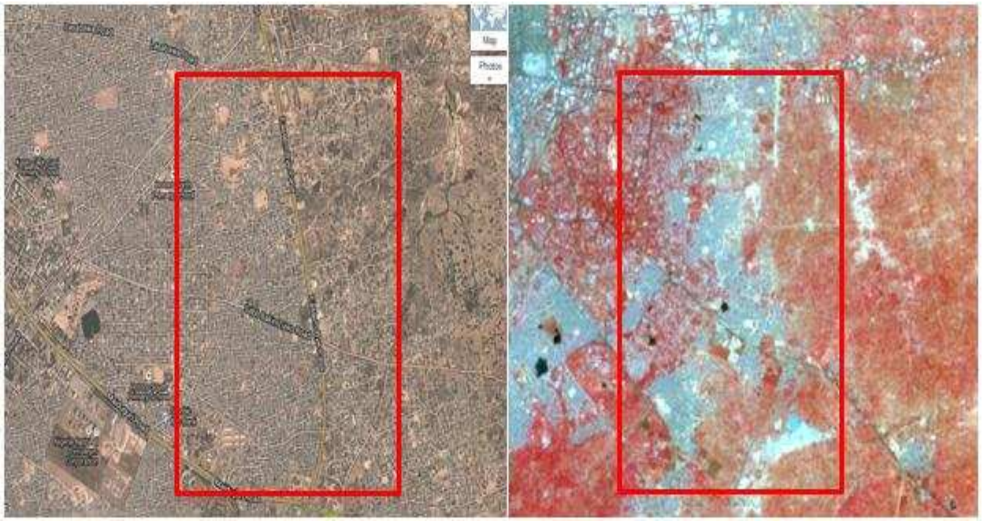


Figure 41: Google map in comparison with land sat image of 1999 and change detections identified at the eastern by pass

3.10 Image pre-processing

Image pre-processing is a remote sensing data that are very useful. This is when radiometric correction has been done particularly in the study of image classification. It connects data with physical features that need a lot of image processing step by step for good identification of imageries features (Akhter, 2006). This involves both atmospheric correction and geometric correction.

- **Atmospheric correction;** This application is very important in remote sensing particularly in this study when two important things are needed in any atmospheric correction. The first thing is to look carefully and compare the similarity between the field data and spectral information of two different date imageries and the second reason is when image capture dates have different atmospheric condition during the data collection. The important is that, this correction application has some adjustment values that reflect at each pixel; that is from sun to the ground and sensor is the composition of radiometric correction.
- **Geometric correction;** This is also an important application in remote sensing that has the application of processing and sharpening images in order to fit the plan metric grid or map projection. This process is very difficult in remote sensing and change detection

analysis. Any studies analysis that requires field information in order to solve problems of remote sensing errors of two different date images will not be more than 0.5 pixels.

3.11 Radiometric Enhancement

The radiometric correction is used to monitor digital numbers (DN) on screen grey, tones and colours. In the processing the satellite digital imagery, it usually depends on what application to be applied. This is in the case of satellite sensor in the visible and near-infrared of the spectrum signature for the spectral enhancement. This includes spectral Haze reduction that involves re-size of images to compare the output images with input image. Enhancement is important because it provides the quality of the image; the image appears in a clear view most especially human vision of viewing and interpretation which require Haze reduction and Noise removal (Sabin 1997).

3.12 Visual Interpretation

Image classification in remote sensing requires image enhancement operation. Noise removal are needed for visual image interpretation in spatial image enhancement with some radiometric enhancement processing of satellite images that requires visual interpretation of the satellite images particularly urban studies that requires remote sensing analysis of satellite images. In this study that requires image visual interpretation in order to identify some important areas for observation so as to extract meaningful information on the satellite images that was captured in different date and different bands combination of image visualisation. It has some tones with the fundamental element of image tone which are shape, size, pattern, and texture (Lille sand 2004).

3.13 Image filtering

Haze Reduction: This is a situation when satellite images have haze cover over the image remote sensing software like Eras provide tools for haze reduction that is to reduce image contrast that always have poor visual of images that need image enhancement improvement of image interpretation analysis and the satellite digital number (DN) from 0-255 in different bands can only take the short spectral range of view (Sabin 1997)

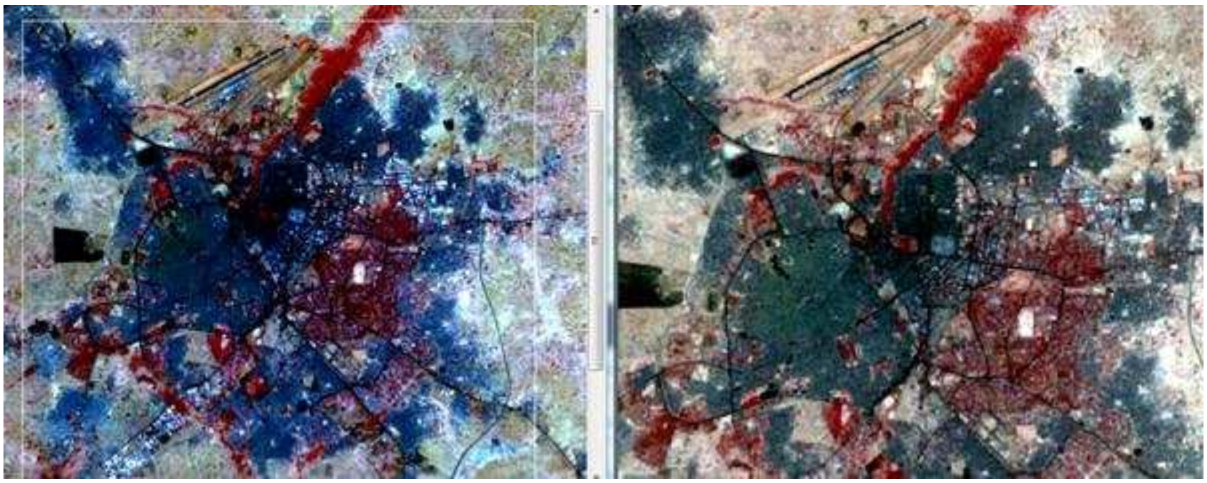


Figure 42: Before and after Haze Reduction 2003 output image

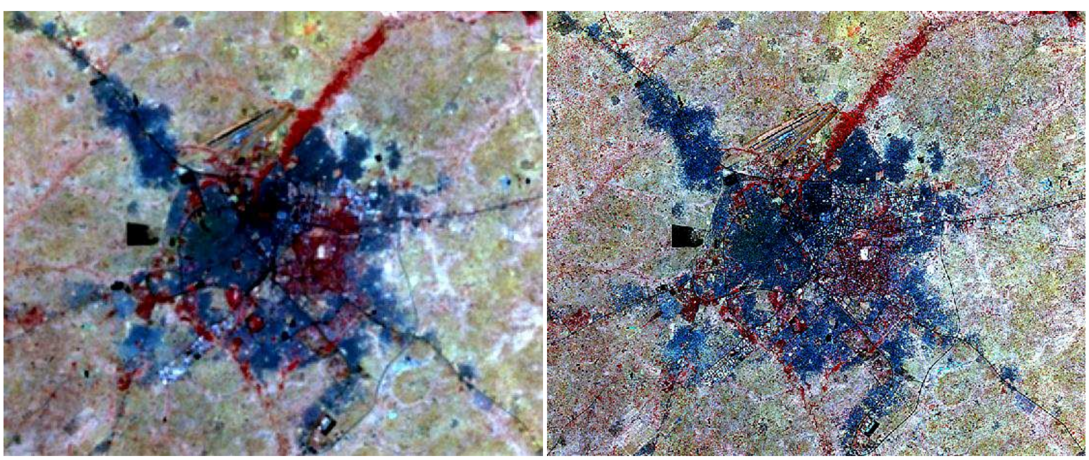


Figure 43 Composite images before haze reduction and after

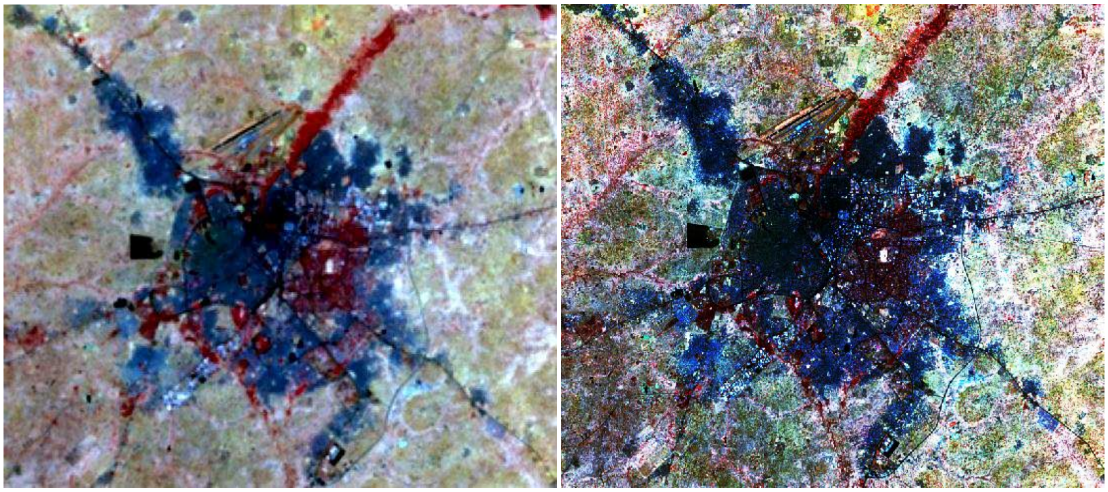


Figure 44 show before sharpen and after sharpen in images filtration

Noise Reduction: Image noise removal is important in image classifications where image noise is usual problems that disturbed image visual interpretation of image data this is because of some shortcomings of sensor data capture processing image noise can degrade the radiometric information of digital image classification analysis.

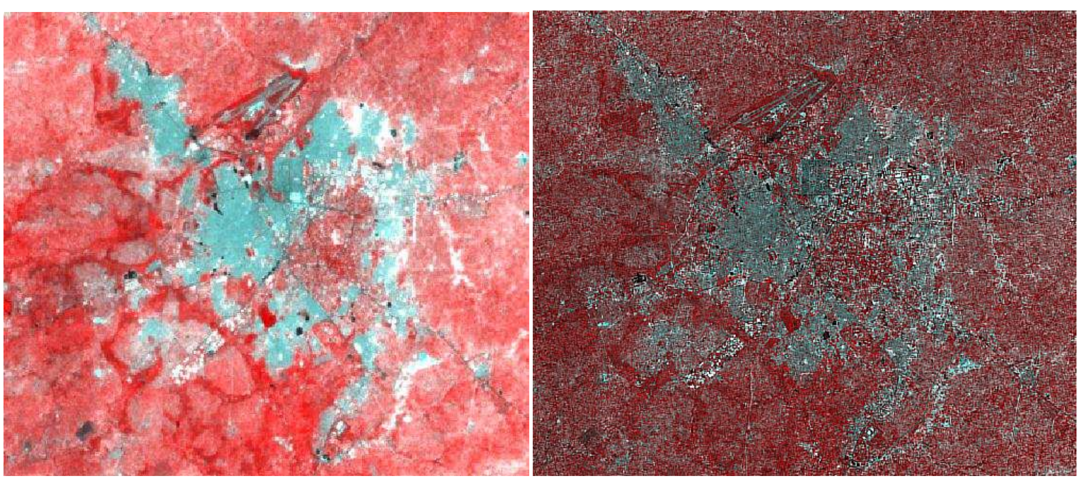


Figure 45 Haze reduction 1999 composite image before and after

3: 14 Spatial Enhancement

Digital image processing requires enhancing image display. This is where the spatial filters improved the spatial properties of an image compared to spectral contras. This spatial enhancement is very good in detecting images as well as edge of the image.

Crisp: this is one of the techniques of spatial enhancement which aids in sharpening the pixel values. It provides clarity to the images so as to depict the land cover without much stress. This can be seen in a figure 45 below.

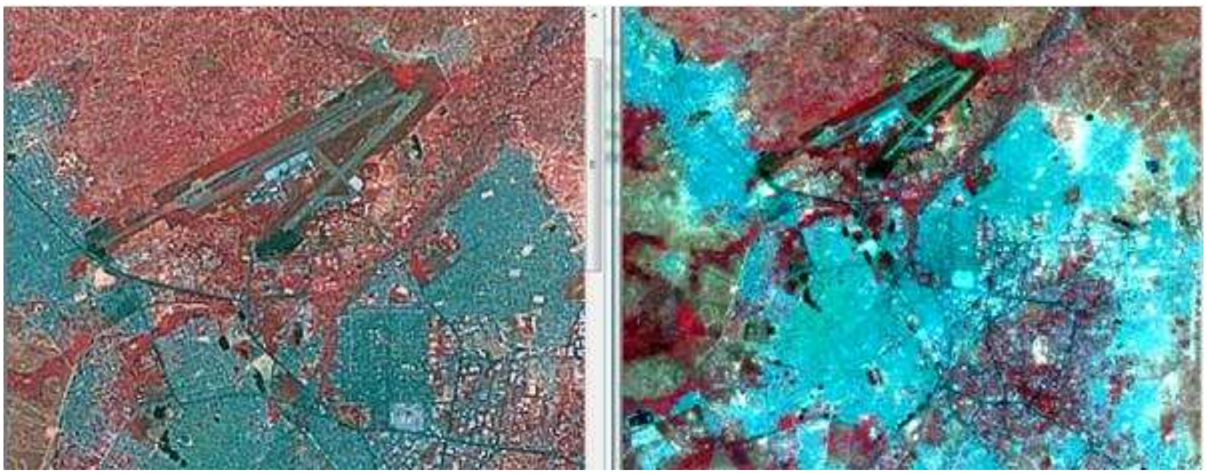


Figure 46 Crisp enhancement 1999 image and before crisp

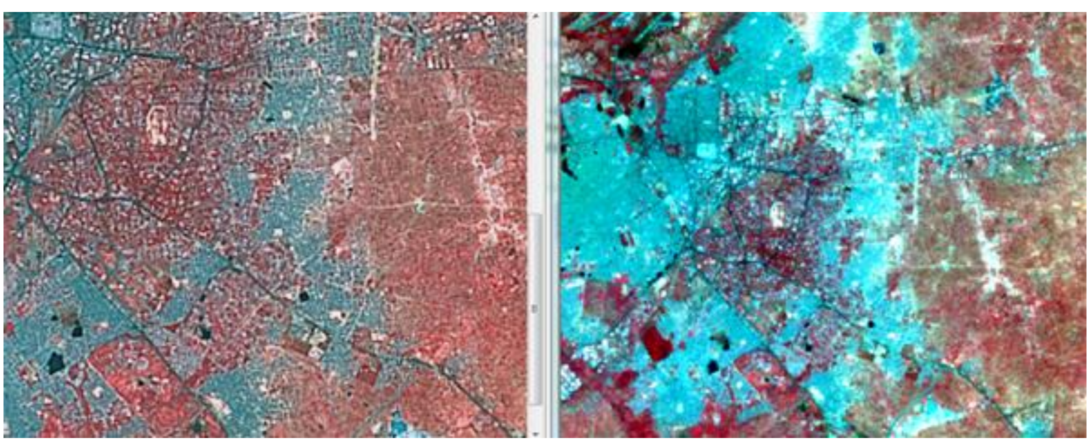


Figure 47 an output Crisp 1999 image and before crisp enhancement

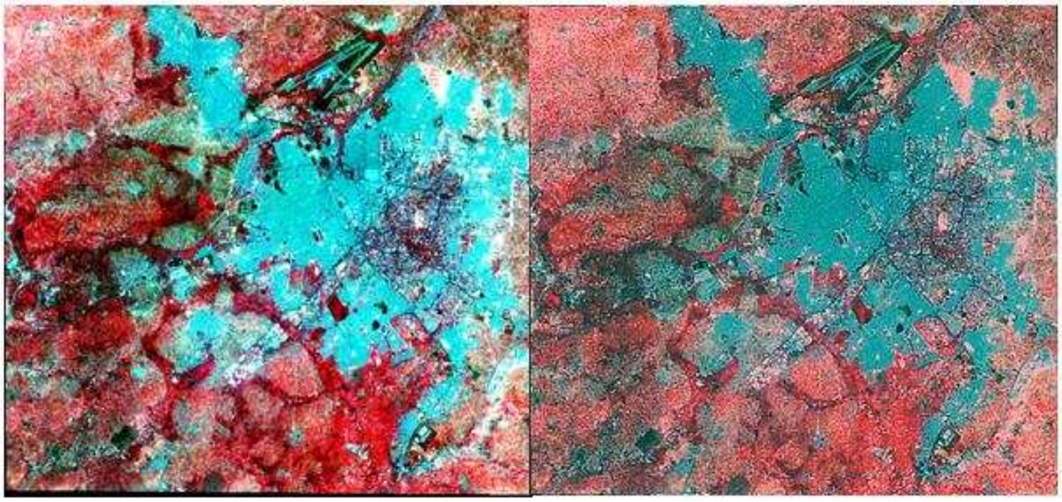


Figure 48: Before and after Crisp enhancement 1999 image

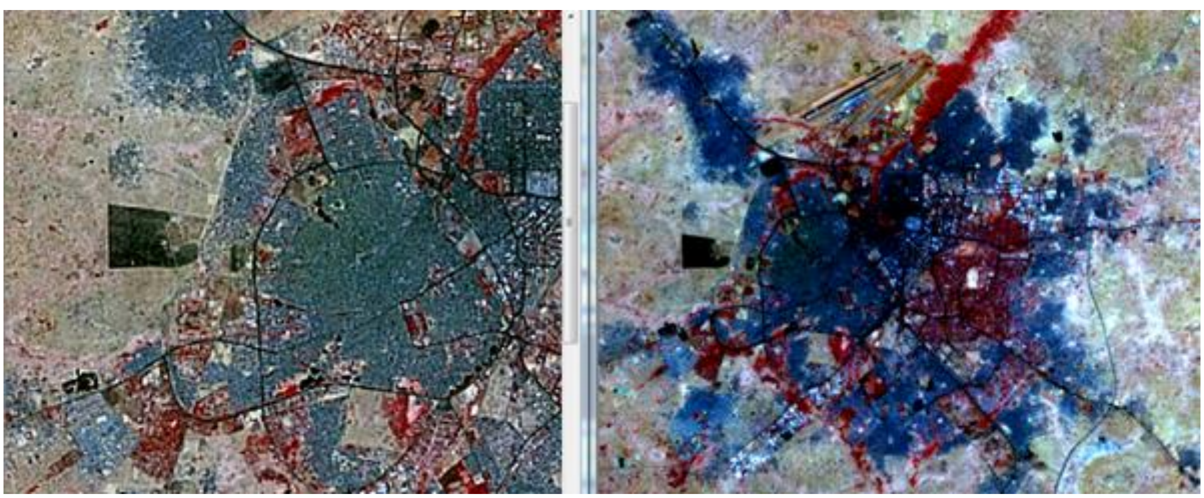


Figure 49: Crisp 2003 image and before

Figure 50: Before and after Crisp enhancement 2003 image

3.15: Image Transformation

This is a very important technique in remote sensing application that is applicable in this branch of studies that involves land use and land cover analysis of change detection. The function of image transformation like principal component analysis has good advantages of reducing data redundancy that are within satellite images bands in order to have the components information. This technique helps analyst in pointing out key areas in the process of identifying changes on the output image. But the shortcoming of this principal components analysis is the difficult in term of image interpolation of change detection on the transformed images

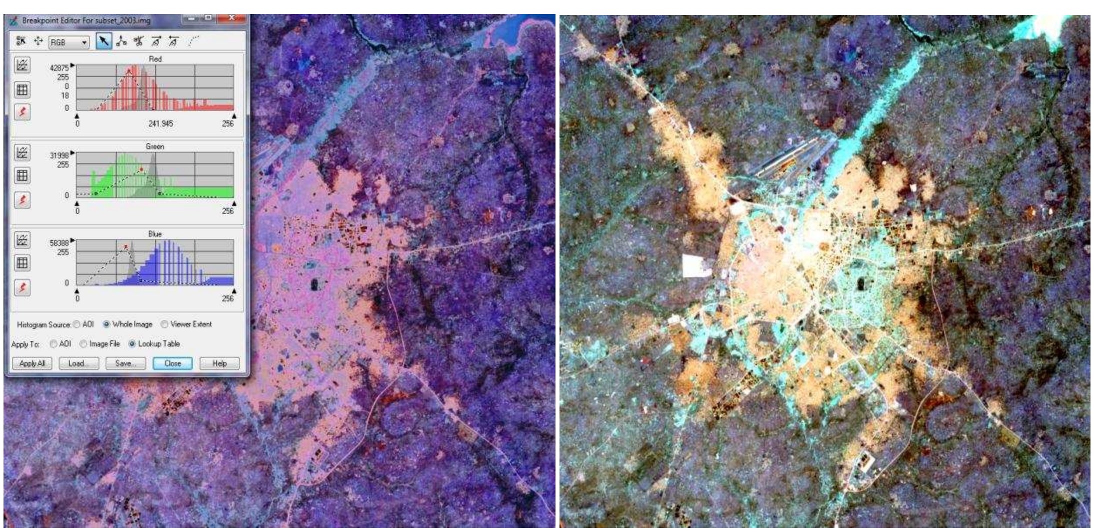


Figure 51: Showing an invert image of 2003

3: 16 Principal Components Analysis:

This is usually measured data of spectral reflectance in three composite colours of Red, Green and Blue near infrared principal components analysis. Usually it is a transformation application that provides uncorrelated output bands to separate the noise components of data sets principal components analysis in remote sensing application. It is quite standard method of reducing spectral redundancy principal component analysis. It is also a linear transformation with image projection of each pixel PC1 band that has large sets of data variance and PC2 band data that is second to PC1 in term of percentage of data. The last PC band usually has noise which is because of the very little variance, (Richard, 1999).

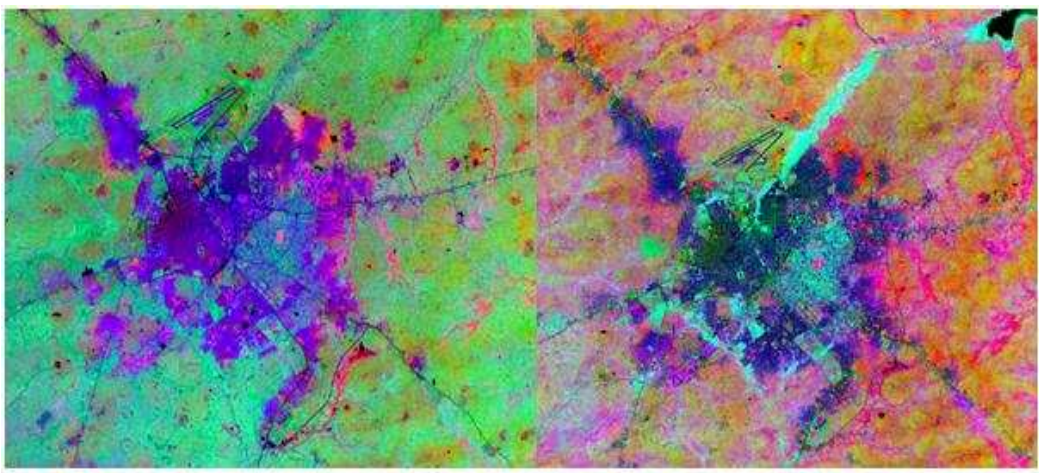


Figure52: PC of bands [123] of 1999 and PC of bands [123] of 2003

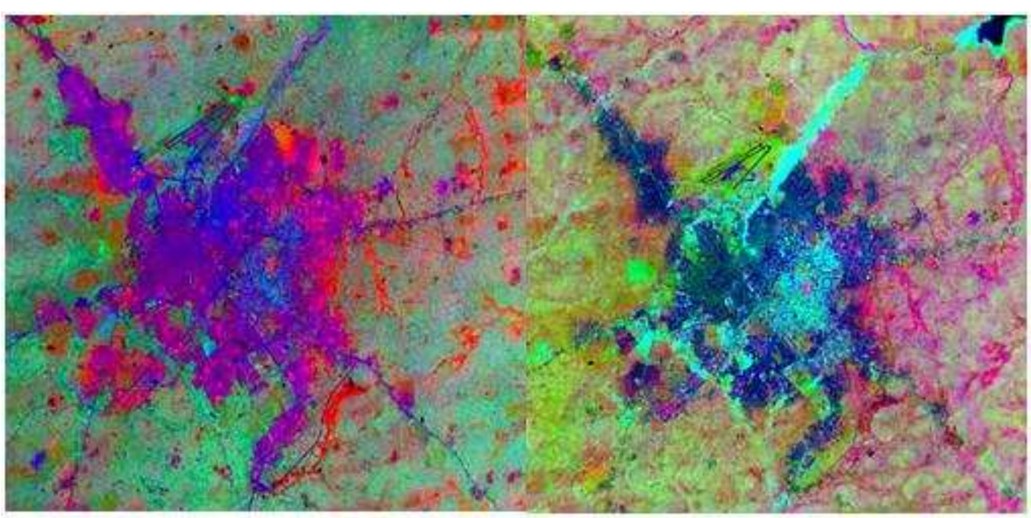


Figure 53: PC of bands [125] of 1999 and PC of bands [125] of 2003

3.17 RGB to IHS

This is part of image transformation that are in Red, Green, and Blue (RGB) and Intensify –Hue-Saturation (ISH) colour generated by the three bands of image transformation, in image spectral enhancement and image transformation application in transforming RGB to HIS. The processes are used to obtain the image spatial resolution that mostly provides good details images which should be in bands 123.

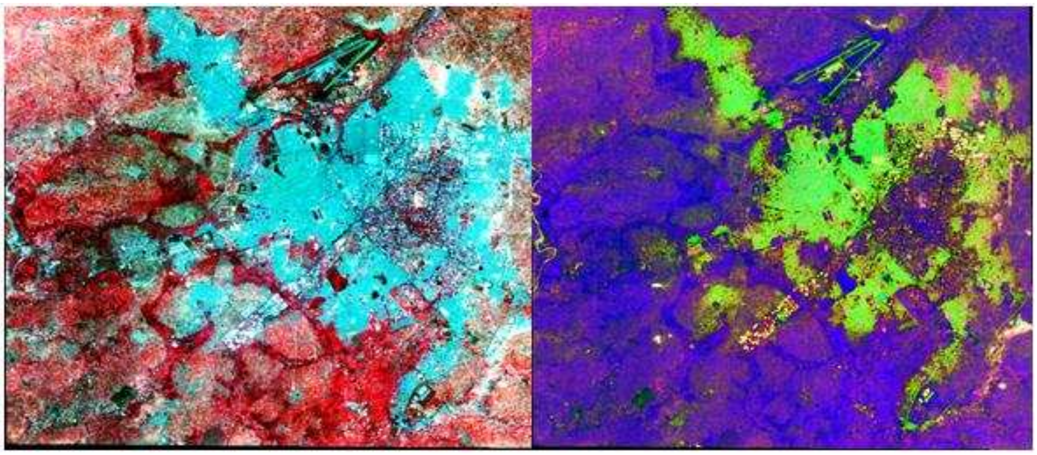


Figure 54: Before and after RGB to HIS of 1999

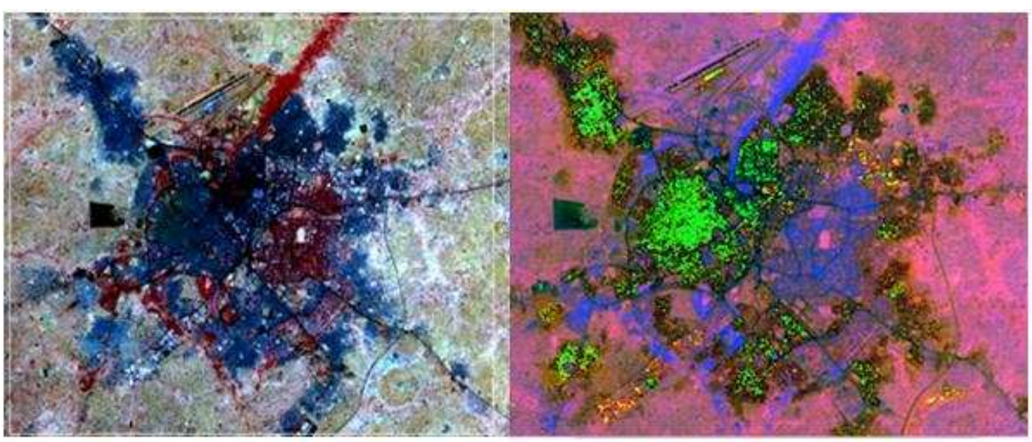


Figure 55: Before and after RGB to HIS of 2003

3:18 Normalized Different Vegetation Index (NDVI) Image

The normalized different vegetation index (NDVI) refers to vegetation cover study in remote sensing application that determines the vegetation cover. Whether global or regional, monitoring global food change and the like or global vegetation cover changes all about NDVI is normalized ratio that usually range -1 to 1 from the near infrared in which the red bands is an indication false colour vegetation cover (Sabin, 1996). In regard to the study area, most of the bare surface lands are arable lands for crops cultivation in rainy seasons.

Equation; NDVI = (NIR-RED)/ (NIR+RED)

Where NTR is the near infrared band response

RED is the red band response for given pixels

The NDVI pixel values always are ranges from (-1) to (+1). These values indicate that close to +1 that is (0.8-0.9) is showing the highest concentration of vegetation cover and those at 0.1 means that are with no vegetation cover. While grass land will indicate values like 0.2 to 0.3 that is grass cover, (weir and Herring, 1999).

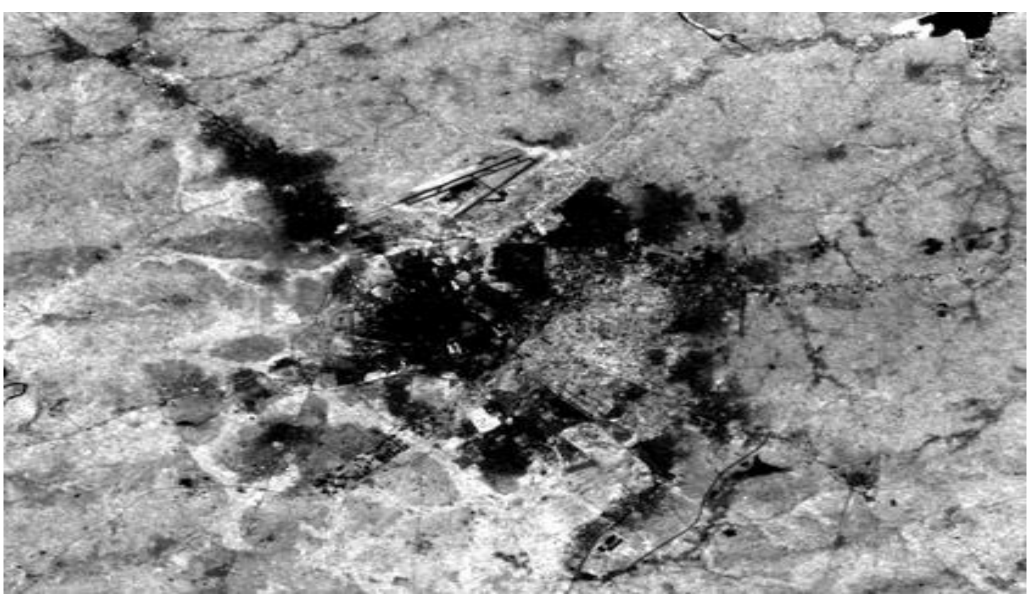


Figure 56: Showing the output image of NDVI

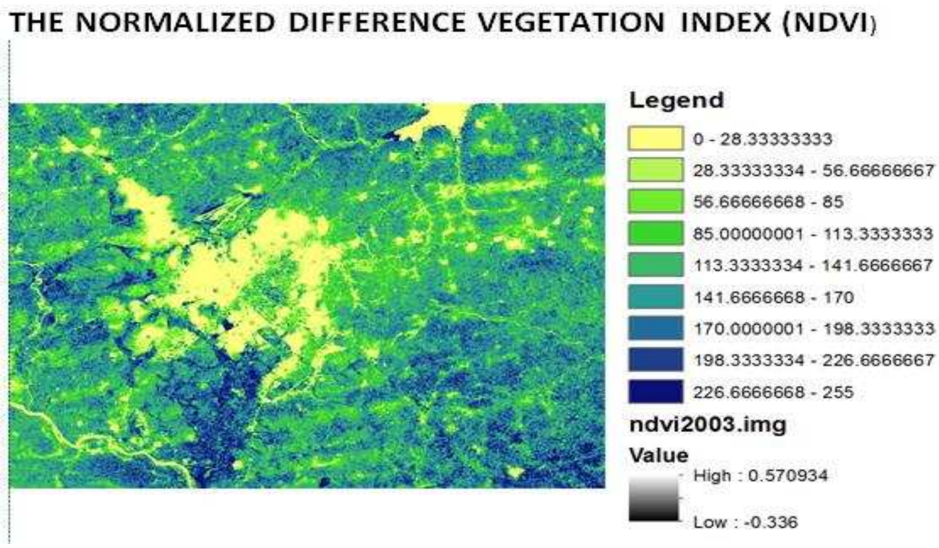


Figure 57: Showing vegetation index

3:19 Image Classification

Remote sensing digital data satellite imagery interpretation is used to interpret the experiential image data so as to classify both natural and anthropogenic features. The mage are classified using classification methods which includes unsupervised classification methods and supervised classification (Lille sand 2004).It was explained as another part of image classification analysis is the identification of pixels group with specific spectral characteristics of identifying many objects and other Geographical features of the land use classes that are displayed by this groups (Lilli sand et al, 2008).Digital image classification is the way of displaying image pixels in a limited number of each classes that defend on the spectral information which end up with classified of thematic map output information from the input image. Remote sensing image classification analysis is mostly classified as either one of this two notable primary approaches; supervised classification and unsupervised classification methods.

1. Manual Image interpretation
2. Automated computer identification

3:20 Unsupervised classification

The unsupervised classification of satellite images methods are situation where little information of the site to be classified and unsupervised classification application analysis is allowed the computer to select and define datasets by detecting clusters within objects. This method is known as cluster analysis with simple algorithm of interactive self-organizing data analysis (ISODATA) that is available in ESRI and ERDAS Imagine

1. Does not need any training data
2. An output result may end up with very poor information

3: 21 supervised classification

This application requires human skills that the image analysis should have specific defined classes in which the machines are trained by some similarity of image objects and features.

1. There is need for training sites by using substantive training data
2. Image output information of image classes may not be very accurate and compatibly.

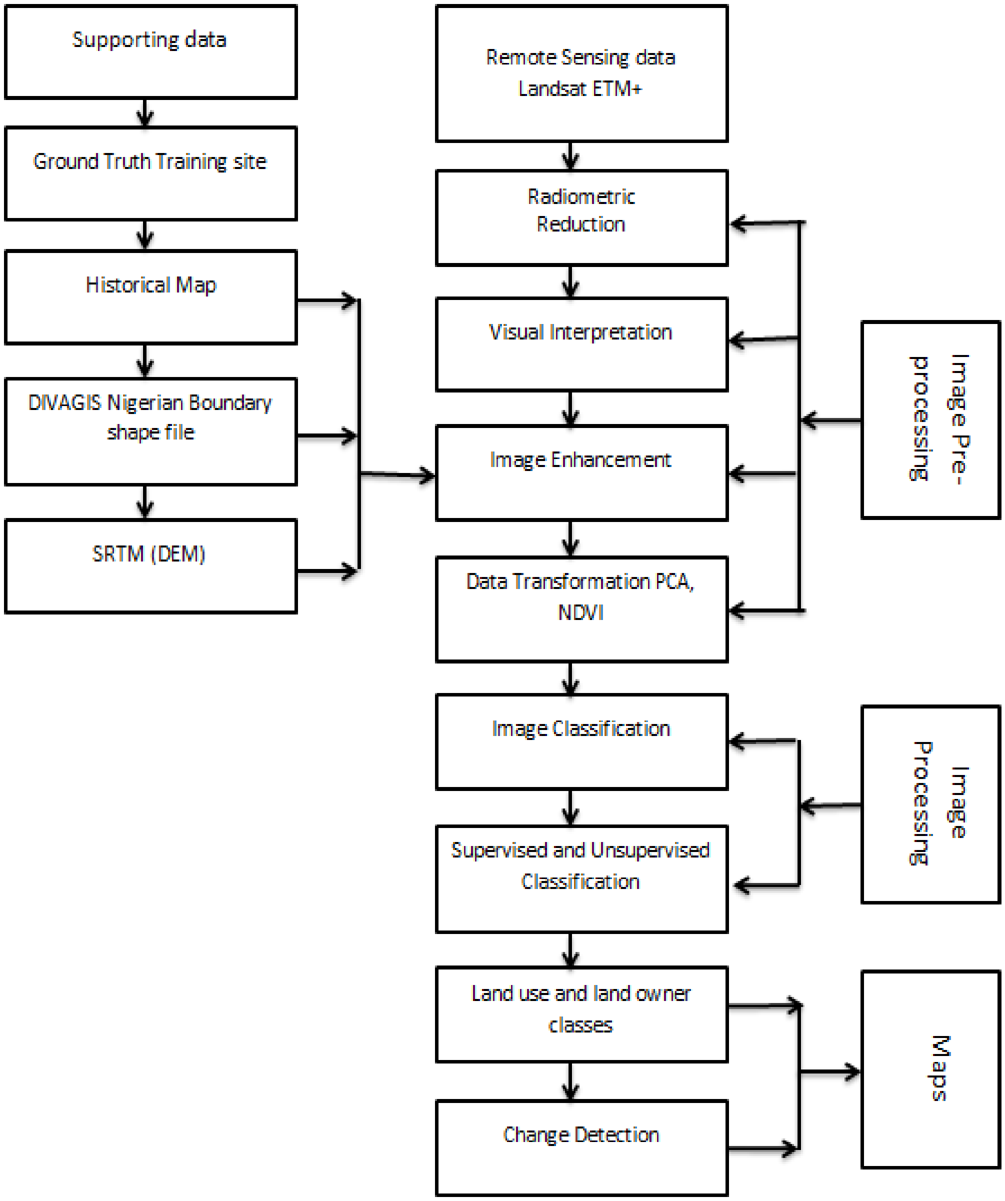


Figure 58: Flow chart for land use and land cover change detection map classification

CHAPTER 4: DATA PRESENTATION AND ANALYSIS

4.1 Introduction

This chapter presents and discuss the results spatial changes in urban growth of Kano-Nigeria.

4.2 Image processing

After downloading the image from United State Geological Surveys (USGS) website, it was added into Erdas imagine software for the composite layers. The composite layers were made by layer stacking of all bands layers of each image captured in two different date images. These are displayed in the figures below (presented here before the sub-set image of the study area of this two different date images):

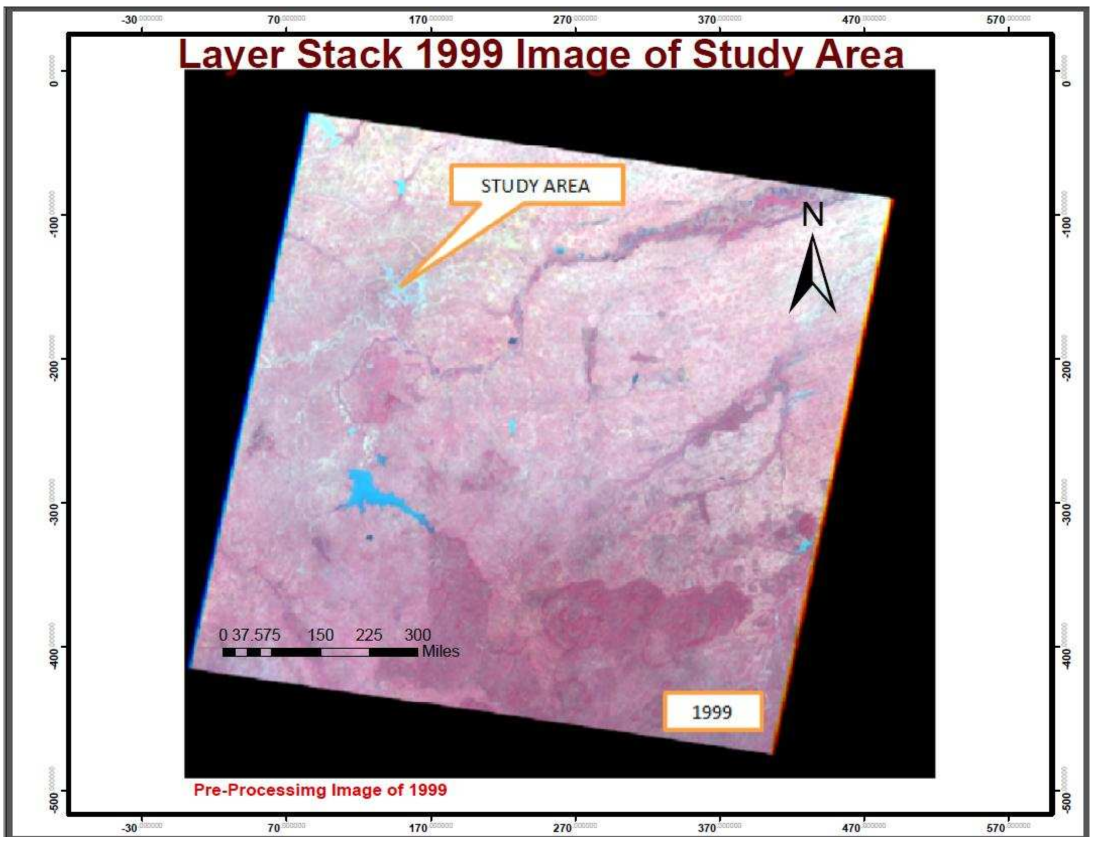


Figure 59: composite Bands 432 Image of 1999

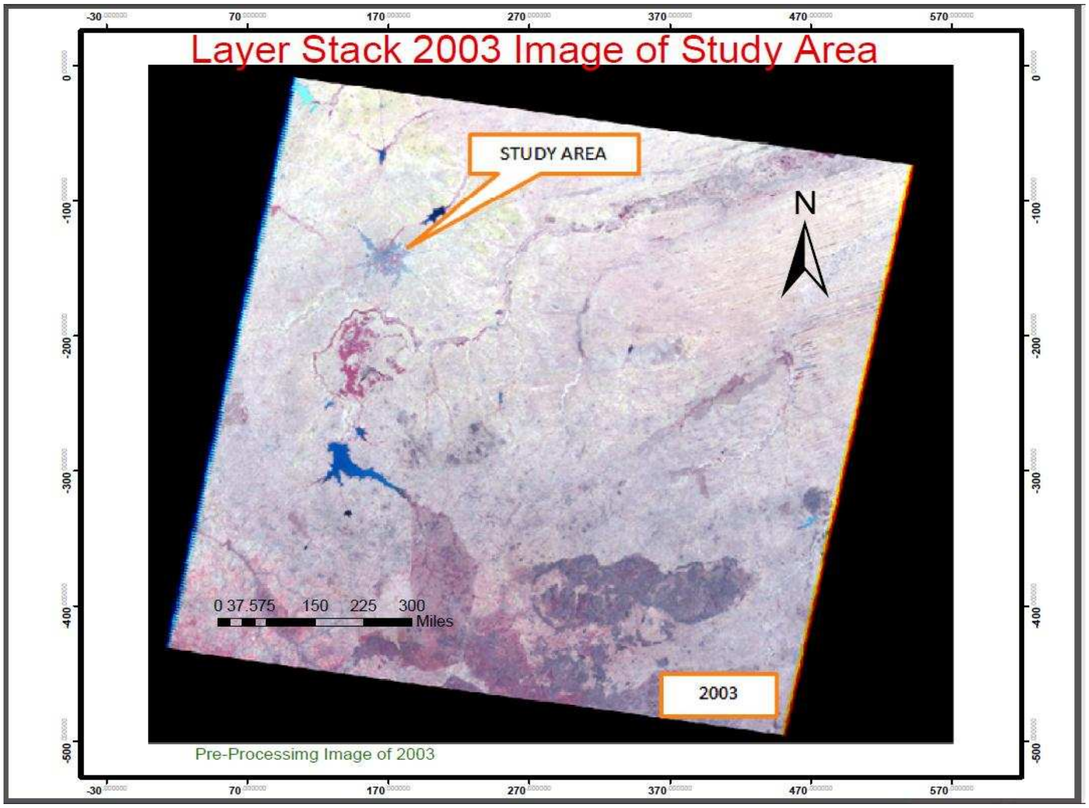
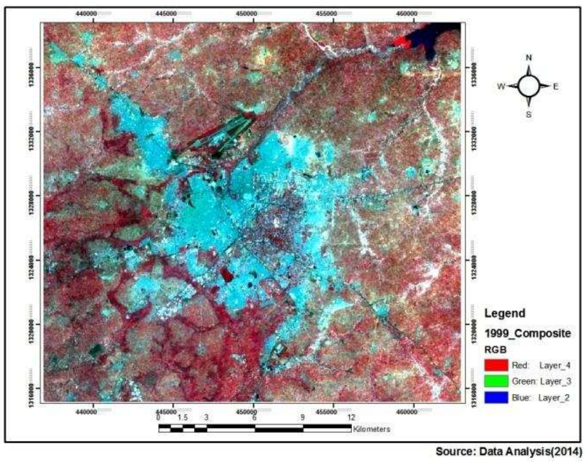


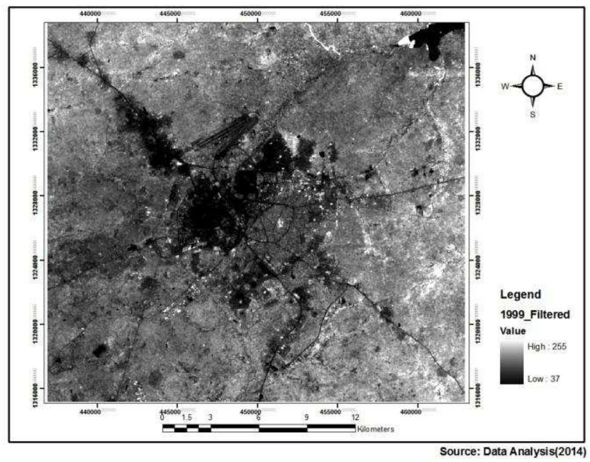
Figure 60: composite Bands 432 of 2003 Image

Figure 61: Showing the study area land sat image in 3D perspectives

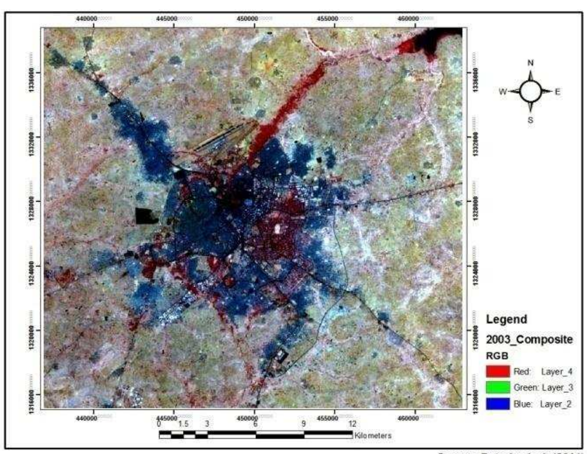
4. 3 Image Filtering

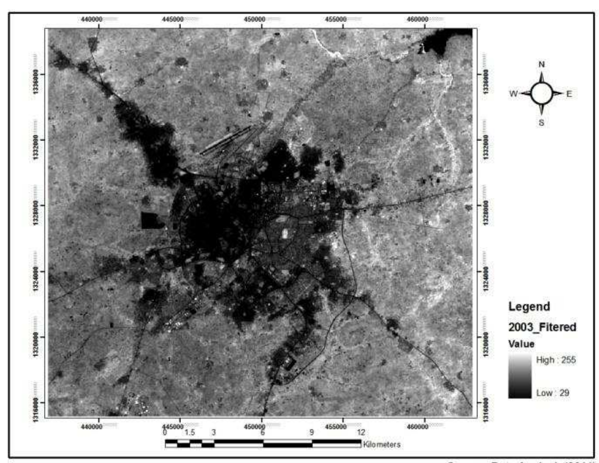
All images that were filtered in Arc GIS using filtering tool in ArcTool extension with the panchromatic band produced new Images with better visual quality and features those were clearer than their original images. This made it easier to distinguish different colour combinations in the false composite. Images Figure 62 shows the contrast between a normal composite image and filtered mage.





1999 Image Before Filtering 1999 Image After Filtering





2003 Image Before Filtering 2003 Image After Filtering

Figure 62: Land sat 7 ETM+ Composite and Filtered Images (R:4, G:3, B:2)

4.4 Image Classification

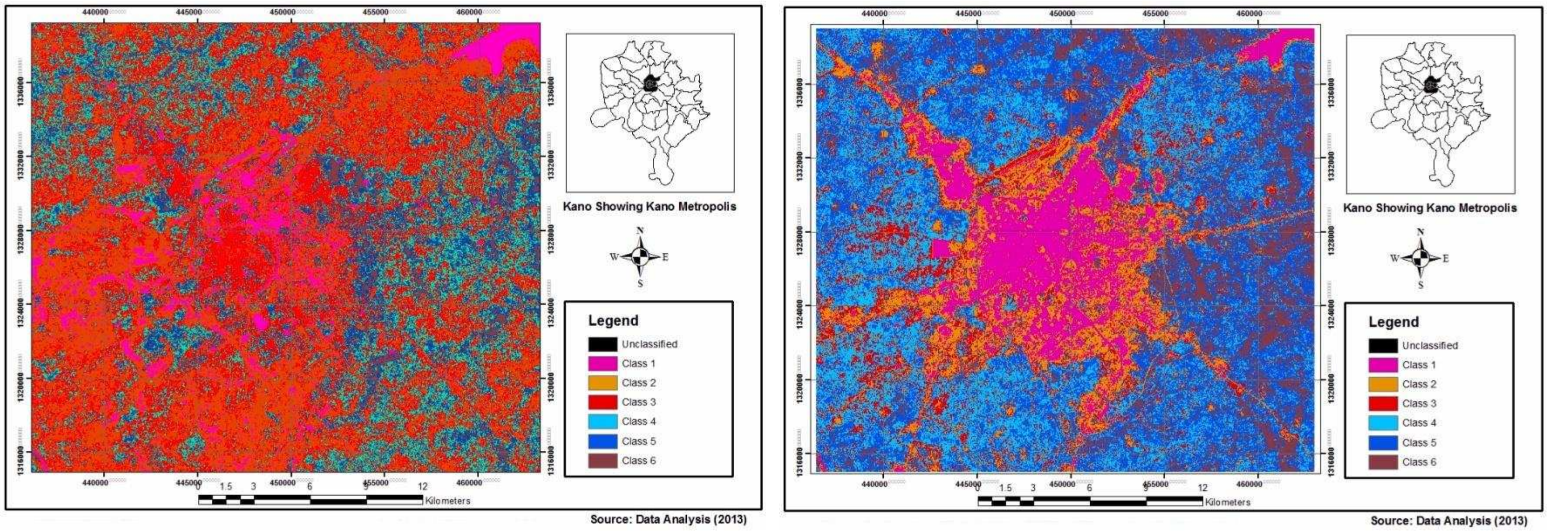
4.4.1 Unsupervised Classification

Prior to change detection analysis, the images of both dates (1999 and 2003) were classified using Isodata unsupervised classification technique. The idea was to ensure that the clusters generated provide an insight to the number of features class within the images and perhaps guide the ground-truthing exercise. Six clusters were identified on each image date (Table 7). The spatial distribution of the clusters is presented in Figure 63.

However it is important to note that the unsupervised classification has limitation in that the number classes may not match with actual classes in existence and it is more appropriate where the researcher has no prior knowledge of the area. Thus supervised classification was then adapted in this study because it reflect the realities on the ground.

Table 7: unsupervised classification results table

No.	Land Use Class	1999 Area (ha)	Area (%)	2003 Area (ha)	Area (%)	Change Detection	Result
1	Class 1	88642	3	104157	3	15515	Increase
2	Class 2	607259	20	622713	21	15454	Increase
3	Class 3	812828	27	782817	26	-30011	Decrease
4	Class 4	750266	25	727528	24	-22738	Decrease
5	Class 5	566859	19	576029	19	9170	Increase
6	Class6	200930	7	213540	7	12610	Increase
	Total	**3028783**	**100**	**3028787**	**100**		

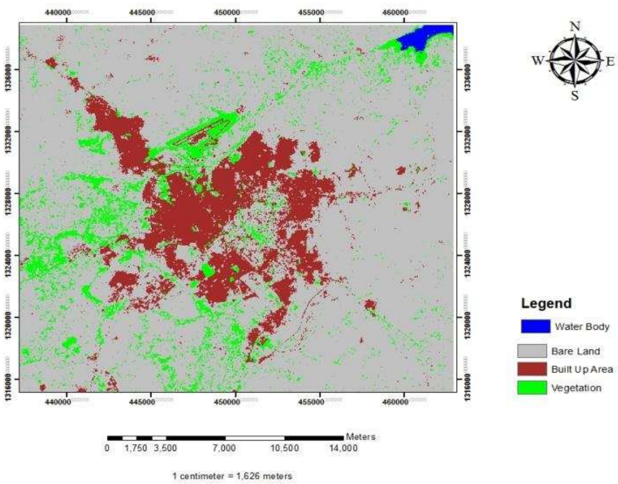


A) 1999 B) 2003

Figure 63: Classified Images of urban Kano and the surrounding area using ISODATA unsupervised classification technique

4.4.2 Supervised Classification

Having noted that the unsupervised classified images were unfitted for any analytical use in the study, the images were then classified using MLC techniques using four class schemes: water, bare land, built-up area and vegetation.



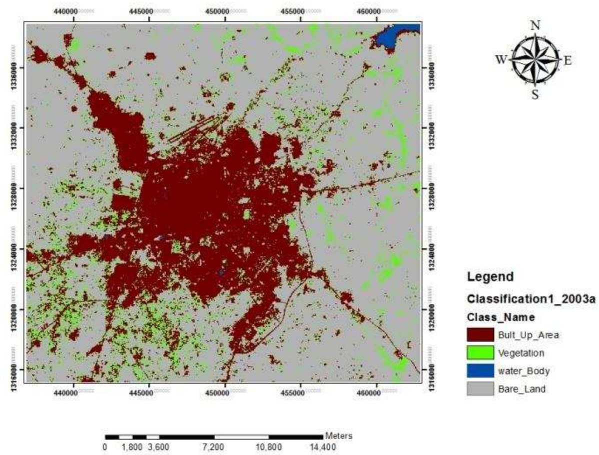


Fig. 64: Supervised classified image of 1999

Fig. 65: Supervised classified Image of 2003

4.5 Change Detection

The changed that happened between 1999 and 2013 where obtained by combining the two classified that were overlaid in ERDAS imagine, for identifying the changes that took place. The results for the change were displayed in figure 70.

4.6 Land use and Land cover change analysis

The results show that the static land cover distribution for each study year that was derived from supervised classification with output classified maps was successfully presented in the classes table below.

Table 8 showing supervised classification result

Table 8: Distribution of Land cover classes between 1999 and 2003

Land Use Class	Area (ha) 1999	Area (ha) 2003	Net Change (ha)
Built Up Area	8188.38	10970.55	2782.17
Vegetation	4912.38	3915.09	-997.29
Water Body	283.14	193.86	-89.28
Bare Land	48337.83	46642.23	-1695.6
Total	61721.73	61721.73	

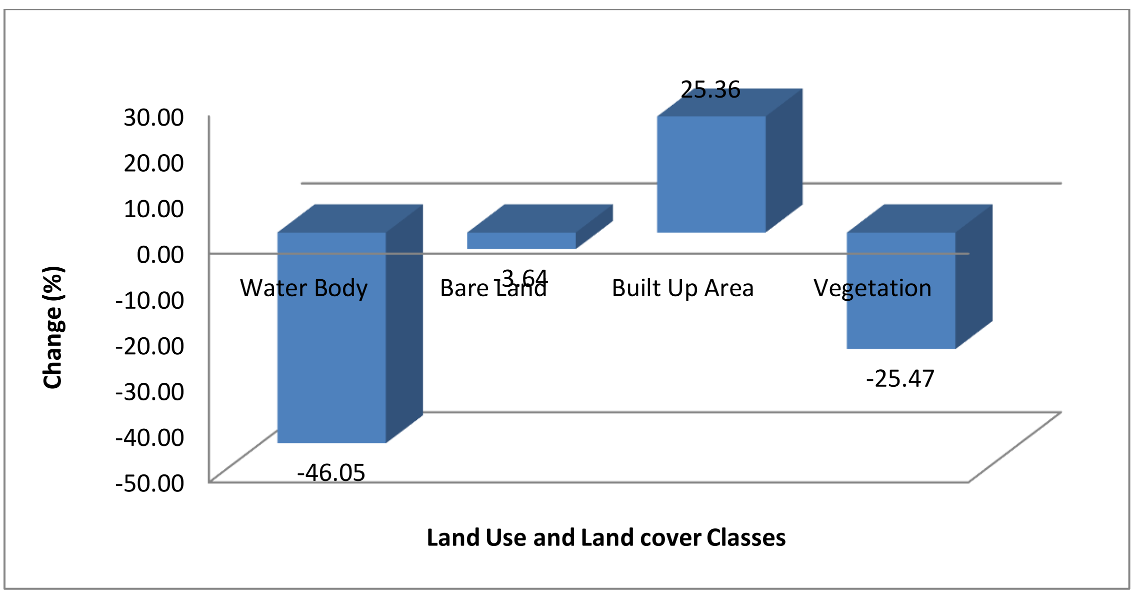


Figure 66: Percentage change in the Land cover class. Result for Supervised Classification (1999-2003)

As can be seen from table 8 in and the charts results in figure 69 the vegetation cover has decreased in 2003. This is mainly due to the population growth and two major reasons that lead to the deforestation in the study area namely rapid urbanisation accomplished with increase built-up areas and road infrastructure in the study area and extraction of fire wood for cooking.

The rapid urbanisation taken place in the area can be attributed to the commercial activities that are taken place leading to the massive relocation of people from other places to urban Kano. Newly construction activities are taken place from private, commercial, and public buildings and also new estate development. As observed in table 8 built-up areas increased by 25.36% in the year 2003.Decrease of vegetation cover was a result of fire wood collection for cooking and bush burning or land clearing during the periods of this study (1999 to 2003), which most of the vegetation cover lost to built-up areas and other roads infrastructures. The cause of urbanisation activities that include estate developments results into decrease of vegetation cover in the study area which known to be a savannah type of vegetation. This is clearly indicated in the table 8. The vegetation cover reduces by 25.47% from 1999 to 2003.

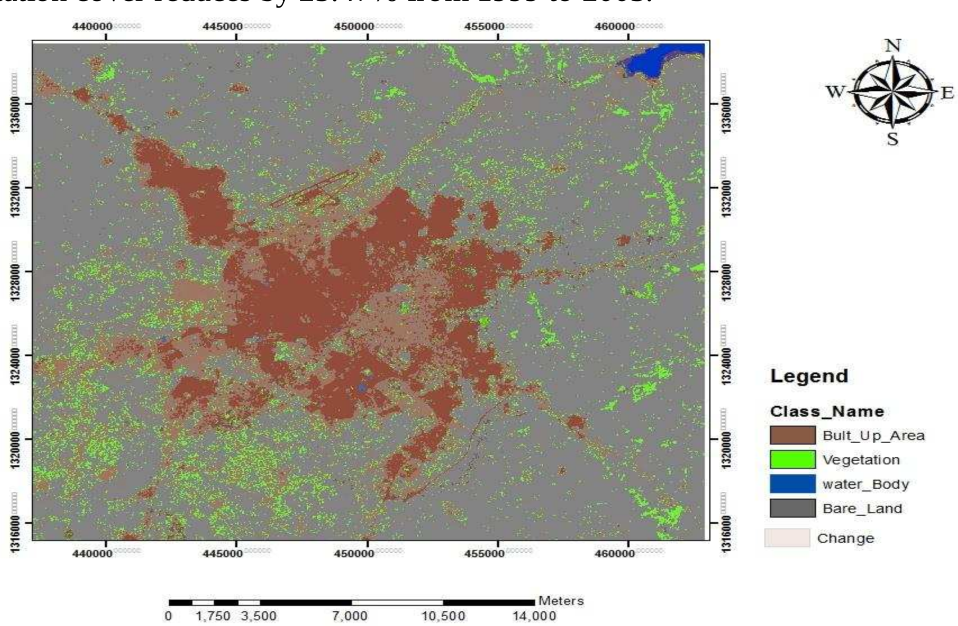


Figure 67: Change Map (1999-2003)

Table : 9 "From to" distribution of the changes for different land cover types in Urban Kano between 1999 and 2003

1999	**2003**								
	Water Body (ha)	**%**	**Bare Land (ha)**	**%**	**Built Up Area (ha)**	**%**	**Vegetation (ha)**	**%**	**Total (ha)**
Water Body	173762.38	0.313	0.00	0.000	0.00	0.000	729.07	0.001	174491.45
Vegetation	49171.92	0.089	2309135.91	4.156	116813.68	0.210	1048811.88	1.888	3523933.39
Bare Land	243.02	0.000	38667029.70	69.601	258901.89	0.466	3056030.60	5.501	41982205.22
Built Up Area	31674.17	0.057	2532232.22	4.558	6994563.46	12.590	316012.60	0.569	9874482.45
Total	**254851.49**		**43508397.84**		**7370279.03**		**4421584.16**		**55555112.51**

Source: Data analysis (2014)

From the “from to” distribution of the changes in Table 9, it could be observed that the water class has lost a fraction (0.001%) of its area to vegetation class. The explanation for this might be attributed to a slight draw down in the water level along the Jakara dam, and subsequently got colonized by vegetation. While vegetation class in 1999 was submerged in some areas reflecting a class change to water body. Moreover, much of vegetation cover has changed to either built-up area or bare land, while only a little proportion was retained as vegetation (0.089%).

On the other hand, about 69.6% of the entire study area remained unchanged as bare land, and 5.5% changed from bare land to vegetation cover due to urban greening and peri-urban agriculture around the urban fringes. Built-up area has gain very little from other class owing to the little time frame. However, on a long term analysis built-up area may have gain quite much area looking at historic data. For instance, Figure 67 depicts Urban Kano in three stages: 1967, 1999, and 2003.

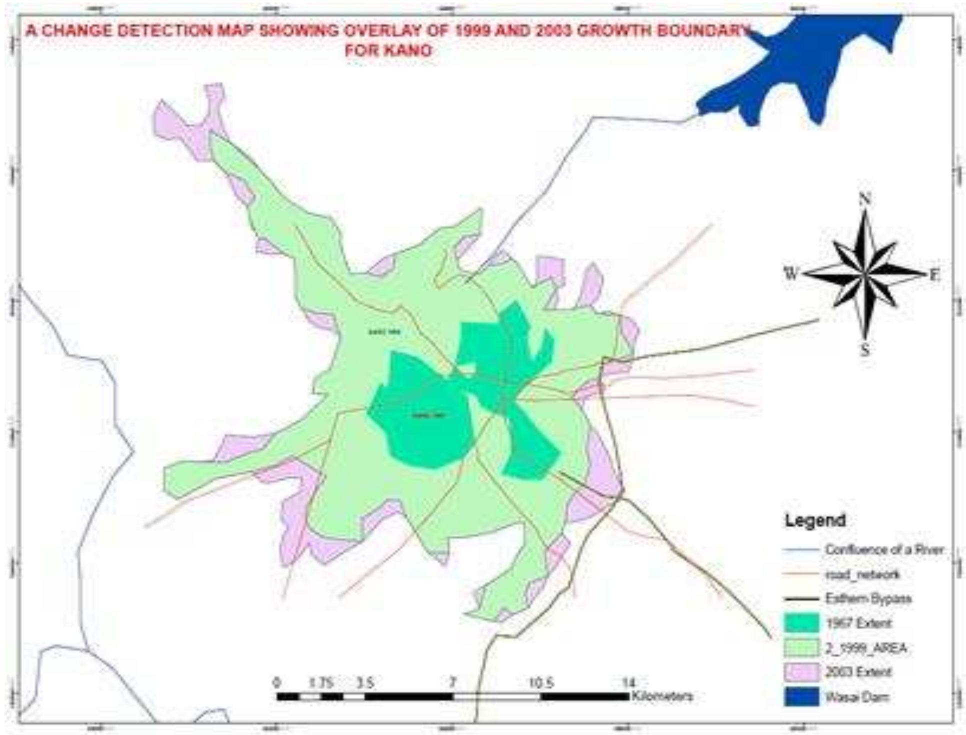


Figure 68: Urban Kano in three different periods: 1967, 1999 and 2003.

From the foregoing it could be said that changes have occurred in urban Kano, but much of the change are either slow or silent.

Chapter 5: Conclusion and Recommendation

5.1 Conclusion

This study has demonstrated the use and application of remote sensing and GIS techniques as powerful tools to extract meaningful information for using thematic maps of the area for two different date. The study has shown, the build-up area has increase while the water body and vegetation have significantly reduced between 1999 and 2003. This is largely due to urbanisation. The study developed more emphasis on extension cause by built-up areas as a result of population increase. The study has also determined the use of land sat images for change detection with respect to many similar techniques of detecting changes in urban. Meaningful information has been reviewed in this work particularly under chapter two (literature review section) on change detection using both techniques of GIS and remote sensing to determine urban land use and the physical planning. The study has integrated remote sensing and GIS, benefiting from both of the tools to achieve its objective. Chapter 3 was the implementation stage and data analysis processes and applications of both techniques was successful with refer to literature reviews of image change detection from image classification and classified classes of environment and its uses.

Remote sensing data result from the analysis of this study has provides a temporal data for the decision makers for future planning against the uncontrolled developments as results of rapid population increase in Kano which has affected the planning in the area. The study has demonstrated the use of two different date satellite images of the study area for the analysis of change detection of Kano which was very successfully with remote sensing and GIS environment. The objectives of measuring urban change detection of land use and land cover

(LU/LC) in Kano has been met with the results from image classification. The study has improved the use satellite images data to provide spatial information to other GIS and remote sensing analysts.

GIS is needed in developing countries of Africa particularly Nigeria in the area of physical development and environmental programmes. There is the urgent need for remote sensing and the GIS techniques to Governments and private institution for implementation and decision making to improved their general physical and environmental policies, physical infrastructure and urban planning.

5.2 Recommendation

This study has made special recommendations to the physical planning authority to improve their planning activities at both technical and management level. These include:

- The National Planning and Monitoring Agency should use the results of this study in their environmental and sustainable development programmes.
- The Urban and Development Planning Agency in Kano State should also use the results for development planning against the unplanned buildings in the study area.
- The local planning authority in the study area should improve their monitoring activities at the local government level in relation to the rates of changes that were detected in this study.
- The immigration agency should improve their policies in relation to the population growth in the study area.
- City planners should use the remote sensing data with good spatial resolution to improve their planning for development.

- ❖ The study has provided a different date data within the study period to decision makers for further implementations and future planning of the growing city to prevent uncontrolled developments area with reliable information for monitoring and evaluations for sustainable development of the general environment.
- ❖ This study has made some provisions for further urban studies in the area been recommended.
- ❖ This study has discovered land use changes within the study periods that need urgent attentions from the management level to implements relevant environmental policies for the development and land resources sustainability.

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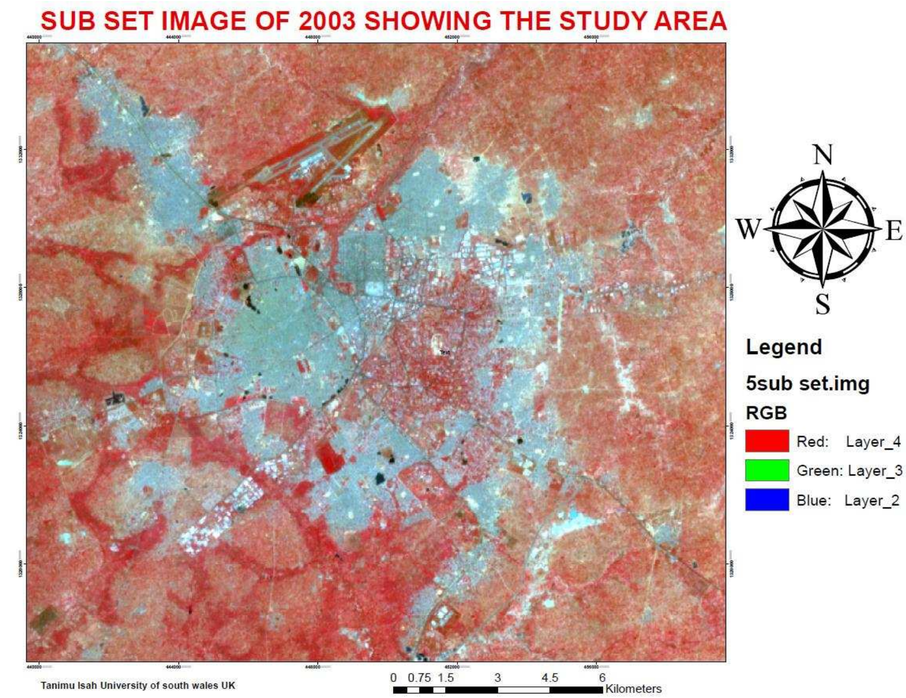
Appendix


SUB SET IMAGE OF 2003 SHOWING THE STUDY AREA
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Blue: Layer_2
Tanimu Isah University of south wales UK
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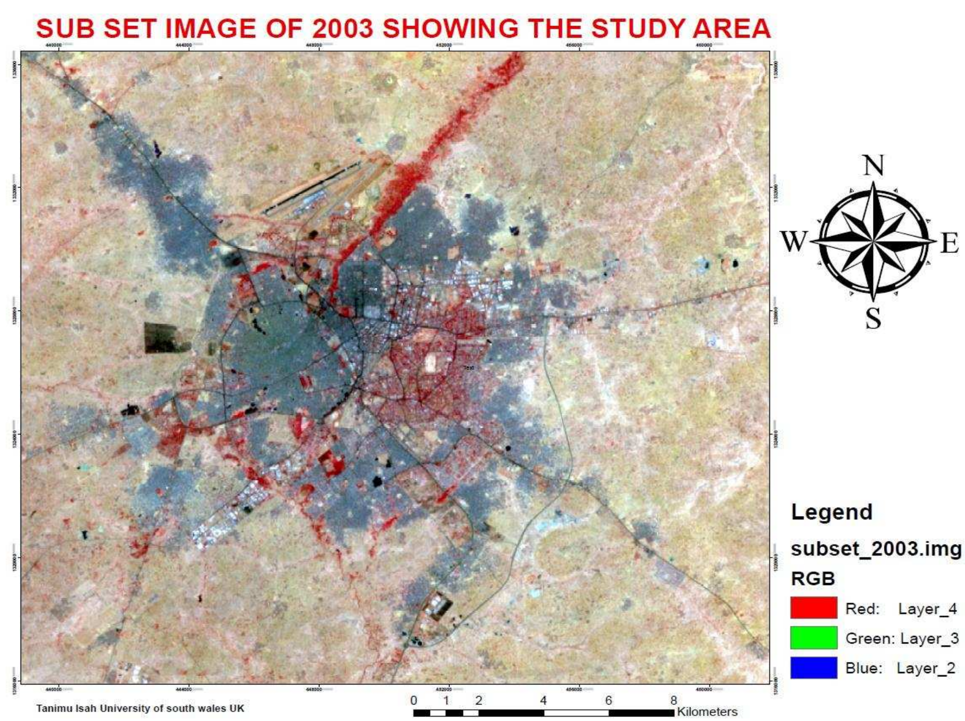
Kilometers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Legend
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Green: Layer_3
Blue: Layer_2
Tanimu Isah University of south wales UK
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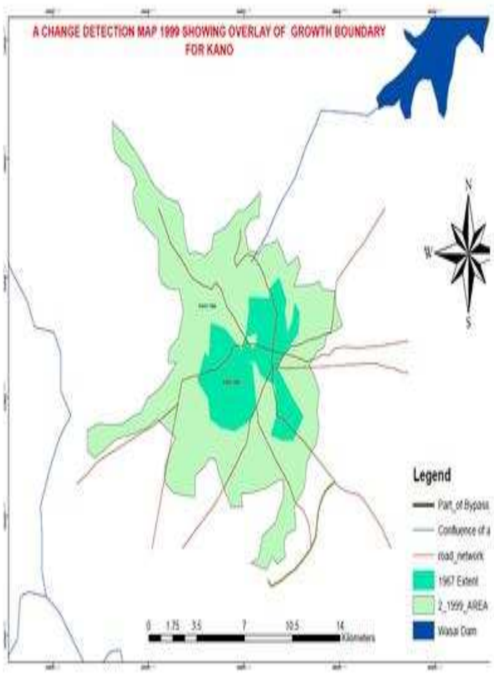
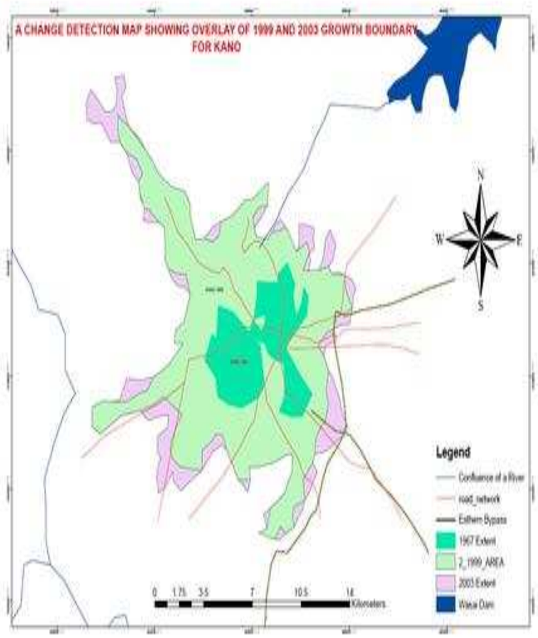
Kilometers

Change detections RESULTS





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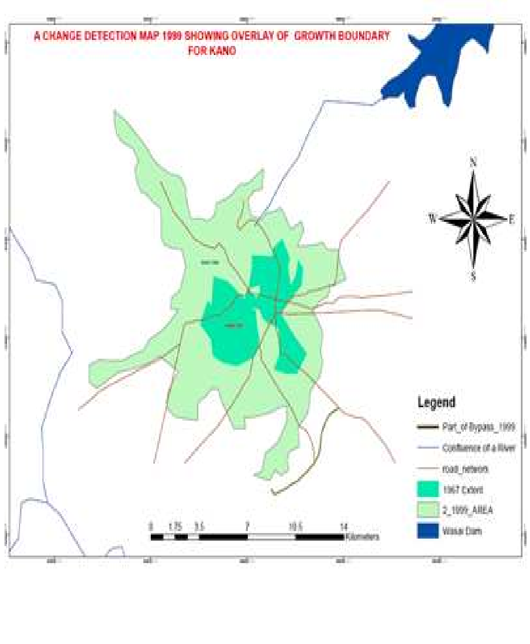
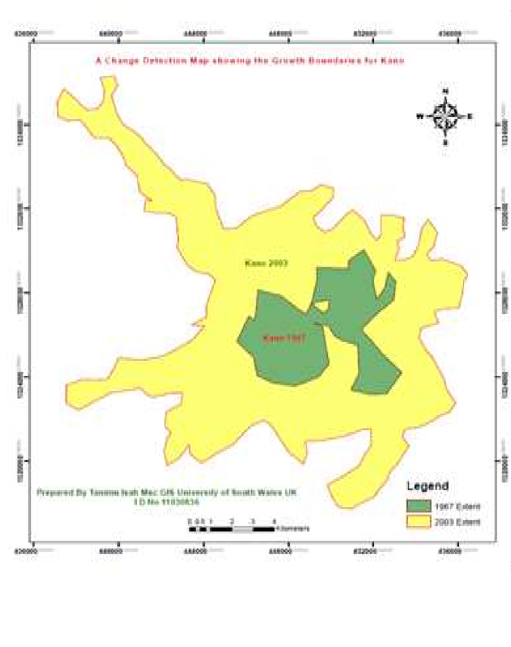
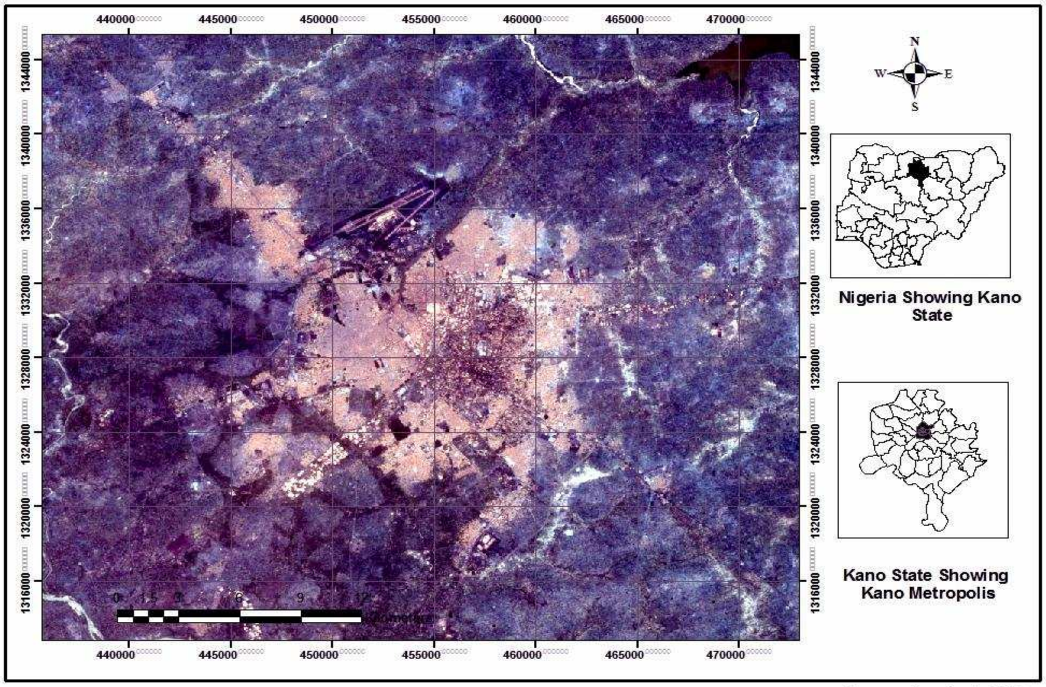




LAND SAT IMAGE WITH GRIDS REFERENCE



Source: Landsat, 1999

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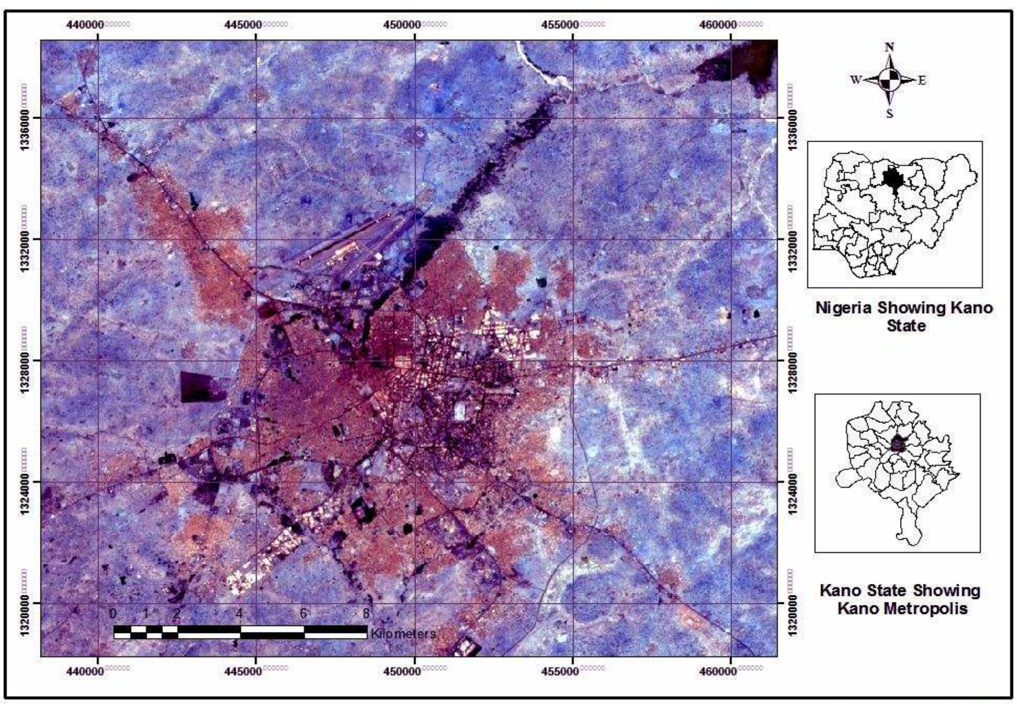
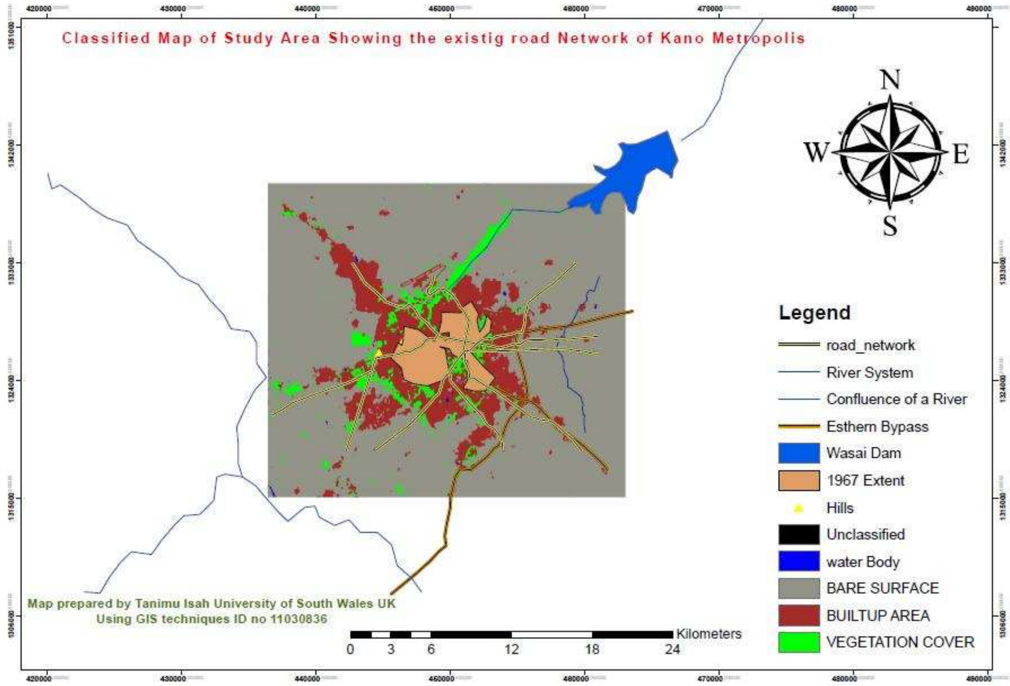


Source: Landsat 2003

CLASSIFIED IMAGE 2003



SRTM DATA

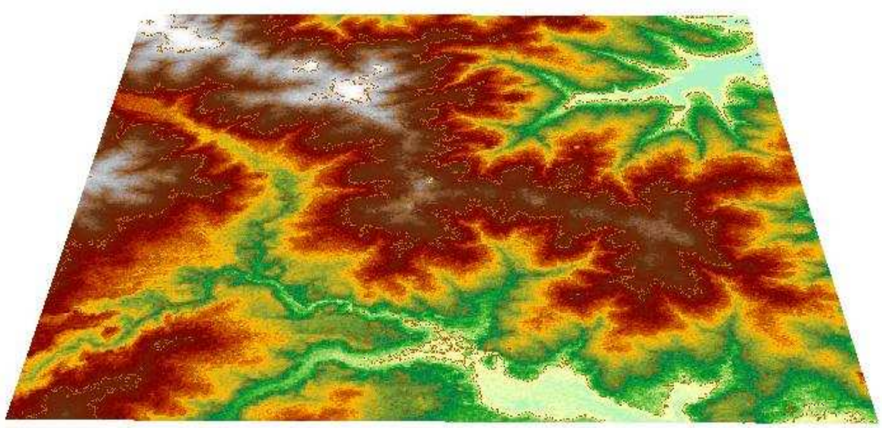
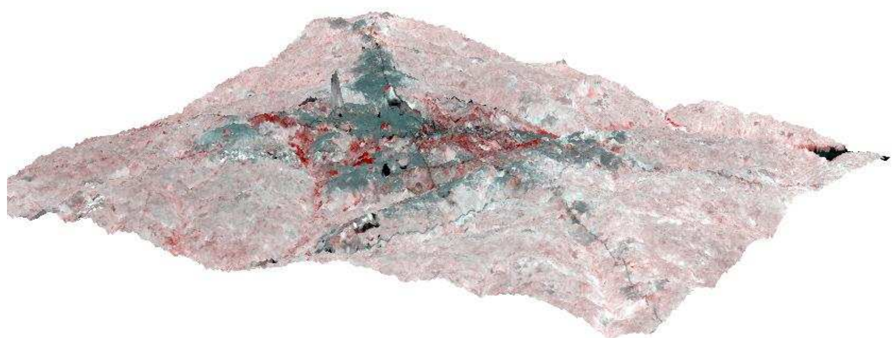
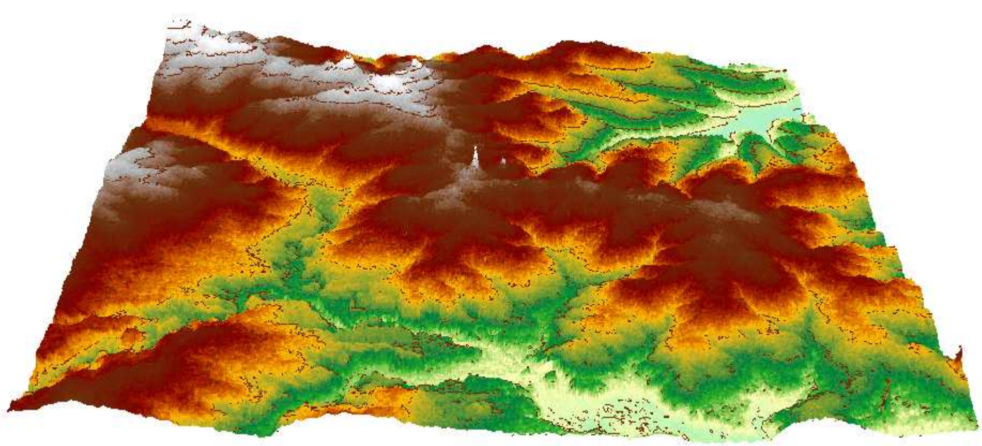


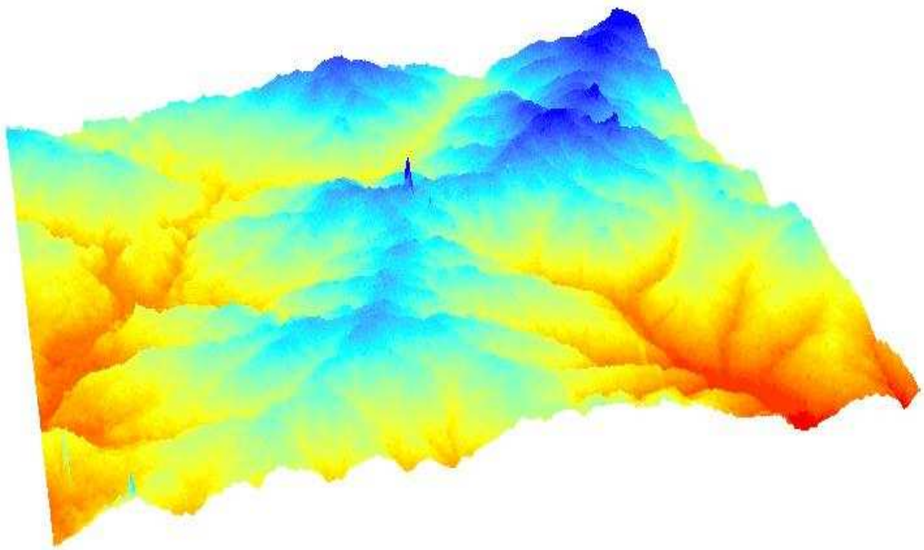
IMAGE IN ARCSCENE



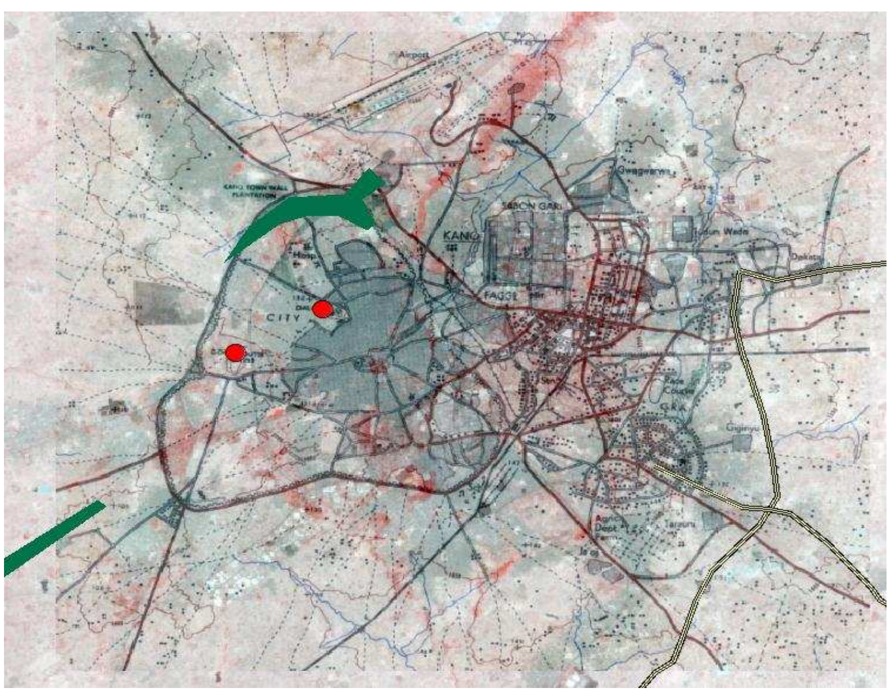
DIGITAL ELEVATION MODELS



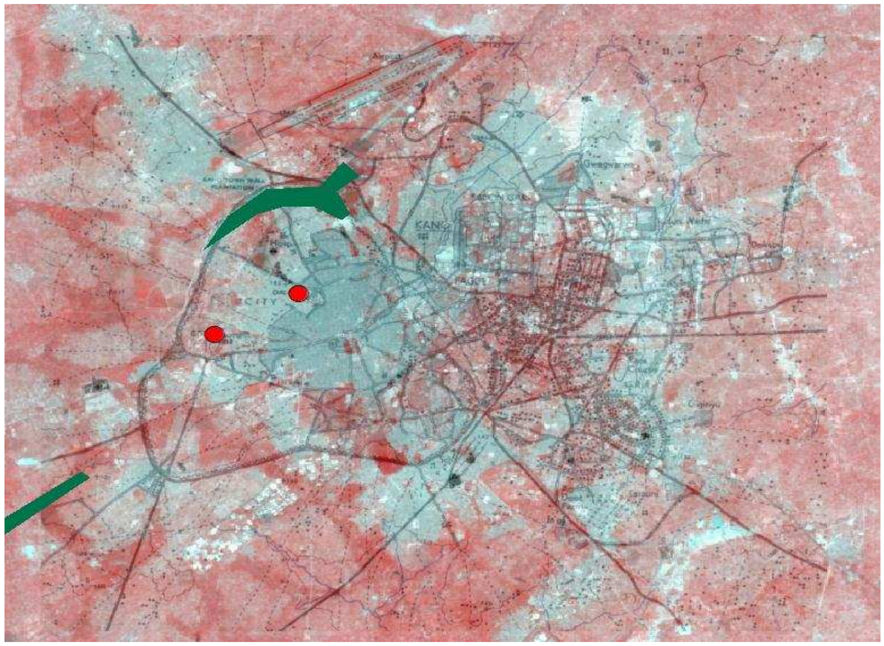
DIGITAL ELEVATION MODEL (DEM)



OVERLAY WITH TOPO MAP



TRANCEPARENT IMAGE OVERLAY



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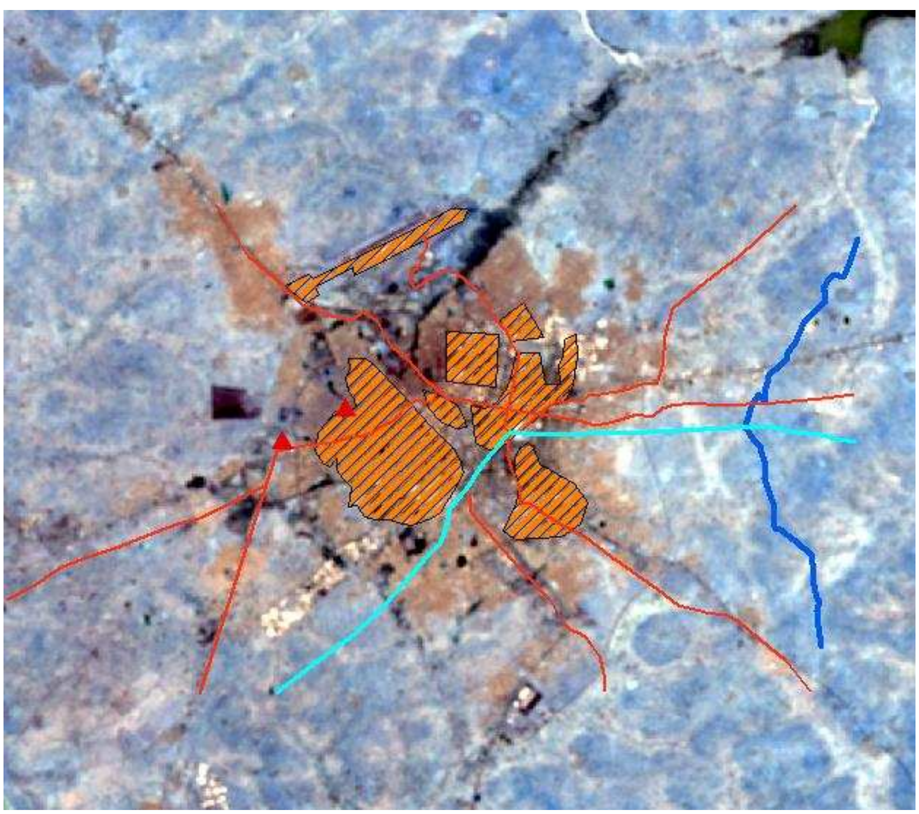

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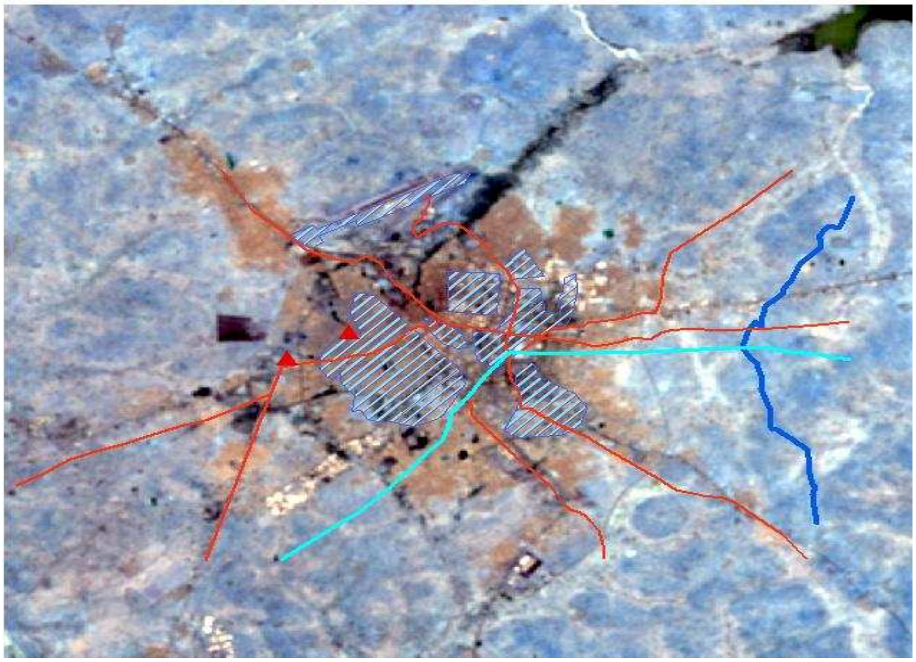

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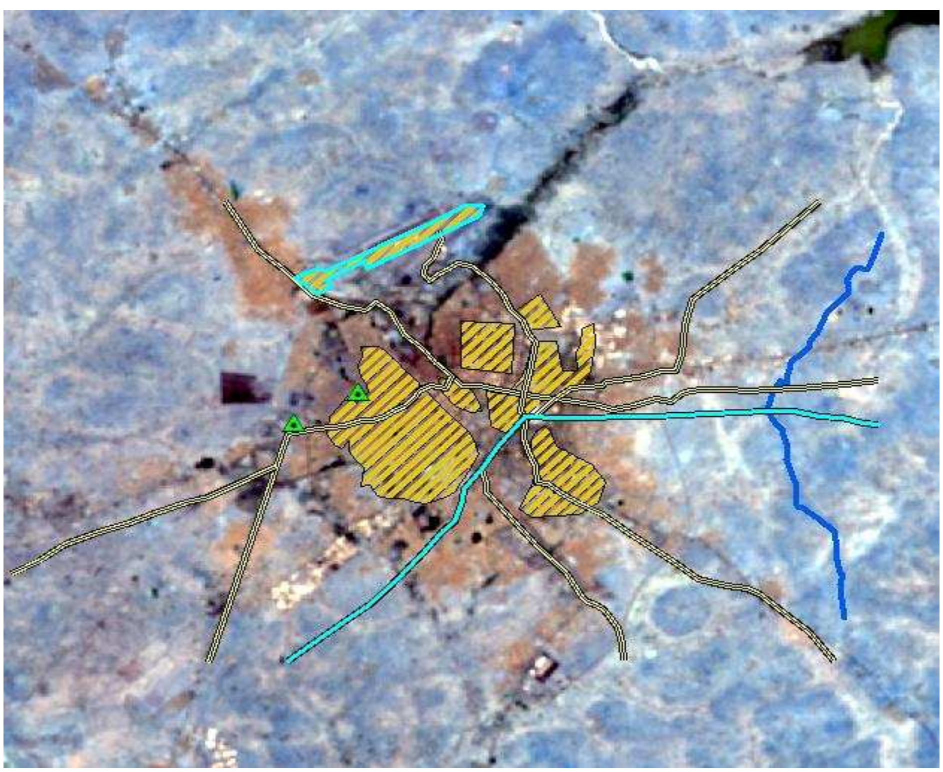
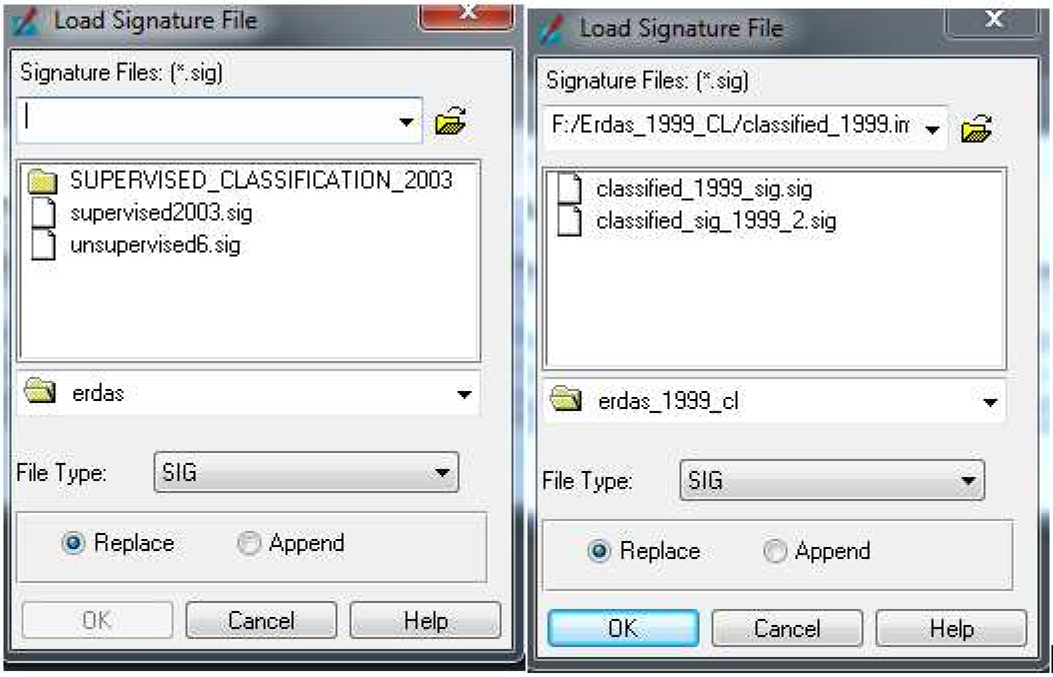


CHANGE DETECTIONS

SIGNATURE FILE



SIGNATURE MEAN PLOT CHART