AN INTEGRATED USE OF SPOT XS AND GPS DATA WITHIN A GIS FRAMEWORK IN UPDATING TOPOGRAPHIC MAP OF KADUNA AND ENVIRONS

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MTECH/SSSE/944/2003/2004

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CERTIFICATION BY SUPERVISOR

I, DR. G. N. NSOFOR HEREBY CERTIFY THAT THIS PROJECT WAS CARRIED AND THESIS PREPARED BY THE STUDENT, ALH. LATEEF YINKA SHITTU (MTECH/SSSE/944/2003/2004) FOR THE AWARD OF MASTER OF TECHNOLOGY (M.TECH) DEGREE IN REMOTE SENSING APPLICATION OF THE FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

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DEDICATION

DEDICATED

TO

MY LOVING LATE MOTHER
ALHAJA MARIAMOH ANIKE OLAORE

AND HER GRAND CHILDREN
SHERIFFDEEN AND SHAMSUDEEN

ACKNOWLEDGEMENT

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ABSTRACT

The existing topographic maps of Kaduna and environs were produced in 1965. These maps are obsolete considering the various level / types of development that may have taken place since then. To produce new maps using Photogrammetric or Land Survey method is out of the way. A computer technique was used to separate and extract spectral reflectivity variations and topographic information from SPOT satellite imagery. Global Positioning System (GPS) technology was combined the image data within the framework of Geographic Information Systems (GIS) to update the topographic map of Kaduna and environs. And the analyses conducted revealed that Satellite Remote Sensing has several unique advantages over alternate or conventional means of data collection such as air borne and ground surveys, which make it an ideal tool for fulfilling certain geographic information needs. The advantages are anchored around the use of up-to-date data, cost effectiveness and economic importance of database. The digital topographical map produced can be used as an effective tool for exploration, exploitation and effective management of natural resource as well as the provision of infrastructure facilities

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CHAPTER ONE

1.0 INTRODUCTION

1.1 *Background Information*

The developed countries of the world are the best mapped with Europe and North America achieving an average of 91% and 60% respectively. While Africa and South America are only mapped to 29% and 27% respectively, [Petrie, 1996]. It is thus apparent that there is a strong correlation between development and availability of maps. Therefore, the developing countries have a greater need for mapping for their total development. It implies that mapping in the developing world and particularly Nigeria cannot be over-stretched and obviously, this cannot be achieved by manual Land Surveying only, hence the need for the application of satellite remote sensing.

Remote sensing as an information generation technique has provided mankind an enhanced opportunity to appraise, monitor and model their natural resource. Its uses in these ways have contributed to the improvement of the standard of living in several countries, (Adeniyi, 1994). Basically, remote sensing is concerned with the extraction of accurate and detailed geometric and thematic information from imagery. This technology has been enhanced with improvement in spatial resolution of commercial satellite imageries, namely: - Landsat TM, SPOT [P-mode], Orbviews-3, Quickbird and Ikonos with spatial resolutions of 30m, 10m, 1m, 0.61m and 0.81m respectively, and as well as spectral and temporal resolutions.

Because of its unique nature of acquiring data about the earth, remote sensing has an upper hand or advantage over other conventional methods hitherto used. This technology ensures the continuous availability of the earth's imagery unlike the Photogrammetric method. Hence, new maps can be made and updating can be carried out on a continuous basis. Remote sensing can be put to best use if incorporated into Geographic Information System [GIS]. GIS is designed to accept large volumes of spatial data, derived from a variety of sources, including remote sensing, and to efficiently store, retrieve, manipulate, analyze and display these data according to user-defined specifications, [Ehlers 1992]. GIS therefore, when combined with up-to-date data from remotely sensed data can assist in the automation of interpretation, change detection, map computation and map revision functions.

Mapping is, per excellence, a public service. It is not an end in itself but a means to present geographic data in such a way as to be used to promote higher standards of living and proffer solutions to economic, social, health and related problems, (Henseler, 2004). Maps are basically categorized into thematic and topographic maps. The thematic map refers to a map produced for a specific purpose. While the topographic map refers to a map that gives a vivid and comprehensive description of an area. Topographic maps are available at various scales produced by the Federal Surveys of Nigeria covering the entire country between 1963 and 1965. These maps are obsolete and require updating. To explore the use of RS/GIS techniques for the purpose of updating maps is expected to form the basis for a change in the mapping policy of Nigeria.

1.2 Aims and Objectives

1.2.1 Aim

This project is aimed at producing an up to date topographic map of Kaduna and Environs using Remote sensing technology.

1.2.2 Objectives

a. To update the existing topographic map of Kaduna and environs.

b. To digitize the existing topographic map

c. To generate layers of information, such as road, hydrographic, vegetation, built-up area and relief needed for topographic mapping of Kaduna using remote sensing/GIS techniques.

d. To produce the digital map of Kaduna thereby creating spatial and attribute databases.

e. To obtain the Digital Terrain Model [DTM] of the project area.

f. To determine the amount and extent of changes in the study area.

1.3 Statement Of Problem

It is not possible to make desired progress without accurate, timely and adequate information on the nature, amount and distribution of human and natural resources. Landmass is a dynamically changing entity. For instance, rivers change course, forests are cut, structures are now on former vegetated areas, houses and roads are built etc. Consequently, the information stored in a map is only a static model of the real world and has to be up dated regularly. Environmental monitoring and management of natural resources, as well as effective policy decision- making about people, space and development require versatile tools. Experts involved need maps as a base for effective performance. Unfortunately, adequate maps are not available. The following problems have been hindering the effective production and use of maps:

a. The existing Topographic Map Series of Kaduna are old and do not represent the current status of the topography.

b. Updating a map using conventional method is very costly, labourious and time consuming.

c. To collect data [maps] for project where available is very difficult because of the filing- system, which is manual.

In view of these, the research question worth asking is: is it possible to obtain an up-to-date, comprehensive and cost-effective topographic map of Kaduna and Environs using remote sensing technology? The need to provide answer to this question constitutes the problem of interest to this study.

1.4 Focus, Scope And Limitation

This project focuses on Kaduna and Environs whose area is delineated by Latitudes 10^0 23' 30"N, 10^0 38' 00"N, and Longitudes 7^0 21' 30"E, 7^0 30' 30"E (Fig. 1:1). It involves the production of the topographic map of the study area using remote sensing/geographic information system techniques. Since remote sensing & GIS are tools for managing spatially distributed information in large quantities and at a variety of scales, they are to be used in this research study to generate and manage information required of a topographic map.

The topographic map of Kaduna is expected to be in layers, each representing the various categories of terrain features. The results could be in hardcopy or softcopy.

The limitation of this research has to do with high cost of purchasing data required, processing them into information as well as the cost of movements and other contingencies. This limitation hindered the procurement of very high-resolution satellite imagery such as *Quickbird* and *Ikonos* with less than 1m spatial resolutions in the panchromatic mode.

1.5 Justifications

The existing topographic maps of Kaduna at different topographic map scale series were produced based on aerial photographs of 1963-65 and new prints in the 1980s. Huge population growth coupled with variety of natural and environmental factors have greatly affected the topographic structure of the town. Infrastructure has greatly expanded and so many roads and houses have been constructed. The area extent of the town has also increased. Based on all these, it is pertinent to produce an up –to-date topographic map of Kaduna.

In terms of proper development, Kaduna requires adequate topographic map on which to base planning for:

a. Site suitability analysis

b. The provision of infrastructures

c. Urbanization

d. Agricultural activities

e. Engineering projects.

1.6 Description Of The Study Area

1.6.1 *Geographic Location*

The project area is Kaduna and Environs, located between latitudes 10^0 23' 30"N and 10^0 38' 00"N, and longitudes 7^0 21' 30"E and 7^0 30' 30"E. [fig.1.1] Having an area extent of about 43560 ha [435.6 KM^2], the project area covers Kaduna North and South Local Government Areas as well as parts of Chikun and Igabi local government areas [fig.1.2]. It is the capital area of Kaduna State and bounded by Kachia, Kajuru, Kaura, Soba, Zaria, Giwa and Birnin Gwari Local Government Areas of the State and at the South Eastern part, by Niger State The 1991 census provisional results put the population of the people within this area at about 396,055.

1.6.2 Climate

Kaduna State in which Kaduna town is part of, experiences a typical tropical continental climate with distinct seasonal regimes oscillating between cool to hot dry and humid to wet. This seasonality

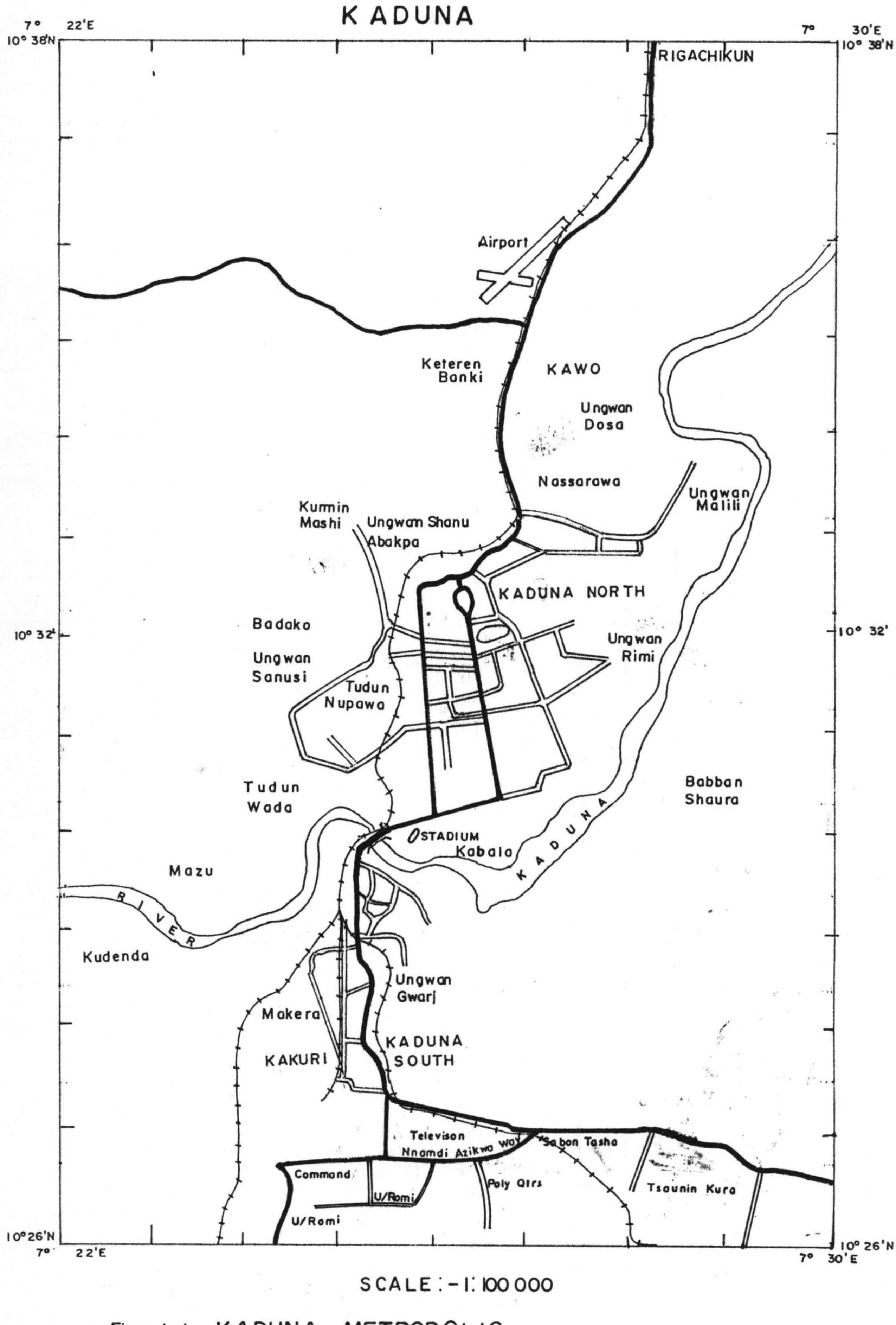


Fig : 1·1 KADUNA METROPOLIS

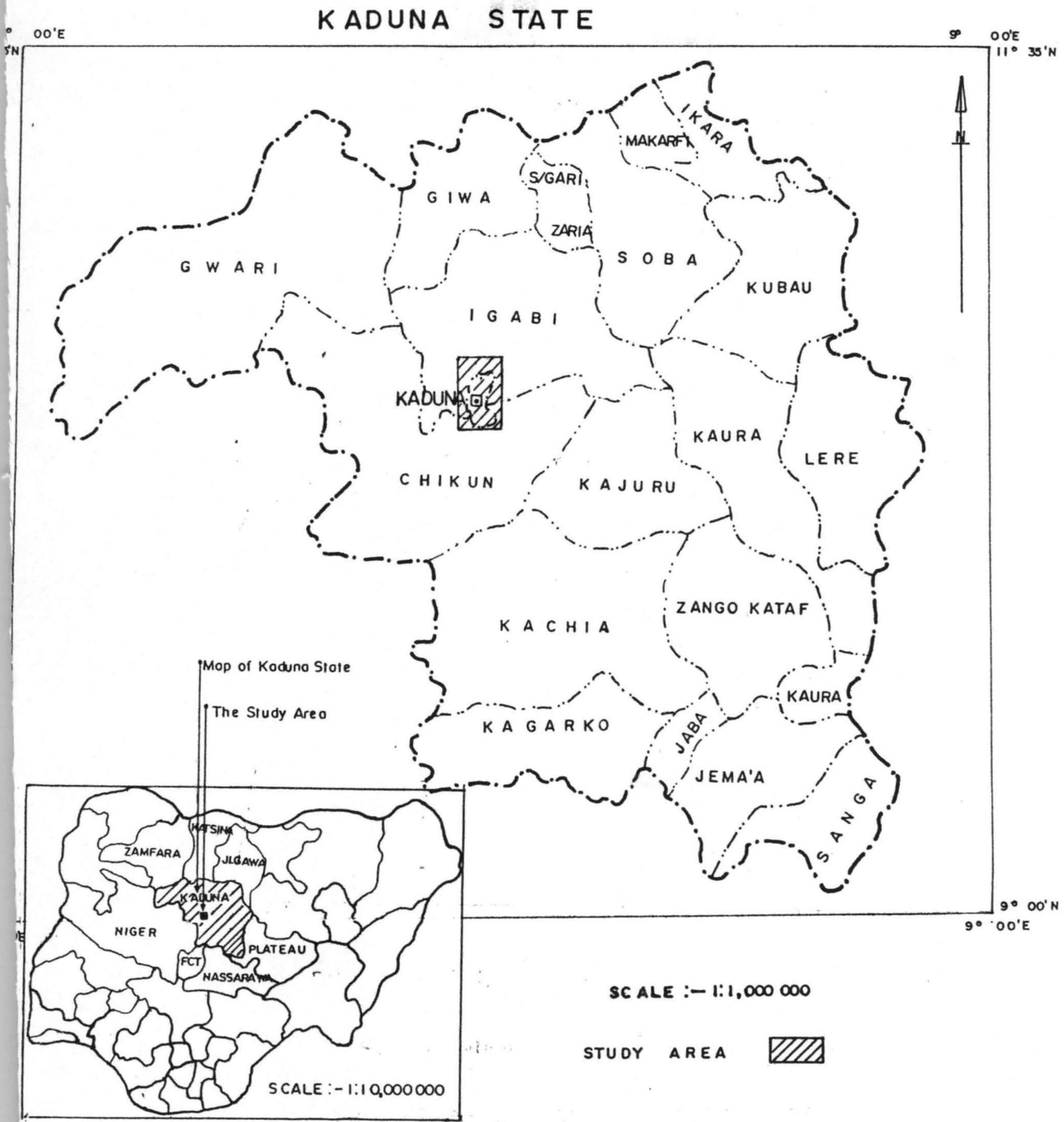


Fig. 1·2 MAP OF KADUNA STATE SHOWING THE STUDY AREA is pronounced with cool to hot dry season being longer that the rainy season.

1.6.3 Topography

The general land structure consists of an undulating terrain. Rocks and hills could be seen everywhere especially in places like Narayi, Sabon Tasha, and Doka. Almost all the hills lie between 570m and 650m above sea level. Landforms in the state are associated with rocks in which they are derived. And rock types are related to the type of soils found in the town.

1.6.4 Drainage Pattern

River Kaduna is the main river that cut across Kaduna town. The town has a good drainage system through which water are channeled to the rivers especially during rainy season. The rivers serve as sources of domestic and industrial water supply to the state. They also serve as sources of irrigation. During the dry season, farmers draw water from the rivers and stream to water their farm crops. The rivers vary in water level a great deal according to the season.

1.6.5 Landuse

Kaduna land use can be classified into residential, commercial, recreational, institutional, industrial and religious. The commercial and residential areas are inter-woven. It will be difficult to separate these two. The industrial area is restricted to the southern part of the town, while educational institutions as well as other landuses are scattered all over the town.

1.6.6 Soils And Vegetation

Generally, the soils and vegetation are typical red-brown to red-yellow tropical ferruginous soils and Savannah grassland with scattered trees and woody shrubs. The soils in the upland areas are rich in red clay and sand but poor in organic matter. However, soils within the "Fadama" areas are rich in Kaolinitc clay and organic matter.

1.6.7 Natural Resources

Kaduna town and environs are endowed with wide range natural resources waiting to be fully utilized. The natural resources potentials are classified into Agriculture/Forestry, livestock and minerals.

Agricultural and forest resources are enormous. On the rolling high plains, the tropical ferruginous soils have been intensively used for cereal cultivation. The not so-rich soils, with good conservation and land management practices are capable of supporting calcium rich grass for livestock feeding. Yam, maize, cereals, cassava and ginger are commonly cultivated in the town. Forest reserves are limited, except in some few riverine areas.

Livestock resources are still in small scale, even though there are potentials for excellent rangeland to support large-scale livestock production. Also, the broad river valleys are rich sources of sand, granite rocks and clay that are usually exploited for building.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 *Remote Sensing Concepts*

Adeniran [1999] defined remote sensing as the science and technology of recording and analyzing the characteristics of earthly phenomena by airborne and space borne platforms to assist in inventorying mapping and monitoring of earth's resources. The platforms are equipped with electromagnetic energy resource, which acquire data on the way various earth surface features emit and reflect electromagnetic energy and these data are analyzed to provide information about resources under investigation. In another vein, Sabins [1987] defined remote sensing as the science of acquiring, processing and interpreting images and related data obtained from aircraft and satellite that record the interaction between matter and electromagnetic radiation. He further explained that remote sensing refers to methods that make use of electromagnetic energy such as light, heat and radiowaves as the means of detecting and measuring target characteristics.

A geographic information system expert, Aronoff [1993], described remote sensing as the art and science of obtaining information from a distance about objects or phenomena without being in physical contact with them. The science of remote sensing, according to him, provides the instruments and theory to understand how objects and phenomena can be detected. He also explained the art of remote sensing as the development and use of analyses techniques to generate useful information.

From the above descriptions, it is obvious that an object or environment of interest can be studied, investigated and mapped using remote sensing technology where no physical contact is required. It can also be deduced from the description that a device is required to obtain information. These deductions are corroborated by Okhimamhe (1999), who succinctly put the definition of remote sensing, "as a set of techniques [aerial photographs and satellite imageries] used for obtaining information about the environment [earth surface and atmosphere] at some distance from them, usually by means of sensors which detect and record electromagnetic energy"

Furthermore, Jones [1997] described remote sensing as art and science of deducing information about objects by analyzing the energy received from them and the energy that illuminates them. When electromagnetic energy such as light from sun, illuminates objects on the earth's surface, it interacts with them. Some of the energy is absorbed, some is transmitted through the object, some is reflected back from the object, and some is emitted. It is the energy reflected and emitted back from an object that is available for detection. By recording and analysing the way the energy received from an object has been changed, information about that object can be derived.

Remote sensing obtains information by "detecting and recording electromagnetic energy reflected/emitted by objects", [Aronoff, 1993].

Remote sensing technology uses sensors on-board satellites or aircraft to detect and record data. These sensors have been designed for detecting and recording spectral responses of earth features. Sabins [1999] defined sensor as a device that receives electromagnetic radiation and converts it into a signal that can be recorded and displayed as either numerical data or an image. Swain and Davies [1989] on their own defined sensor as any device that is sensitive to levels or changes in physical quantities [such as high intensity or temperature] and converts these phenomena into a form suitable for input into an information gathering system.

Okhimamhe [1999] also described sensors as instrument or devices, which detect and record electromagnetic energy reflected or emitted by the earth surface, though the intervening atmosphere modifies the energy. She categorized sensors into four, namely: photographic, linescan, active and passive microwave sensors. According to her, photographic systems employ cameras and films to record radiation only in the visible and part of the near- infra- red section of electromagnetic spectrum (EMS). Linescan systems use a wider range of wavelengths but a particular linescan system depends on the nature of detector used. The active microwave systems transmit pulses and record the received signal; and passive microwave systems only senses emitted radiation from the earth's surface.

The quantity most frequently measured in today's remote sensing system is the electromagnetic energy emanating from the object of interest, (Swains and Davies, 1989). And so the basic principles underlying the remote sensing systems are formed on electromagnetic energy, which is the only form of energy transfer that can take place through a medium or a vacuum like outer space. Lo [1986] shows that the electromagnetic radiation can be arranged according to wavelength, frequency or energy to form what is called the electromagnetic speculum. The electromagnetic spectrum is a continuum that is divided into arbitrary regions of wavelength bands commonly measured in micrometer [μm]. The most important sections of the electromagnetic spectrum are those found between gamma rays and the radiowaves, [Ndukwe, 1997]. However, the visible light, infrared, thermal infrared and microwave regions of the spectrum are the bands used in remote sensing for mapping the earth's surface.

Since information-transfer from object to sensor is accomplished by electromagnetic radiation, the information "can be regarded as a wavelength -intensity information which has to be decoded for the image to be understood", [Okhimamhe, 1999]. Electromagnetic radiation possesses characteristics associated with both wave and particle theories, [Adeniran, 1999]. The wave theory states that the speed of light is proportional to the product of frequency [V] and wavelength [λ] i.e.

$$C = V\lambda$$

$$V = C/\lambda$$

The particle theory states that the electromagnetic energy [E] is proportional to the product of the frequency [V] and the Plank's constant [h], i.e.

$$E = hv$$

$$V = E/h$$

The wave theory can be related to the particle theory since frequency is common to both. Mathematically, this is represented by:

$$C/\lambda = E/h$$

$$E\lambda = Ch$$

$$E = ch/\lambda$$

The above relationship indicates that the quantum energy is inversely proportional to the wavelength. Hence, the longer the wavelength involved, the lower the energy content and vice-versa. The low energy content of long wavelength radiation must view large areas of the earth at any given time in order to obtain a detectable energy signal.

Another law of electromagnetic radiation useful to remote sensing is the Stephan-Boltzman's law, which states that the emissivity of black body is proportional to the product of the fourth power of the absolute temperature and the Stephan-Boltzman's constant, i.e.

$$M = Ot$$

This law stems from the fact that all matter emits electromagnetic radiation at temperature above absolute zero [0^0k or –273^0c], and the energy radiated by an object depends on its surface temperature among other things, [Okhimamhe, 1999].

Kirchoff's law is the next law of radiation, which forms the basis for defining emissivity [E], and it states that the ratio of emitted radiation to absorbed radiation flux is the same for all blackbodies at the same temperature. This law is given by:

$$E = M/Mh$$

Where M = Emittance of a given object, and

Mh = Emittance of a blackbody at the same Temperature.

Remote sensing also uses the Wien's displacement law as one of the radiation laws. The law specifies the relationship between the wavelength of radiation emitted and the temperature of the object. That is

$$\lambda m = A/T$$

Where A = 2898 μm

T = Temperature of maximum spectral radiant exitance [μm],

M = wavelength of maximum spectral radiant exitance [μm].

Okhimamhe [1999] describes this law as showing that; maximum spectral radiant exitance is inversely proportional to the blackbody's absolute temperature, implying that, as an object becomes progressively hotter, the wavelength of maximum emittance shift to shorter wavelengths. Wien's displacement law explains the difference in magnitude of energy from the sun and the earth.

Remote sensing technology is used to obtain high-resolution satellite imageries of any part of the earth's surface. Today, it is the best approach to make inventory and to map, monitor and model natural resources. It is a field that has found application in nearly all fields of human endeavour, [Adeniyi, 1996]. Most natural resources mapping is done using remote sensing. Aerial photography has been used to produce virtually all-topographic maps and most forestry, geology, land use and soil maps. More recently, airborne radar and scanner data as well as satellite imagery are being used for the production of these maps, [Aronoff, 1993]. Remote sensing techniques are used extensively to gather measurements of landscape features to produce topographic maps.

Remote sensing plays, primarily the role of a surveying, inventorying or mapping tool for environmental features, [Lo, 1986]. Ndukwe [1997] opined that one important advantage [among others] of the use of remote sensing is the possibility of producing a repetitive coverage of the earth's surface within a few days, so that new developments or environmental impacts are picked up within a few days of their occurrence. On its own, remote sensing boosts the level of development and status of nations, states and cities that utilize it. Imagine, studying an entire large area without physically being there, [Samaila-Ija, 2001].

Remote sensing was viewed as a science that provided definitive end products, such as maps, statistics or tables. These end product are now produced in digital formats to be used with geographic information system [GIS]. Several factors are responsible for this. The factors are:

a. Recent developments in hardware and software for GIS, [Dangermond, 1988].
b. Availability of high resolution satellite data in digital format,
c. Progress in automated information extraction, especially the application of image matching techniques for digital elevation model [DEM] generation, [Ehlers, 1992].

For different application areas of remote sensing and GIS, satellite imagery has been demonstrated to be suitable for base map production and map revision tasks at scales which were previously deemed to be impossible for remote sensing application, [Gugan and Dowman, 1988].

2.2 Geographic Information System Application

Odedare [1999], defined GIS as a "system for integration of spatially referenced data for decision making in a problem solving environment. In other words, GIS is a decision making tool and it deals with decisions that have to do with utilization of space, how we organize things in space and so, the emphasis is on spatial data. Its strength is in ability to bring in data from different sources, integrate them in different ways in order to solve particular spatial problem". This definition seems to be very elaborate by incorporating all the attributes of GIS.

Jones [1997], defined GIS as "computer system capable of acquiring, storing, retrieving, processing, analysising and displaying geographic data". This definition seems to agree with the concept approach above. It spells out the functionalities of GIS. Sowon [1990] also defined GIS as a system that allows the capture and display of a number previously unconnected datasets, bringing them into a common reference system for spatial analysis from which relationship can be identified and decision made.

GIS technology has developed so rapidly over the 3 decades that it is now accepted as an essential tool for the effective use of geographic information. It has provided an axciting potential for geographic information to be used systematically and by greater diversity of displine than ever before, [Aronoff, 1993]. This tool has become popular in establishing the real world model in a defined space and time reference system. It integrates all natural, social and economic phenomena with their attributes of space and time, [Jones, 1997].

GIS application involves the use of geographic information system in satisfying a given need. However, applications depend on how GIS is being used. In some cases, it is used as an organizing frame work for systematic collection, storage and analysis of data, while in others, it is used as a means of taking appropriate decisions in which case, it becomes part of decision support system [DSS]. When these two are combined, GIS would be seen to possess a wide range of applications [Adeniran, 1999]. Spatial problems require that decisions be made over space. One of such decisions is on the selection of locatfor some activities such as infrastructures.

The major concern of physical planning is the proper designation of suitable areas for appropriate landuses. The selection of these sites must be based on a set of criteria to ensure that the minimum cost-benefit ratio for a commodity is attained. The various characteristics of a site influence its suitability for a specific landuse, Identification of sites that meet particular criteria is one of the main spatial analytical applications of GIS. More so, it is one of the early motivating factors in developing GIS technology with the need to perform suitability analysis in which the objective is to find sites or regions that satisfy particular criteria of land usage and terrain characteristics [Jones, 1997].

The ability to overlay several thematic layers on a GIS in order to identify regions that combine selected attributes from each of the layers was one of the analytical facilities provided by GIS packages. A suitability map is created by combining maps with rated suitability factors whose importance is dependent on the intended landuse and the characteristics of the site. Based on this importance, the suitability factor is given additional weight to influence the final output. This analysis uses either Boolean factor or Weighted Linear combination for its task [Odedare, 1999].

Jones [1997] distinguishes the two types of analyses by describing Boolean operators as appropriate, if each factor or constraint under consideration is of equal importance. In practice, certain factors may be much more important than others, and it may be desirable to differentiate between candidate sites according to how well they meet the various criteria. The relative levels of importance of the different types of data can be taken into account by attaching numeric weights to each of the layers in an overlay operation. Regions that meet all the search criteria are then associated with weighted summations of the factors in each layer. The use of weighted constraints only goes part of the way to taking into account the relative importance of the different factors.

Apart from the above description of site suitability analyses, other areas of applications according to ERDAS [1997] are in natural resources management, petroleum exploration, mission planning, change detection, urban planning, tax assessment and planning, traffic engineering and facilities management. The crux of the matter is that GIS uses map layers to carry out its analyses and layers of topographic map serve as input into the system.

Geographic information system provides capabilities for mapping, management and analyses of spatial information. And this information, obtained from remotely sensed data are not only effective when used within a GIS, but the GIS can also be used to improve the accuracy of remote sensing analysis [Aronoff, 1993].

2.3 Satellite Imagery

Satellite imagery is becoming commonplace in areas that used to be dominated by aerial photogrammetry. The data is extremely powerful and can save time and money when utilized in the correct system. The most important requirement for a remote sensing application is of course, the imagery. Both photographic and digital mapping systems can acquire panchromatic or multi spectral imagery [Maselli, 2004].

There is currently a wide range of satellite remote sensing systems that are useful for providing data to assist in the resolution of issues of national, regional and global significance. These systems range in spatial resolution from kilometers down to meters and record in wavelengths from ultraviolet through the visible and infrared to the thermal infrared and microwave regions of the EMS. The particular region over which a sensor acquires data as well as its spatial resolution and revisit capabilities are important considerations that determine the usefulness of the data for application in a number of key development sectors such as mapping, change detection, monitoring of hazards etc. ["Third United Nations", 1999].

2.4 Mapping Technology

Mapping is the art, science and technology of representing information about the earth surface or any part of the earth and the presentation of such information graphically on paper, screen, or visual display units, statistical tables and computer data files for the purpose of either visualization or analysis [Petrie, 1996]. Maps and mapping are the subjects of the art and science known as cartography [ERDAS, 1997]. And cartographic presentation of remote sensing data is unambiguously related to its point of origin on the earth with a known standard of accuracy ["The manual" 1995]. In the broader sense, this definition covers all possible ways of presenting geographic information.

As the veteran GIS and image processing authority, Tomlinson (1989) said, "Maps and related statistical data do form the greatest storehouse of knowledge about the condition of the living space of man kind". Therefore, "mapping is, per excellence, a public service" [Henseller, 2004]. Map is an integral part of our environment. It is the most meaningfully way of communicating information about our environment for planning and managing human, physical, social political and economic resources. Map is also essential for effective development, implementation and monitoring of programmes [Ayeni, 2001].

Maps are the graphic media, by which policy can best be prescribed for the development of a country [Henseller, 2004]. The need to secure rights to land and to record dealings with this precious commodity has initiated cadastral surveys, and man's age-old pursuit of power and wealth had determining influences on mapping. Industrial expansion provided the impetus for mapping in many regions. The exploration and exploitation of natural resources, the development of national economies, widespread urbanization of extensive areas, more effective utilization of land and agricultural resources and many other aspects of the universal aspiration of man for a better life, depend on accurate knowledge of the planet earth upon which he lives.

The demand for map is increasing. Today, mankind's existence depends upon a host of maps vital in planning national and global economy and security (Marble, 1990]. For any sustainable environmental management, quality maps are needed to provide information in coherent and systematic form [Ayeni, 2001].

Mapping technologies are currently in the midst of transition from analogue and analytical to digital. This move is being driven by the desire to increase production capability through computer, and take full advantage of new methods, procedures and technologies. Computer graphics technology enables map data to be plotted faster and with greater precision than is possible using manual methods. Map projection can easily be changed, schemes for symbolization of data can be modified very rapidly, and once very demanding visualization of data can be created with ease [Jones, 1997]. The technology also provides the opportunity to interact directly with graphic displays, so that the content of the display can be analyzed in response to the user's interest [Aronoff, 1993].

With the influence of this technology, map making has become much more than just making maps, it has found wider significance as a facility to help analyze and solve world problems. The availability of accurate spatial information is nowadays a must for a well-informed society. Spatial information data sets are vital for sound decision making at local, regional, state and global levels for planning and implementation. Spatial data also plays the role of a significant infrastructure to meet the requirement for sustainable socio-economic development. This is however, due to the availability of high-resolution imagery, expert system and component based software development [Ehlers, 1992].

Maps have catalytic effect on development. It has been used all over the world to monitor the environment. Maps provide the means for geo-spatial study. Different countries of the world have applied maps in different spheres of human endeavour to promote higher standards of living and proffer solutions to economic, social, health and related problems [Henseller, 2004]. Remote sensing and GIS support mapping of all kinds. Remotely sensed data can be fed regularly into a GIS to keep it up-to-date [Aronoff, 1993]. Map is the storehouse for remotely sensed data, GIS can be used to interpret this data more accurately by integrating them with data derived from other sources.

Advanced Space Borne Thermal Emission and Reflection Radiometer [ASTER] is an imaging instrument used in obtaining detailed maps of land surface temperature, emissivity, reflectance and elevation.

Mah [2004] used ASTER data for mapping of surface cover types. He used two imageries of different epochs to demonstrate change detection of vegetated areas. This is an advantage to satellite remote sensing. The state of the environment can be monitored periodically to detect any change [Ndukwe, 1996]. Mah [2004] concluded that surface water and vegetation can be easily mapped using ASTER data, and if multi-temporal data of the same area are available, change detection can also be easily carried out.

Indeed, using timely remotely sensed data to identify and quantify changes of earth's surface has been one of the major applications for GIS analysis [Edwards et al, 1990]. Recently, Ehlers [1992] demonstrated that SPOT data could be used in a GIS environment for regional growth analyses and local planning. The satellite data were operationally used at a scale of 1:24,000, which is suitable for many regional and local planning tasks. The steps involved were:

a. Geo-referencing the SPOT panchromatic and multi-spectral data.

b. Merging panchromatic and multi-spectral data to form multi-spectral images of enhanced spatial resolution.

c. Classification of landcover and landuse,

d. Integration with GIS data base and

e. Rigorous statistical error analyses based on extensive field checking.

From the procedure, Ehlers [1992] concluded that SPOT image data yielded accuracies for growth detection as high as 93%. Once incorporated into a GIS database, the spatial growth pattern then could be analyzed readily.

Determination of future landslide occurrences requires an understanding of the underlying conditions and processes. Roy [2001] described how geo-information processed with GIS could be used for prognostic modeling, a case study of Himalayan landslide. Landslide occurs in mountainous terrain due to both natural and man-made factors. About 25%of the area of India are covered with rugged and fragile mountainous terrain, predominantly in the Himalayan sector. This area is inaccessible due to the Defense ministry's restrictions. Roy [2001] reported that mapping of landslide area from Indian Remote sensing [IRS] satellite imageries proved quite successful. Landuse and landcover maps were computed from the satellite data and were used to study landslide vulnerability on behalf of the inhabitants.

In another submission, Mardiana et al [2004] described a study undertaken to investigate the suitability of using JERS-1 satellite data in complementary with LandSat-TM data for landuse/landcover mapping applications, particularly for areas where cloud free image of LandSat-TM could not be obtained. This was based on earlier study by Tomlinson [1990] that successfully used a combination of SPOT and LandSat-TM imageries to overcome cloud problem in landuse mapping in the tropical areas. However, Mardiana [2004 confirmed that, even though it worked for SPOT and LandSat-TM, JERS 1 could not discriminate the different types of landcover/ landuse features.

Maps developed from satellite remote sensing are used to support sustainable development. In India, for instance, satellite-derived maps are used in conjunction with collateral data on socio-economic, cultural, demographic and meteorological aspects to map unique land units for which specific developments plans are elaborated ["Third United Nations", 1999].

The Ethiopian Mapping Agency [EMA] used stereo SPOT Pan imageries to continue with the 1:50,000 scale mapping of the country. To achieve this, hard copy SPOT Pan imageries were used in WILD BC-2 analytical plotter running on Aviosoft package. Composite sampling, comprising grids of elevation values plus height values measured along rivers, watersheds and terrain break lines were carried out to form a Digital Terrain Model [DTM]. Ground control points were provided using GPS receivers [Petrie, 1996].

Spaced-based mapping systems have proven to be the most effective tool for the acquisition of image data needed for management of earth based resources. Their ability to provide data of varying spatial, spectral and temporal resolutions at cheap cost offers immense advantages in the sustainable use of resources. It is a common experience that the major problem in the way of applying remote sensing method to mapping in developing countries such as Nigeria is the lack of uninhibited access to image data. The launch of NigeriaSat-1 is therefore a happy development, which hopefully will ensure adequate supply of image data for local and international uses [Olaleye et al, 2004]. They highlighted the experiences and results obtained from an investigation conducted on the first set of images of the NigeriaSat-1 for mapping transportation networks. They reported that repeated and independent tests and measurements by different individuals showed that relative errors of between 0.4-2% are present in route location maps compiled from the NigeriaSat-1 image. They also decried the presence of cloud in large sections of the image and concluded that the image quality is poor.

However, Oyinloye et al [2000] partially agreed with the result of above study as revealed by their own findings. Saying that, even though, water features such as rivers are clearly imaged while roads [except express ways, major rivers and National Grid Lines] are not discernible on the Nigeria Sat–1 satellite image. Landuse/landcover features are discernible on the processed image, and therefore, the quality of the image is acceptable for landuse mapping. Their research was on the application of NigeriaSat -1 data for landuse/landcover mapping of an area within Osun State, Nigeria. As an insight to the study, the authors described landuse and landcover as dynamic phenomena characterized by seasonal changes. In order to effectively manage these phenomena, they concluded that it is necessary to map the different themes periodically.

Another research by Oluborode et al [2004] showed that NigeriaSat-1 is suitable for the development of Administrative map at scale of 1:250,000. But, when compared with Landsat-TM of 30m resolutions and similar spectral bands and radiometric values as NigeriaSat-1, which is suitable for mapping at 1:100,000, they said, NigeriaSat-1 is not suitable for urban planning/mapping at that scale. In view of this, they made recommendation, suggesting a way forward in improving the spectral and spatial qualities of subsequent satellite to be launched by Nigeria, so as to favourably respond to the peculiar terrain characteristics and building patterns in our urban cities, thereby making it suitable for mapping and monitoring of the urban growth of our cities.

According to Atilola [1990], the National Population Commission [NPC] in Nigeria embarked on planimetric mapping and map revision, in order to get the complete coverage required for the planning and implementation of the 1991 national population census, including the delineation of enumeration areas. Monoscopic SPOT XS and Pan imageries were used. Annotated image maps and planimetric maps at 1:50,000 were produced. A total of 177 sheets were produced to cover areas of Nigeria that were either without map or very poorly mapped [Petrie, 1996]. The planimetric line maps were compiled using a PROCOM- 2 optical transfer device equipment with a table digitizer, followed by extensive field compilation and verification work to obtain names of places, classify roads and tracks, add missing details and delete erroneous information. Petrie [1993] said the NPC project was regarded a success and as a result, the use of SPOT imagery has since been adopted for map revision purpose at 1:50,000 and 1:100,000 scales by both the Federal Surveys of Nigeria and Shell Petroleum Development Company of Nigeria.

2.5 Topographic Map

Topographic maps are maps whose principal purpose is to portray and identify the features of the earth's surface an faithfully as possible within the limitation imposed by scale, [Robinson, Arthur and Sale, 1969]. The contents of a topographic map could easily be understood through the study of the legend attached to the map. These contents are normally grouped into five, namely: - political, relief, water, vegetation and communication. Each of these features is distinguished through the use of symbolization in terms of colour, size and shape. Topographic maps serve as base for the production of other maps because it contains almost all the features of the earth surface. Its data is a frequent input in many planning and engineering studies ["Third United Nations", 1999].

Appropriate topographic maps are the necessity for a wide range of planning and development activities. However, in developing regions, such maps are scarce and outdated, owing partly to the high cost of preparing them using conventional approaches. The increasing availability of satellite remote sensing imagery is modifying the way in which maps are currently prepared and consequently used ["Third United Nations", 1999]. This technology reduces the problems that are hitherto inherent with conventional techniques of data collection where information synthesizing is costly, time consuming and usually inaccurate.

The Thailand government used high-resolution satellite imageries to up date topographic map of Pasak Basin in order to monitor landuse changes in 1994.

SPOT PLA was applied to up date the topographic map at scale 1:20,000 regarding geometric accuracy. Landuse changes, such as new roads, boundary of residents, rice fields, vegetation etc were digitized. The row and column numbers were transformed to UTM coordinates. Komate [2004] reported that the outstanding advantage of the application of the SPOT PLA is time and cost savings. The planimetic accuracy of the digitized features can be achieved within 7m, which is sufficient to up date map at scale up to 1:20,000. He further asserted that the digital nature of satellite data facilitate data handling and data conversion into other formats and produce map at any scale.

Shantha [2004] also described the use of satellite imagery for up dating terrain information in topographic databases. After some analyses, he concluded that the conventional methods are very slow and expensive, and developing countries cannot afford the time and cost required to capture terrain information. Developing countries require geo-information for their developmental activities. The updating of this information should be cost-effective and less time consuming. Shantha [2004] also opined that with the increasing development of the remote sensing technology, the satellite data have wide application potential in terrain information production.

To buttress the cost-effectiveness and time saving of remote sensing technology in the production of maps, Mehta and Ozha [2004] used different visual image processing techniques for feature enhancement, extraction and sharpening on false-colour-composite of SPOT-1 and IRS-1A satellite imageries. They discovered that it is possible to prepare a base map for ground verification and small contour interval for medium size project maps at considerably short period.

Skender et al [2004] used Russian KRV 1000 satellite imagery [panchromatic 2m spatial resolution] and SPOT multi-spectral imagery to update topographic map of Noro Virje as part of preliminary construction plans for power plant. The map was to be used in a GIS to assess the influence of the proposed power plant on the environment. The topographic data was divided into 7 major object groups, i.e. coordinate network, settlements, communication, vegetation, relief, water bodies and administrative areas, and compared with the existing coverage originally digitized from the topographic map which was used as the test area. Major difference between the old map and the situation on the ground were detected. The final result as described by Skender et al [2004] is a topographic map database convenient for overlaying with thematic data, environmental impact analyses and plotting of thematic maps.

The Institut Geographique Natinale in France put the accuracy of satellite imagery to test. Gugan and Dowman [1988] reported that SPOT is a potential source of imagery data for 1:50,000 scale mapping since the planimetry accuracy of 20m and height accuracy of 8m are suitable for the scale. To confirm this, the Institute conducted a six-month assessment work on 60 SPOT stereo-pairs with various Base/Height [B/H] ratios. Result obtained from 561 measurements demonstrated the high capability of SPOT in cartographic updating of topographic maps and digital terrain model [DTM] production.

Mapping in the Republic of Congo is as challenging logistically as it is technically. Light Detection and Ranging [LIDAR] technology was applied in Gamboma town of Congo Brazzaville where advanced capturing and quality control methods were used to penetrate the jungle canopy and create an accurately detailed digital elevation model [DEM] and a high quality contour map [Tolman and Corsbley, 2004].

In Nigeria, as evident in the vision 2010, committee report [1997], township mapping, topographic map series, boundary maps and administrative maps had been produced from or based on aerial photography right from the 1950s still the 1970s, and satellite imageries for 7 years now [Samaila-Ija, 2001].

Majdi [2004] compared the conventional method of data acquisition with remote sensing techniques for mapping. He enumerated the methodology for conventional approach, which includes:

a. Acquisition of aerial photos.
b. Restitution of the aerial photos
c. Extraction of new features
d. Reliance on ground truthing and traditional surveying and
e. Regeneration of maps.

According to him, this procedure is very costly and time consuming especially in the area of data acquisition.

He also described the procedure for remote sensing approach as involving:

a. Scanning of existing map
b. Acquisition of relevant satellite imagery
c. Overlay and update digital data using satellite information and
d. Regenerate map with up-to date information.

This analysis was done to support the use of NigeriaSat-1 satellite imageries in updating Nigerian Topographic map series.

Satellite remote sensing offers several unique advantages over alternate or conventional means of data collection such as airborne and ground surveys, which make it an ideal tool for fulfilling certain information need.

The advantages drawn from the above reviews of research works generally relate to: -

a. The lower cost of imagery acquisition

b. The speed and relative ease with which space borne imagery could be obtained.

c. The high frequency of data collection resulting in current i.e. up to date information.

d. The homogeneity of data collection by the use of simple instrument to capture data over large areas, and

e. Improved data coverage, particularly in remote areas and for large regions. ["Third United Nations", 1999].

CHAPTER THREE

3.0 METHODOLOGY

3.1 ***Preamble***

3.1.1 Information Layers

As earlier explained, topographic map shows the natural and artificial features of the earth's surface. These features are normally grouped into five and are distinguished through the use of colour, size and shape. The features are political, relief, hydrology, vegetation and man-made.

Based on the main grouping of topographic map features, the following layers of information would be created for this study:

a. Built-up area

b. Communication [roads ad railway]

c. Water bodies [dams, rivers and stream]

d. Vegetation

e. Relief [contour and slope map]

f. Administrative areas [local government boundaries]

g. Other man-made features

Each of these layers consists of point, line and polygon coverages depending on the way digitized contents are represented on the map.

3.1.2 System Selection

The hardware and software listed below were used for data acquisition, manipulation and presentation: -

Hardwares

a. A 3 digitizer [CALCOMP]

b. Computer hardware memory on windows – Compaq, Presario 4528RAM, 32MB, HDD 4.2 GB

c. 14 inch colour monitor [Compaq Presaro 1520]

Softwares

a. ERDAS IMAGINE

b. ArcInfo

c. ArcView GIS

3.1.3 Data Processing

Data processing involves all operations and manipulation of remotely sensed data using electronic computer [digital] in order to obtain information from the raw data. Here, GIS as digital spatial data integration and processing system, plays a complimentary role to remote sensing application to mapping. Remote sensing generates large volumes of digital data while GIS, on the other hand, is capable of handling the processing of such sets of data.

Determination of the relationship between original data samples and ground locations require an understanding of the various data collection techniques and the geometric distortions that they introduce. These include variations in height, orientation and velocity of the sensing devices, changes in the geometric relationship between radiation direction and the earth's surface, atmospheric effects and changes in ground elevation, [Jones, 1997].

Interpretation of pixel values requires radiometric corrections and calibrations, which compensate for non-uniformities and noise in the radiance signals, arising from the data collection process. This is followed by the application of various image enhancement techniques, which help in distinguishing the characteristics of the data between different locations.

The SPOT imagery used for this study is an ortho-image which has been transformed by the orthogonal projection, yielding an image that is free of most significant geometric distortions caused by earth rotation and curvature, satellite motion, attitude and perspective view as well as relief displacement.

3.2 Data Sources

3.2.1 SPOT Satellite Imagery

SPOT satellite imageries can be used in compiling topographic maps with uniform vertical interval of 20m to 50m, perception of large-scale man-made features and gross vegetation features, and direct compilation of digital terrain models. Based on these potentials, the multi-spectral SPOT imagery of 1994 is chosen as the data source for this study. Parts of two scenes covered Kaduna and environs. These scenes were mosaicked to form a composite image from which the study area was extracted. Fig 3.1 is the hardcopy of the satellite imagery covering the study area.

KADUNA AND ENVIRONS

Source: Spot XS, 1994

Scale :-1:120,000

Fig: 3·1 Hardcopy of Satellite Imagery

3.2.2 *Field Observation*

Remotely sensed data are rarely used as the sole data source. Field observations and measurements as well as existing information, such as maps and reports are mostly used together in the analyses. These are appropriate informations that play a dual role in image interpretation. They assist in the analysis and interpretation processes. And are also used to verify the results of analyses and interpretation already carried out. The supportive information for this study was obtained through ground truthing and GPS readings.

3.2.3 *Existing Topographic Map*

The topographic map of Kaduna at scale of 1:25,000 produced based on air a survey of 1963-65 was used as an aid in the interpretation of the satellite imagery. It was used to estimate the quantity of landuse/landcover change.

3.2.4 *Global Positioning System [GPS]*

GPS is a satellite-based positioning system operated by the United States' Department of Defense. The GPS was used to obtain both planimetric measurements of some important features that may not appear on the imagery and the hypsometric information to generate contours.

3.3 *Data Acquisition/Capture*

3.3.1 Area Of Interest

The image area of this study cuts across two scenes of SPOT imageries. The scenes were selected using the index, which describes the paths and rows of the scenes as delineated by the geographic coordinates of the study area. Table 3.1 shows the description of the scenes.

Table 3:1-scenes covering area of interest [Study Area]

IMAGERY	PATH/ROW	DATES [dd/mm/yy]
Scene 1	K72/J329	03/12/94
Scene 2	K73/J329	29/11/94

Using Earth Resources Data Acquisition System [ERDAS] imagine system software, the two scenes were imported from the CD and mosaicked to form a contiguous image over the study area. The area of interest as delineated by latitudes 10^0 23' 30"N – 10^0 38' 00"N and longitudes 7^0 21' 30"E - 7^0 30' 30" E, is a subset of the contiguous image.

To create a mosaicked image, the "Mosaic image" option from the Data Prep Menu was used. The two imageries to be mosaicked were first geo-referenced to the same coordinate system.

After mosaicking, the new image was geo—referenced to Universal Transverse Marcator [UTM] zone 32, with Minna as datum using Ellipsoid Clarke 1880.

Since the coordinates of the study area were defined in Lat /Long, they had to be converted to rectangular coordinates, so as to be able to work with the imagery.

Using the rectangular coordinates, a box defining area of interest was created. This box was used to clip the exact extent of the study area [subset] from the imagery. To do this, the "subset" option from "image interpreter" was used to define the subset area.

3.3.2 *Image Interpretation*

a. INTERPRETATION KEY

Table 3.2 shows the interpretation key for multi-spectral SPOT imagery developed for the extraction of the various topographic map features for this study.

TABLE 3.2 INTERPRETATION KEYS FOR SPOT XS BAND.

S/N	FEATURES	TONE/COLOUR	TEXTURE	SIZE	SHAPE	PATTERN	ASSOCIATION
1.	RAILWAY	DARK GREY	MEDIUM	FIXED	LONG STRAIGHT	LINEAR	CULTIVATED OR UNCULTIVATED LAND
2.	ROADS	DARK GREY	FINE	VARIABLE OR UNIFORM	STRAIGHT WITH SHARP BENDS	LINEAR	BUILDINGS & BARREN LAND
3.	WATER BODIES	DARK GREY	FINE	VARIABLE	ROUND OR VARIABLE	IRREGULAR OR DISPERSED	VEGETATION AND HILL
4.	RIVERS & STREAMS	DARK GERY	FINE	VARIABLE	VARIABLE	LINEAR	CULTIVATED LAND AND SETTLEMENT
5.	RESIDENTIAL	BRIGHT WHITE TO DULL BLUE WITH PATCHES	MEDIUM	VARIABLE	VARIABLE	REGULAR	A GROUP OF HOUSES
6.	URBAN AREA	LIGHT BLUE TO BRIGHT WHITE	MEDIUM	VARIABLE	VARIABLE	RECTANGULAR	ROADS
7.	VEGETATION	REDDISH	MEDIUM	VARIABLE OR FIXED	VARIABLE OR FIXED	IRREGULAR OR DISPERSED	COMMON

b. ON- SCREEN VISUAL INTERPRETATION

Based on the interpretation keys developed above, the on-screen visual interpretation was performed to obtain four coverages. The four coverage/layers were obtained separately through the combined operations of data acquisition [interpretation] and data capture [digitization].

In screen digitizing, vector data are drawn in the "Viewer" with a mouse using the displayed image as a reference. These data are then written to a vector layer. The coverages created from this exercise are for built up areas, communication network, water features and vegetation.

3.3.3 Global Positioning System Readings

a. GPS, a satellite influenced instrument was used to obtained height information of some selected spots in Kaduna and environs. The spot heights were randomly selected to cater for every part of the research area.

The data collected are shown in table 3.3 having being down loaded into computer system for necessary processing.

The GPS receiver (Magellan 315) used for obtaining these spot heights has relative height accuracy of 0.1m. This is good enough for up dating topographic maps at scale 1:25.000 and smaller.

b. The GPS was also used in this study to take the measurements of location of features that are not discernible on the imagery, as well as those that were not on the ground before 1994. In this

TABLE 3.4 SPOT HEIGHTS

X-cord	Y-cord	Elev-m
333113.281	1175728.875	609
322279.188	1175654.875	640
327276.813	1175551.125	640
327495.969	1175392.875	640
320634.094	1175110.875	640
336460.781	1174769.625	609
336277.688	1174375.500	609
336195.375	1174168.500	609
320465.156	1172818.625	640
321123.594	1172159.875	640
320582.188	1169811.500	609
320724.063	1169522.875	609
321411.656	1168135.375	609
321331.938	1167926.000	609
321314.156	1166843.375	609
336067.281	1166467.875	609
336070.219	1161668.000	609
320337.406	1160782.375	579
327893.875	1153460.500	594
327899.094	1153483.000	594
327979.313	1156238.125	632
327991.344	1156229.000	632
328054.094	1156215.750	632
328128.969	1156216.125	632
331405.938	1157702.750	601
331428.656	1157673.625	601
334282.344	1161459.500	601
332725.469	1153416.500	601
330322.156	1155253.625	609
330309.656	1155292.375	609
327509.625	1154538.625	609
327491.094	1154771.000	609
329058.250	1158457.750	594
329084.094	1158427.375	594
330808.844	1158429.250	594
330810.250	1158457.625	594
335794.344	1156952.250	624
334284.063	1157597.750	624
334269.438	1157593.375	624
334693.906	1157326.125	617
334687.563	1157328.000	617
333288.969	1158718.750	609
334965.250	1161650.250	609
335153.344	1160326.750	624
335149.375	1160292.000	624
335151.125	1160263.625	624
335131.969	1159736.000	624
333921.594	1159952.375	624
333903.844	1159960.125	624
322407.813	1158706.375	586
322486.313	1158926.125	586
322479.750	1159009.375	586
326966.281	1161703.250	579
326771.781	1161625.375	579
328808.781	1169274.375	617
329456.719	1169315.875	624
335604.000	1173859.125	601
334539.000	1170904.500	586
334506.250	1170831.000	586

E 3.8 Showing GPS Coordinates for the Eastern Byepass (U/C)

X	Y		s/no	X	Y
324842	1149465		43	338819	1156212
324979	1149486		44	338900	1156360
325214	1149470		45	338979	1156479
325499	1149500		46	339084	1156665
325646	1149538		47	339319	1156999
325802	1149583		48	339458	1157247
325992	1149651		49	339754	1157666
326112	1149712		50	339830	1157788
326573	1149883		51	339979	1157973
326874	1149951		52	340035	1158084
327099	1149980		53	341214	1159743
327322	1149977		54	341370	1159964
327687	1149926		55	341665	1160403
328585	1149798		56	341816	1160650
328948	1149793		57	342044	1161063
330296	1149995		58	342299	1161599
330816	1150048		59	342410	1161866
331845	1149757		60	342524	1162179
332522	1149434		61	342649	1162583
333017	1149367		62	342695	1162682
333938	1149403		63	342707	1162786
334287	1149420		64	342828	1163316
334402	1149447		65	342882	1163606
337570	1153372		66	342935	1163993
337721	1153612		67	342988	1164572
337772	1153735		68	343008	1164642
337893	1153988		69	343043	1164939
337945	1154112		70	343041	1165036
338009	1154171		71	343069	1165348
338022	1154212		72	343077	1165457
338005	1154274		73	343271	1169629
338019	1154344		74	343336	1168379
338054	1154435		75	343353	1168776
338259	1154872		76	343337	1169036
338370	1155777		77	343326	1169154
338443	1155371		78	343257	1169581
338532	1155522		79	343205	1169788
338603	1155728		80	343173	1169871
338656	1155844		81	343092	1170107
338656	1155844		82	342784	1170748
338716	1155996		83	342614	1171000
338785	1156122		84	342270	1171434
			85	342203	1171529

wise, some of the major roundabout locations and new eastern bye-pass dual carriage way were surveyed with the GPS and included in this study. However, the GPS receiver [MAGELLAN 315] used provides relative positional accuracy of 2m.

3.3.4 Tablet Digitizing

Tablet digitizing involves the use of a digitizing tablet to transfer non-digital data, such as maps to vector formats. The digitizing tablet contains an internal electronic grid that transmits data to ERDAS IMAGINE on cue from a digitizer keypad operated by the user.

In this exercise, the existing topographic map of Kaduna at scale of 1:25,000 was used. The nature of topography and the area extent of the built-up area as at 1963-65, were digitized. At the end, two vector layers of contour and built-up area were created.

In manually digitizing the features, the map was affixed to the digitizing tablet and the coordinate system was established with a set-up procedure. The digitizing operation involved the use of hand-held digitizer keypad, which features a small window with cross hairs and keypad buttons. To digitize point features using "Point mode" of ERDAS IMAGINE the intersection of the cross hairs was positioned directly over the point and from the keypad, different buttons were pushed to tell the system to perform different functions.

In the case of contour lines, which are in "stream mode", the keypad was used to trace desired lines. This digitizing generates points continuously at specified intervals, while the keypad [puck] is in proximity to the surface of the digitizing tablet.

3.3.5 *Editing*

Having completed data capture in ERDAS IMAGINE system, the various digitizing errors were identified and corrected in ARC/INFO system software. Since ARC/INFO and ERDAS IMAGINE are compatible softwares, all the coverage created in ERDAS Imagine were opened in Arc/info without re-writing / importing the data in any other format.

To carry out the editing of the errors, the digitized arcs and label points were first verified for accuracy and all the errors identified. The verification involved checking if:

a. Arcs were accurately traced during digitizing.

b. Any arc or label point was missing, and

c. Circle end-points [nodes] matched correctly or dangling nodes are present where arcs should meet.

After identifying the digitizing errors, the following basic stages of Features–Oriented Editing was adopted:

a. Feature class to edit was selected [choice are ties, arc, mode, label and connotation].

b. Specific features within the edit features class to be edited were selected.

c. Selected features are edited using various commands editing commands [e.g. copy, more, rotate, delete etc].

The end product data acquisition and processing is the information, which will be used in the analysis required for this study. There are two ways in which the information would be presented. These are:

i. Hardcopy and Softcopy maps

ii. Digital data files.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 *Map Design And Presentation*

Topographic map visualises, limited by its scale, the earth's surface as accurately as possible. It brings the features of the earth surface to a focus. These features include infrastructures (roads and railways), landuse (vegetation and built-up), relief and hydrology. The inclusion of geographic names and other reference system enable the use of the map.

The design of topographic maps is mostly based on conventions of which some date back to the last century. Examples are water in blue, vegetated areas in green, major roads and very important features in red, man made features in black etc, while others are based on a set of cartographic rules e.g. brown for landforms. Generally they are very important in the design of a map. They are usually encountered in symbolization and map composition. In this research study, Arc View software was used in the symbolization and composition of the map.

4.1.1 *Symbolization*

Symbols used for the production of the topographic map of Kaduna and environs were in different sizes, colours and patterns to represent different features. Their placements were crucial to give effective communication.

At the data capture stage, five layers were generated i.e. Relief, Roads/Railway, Built-up areas, Rivers and vegetation layers.

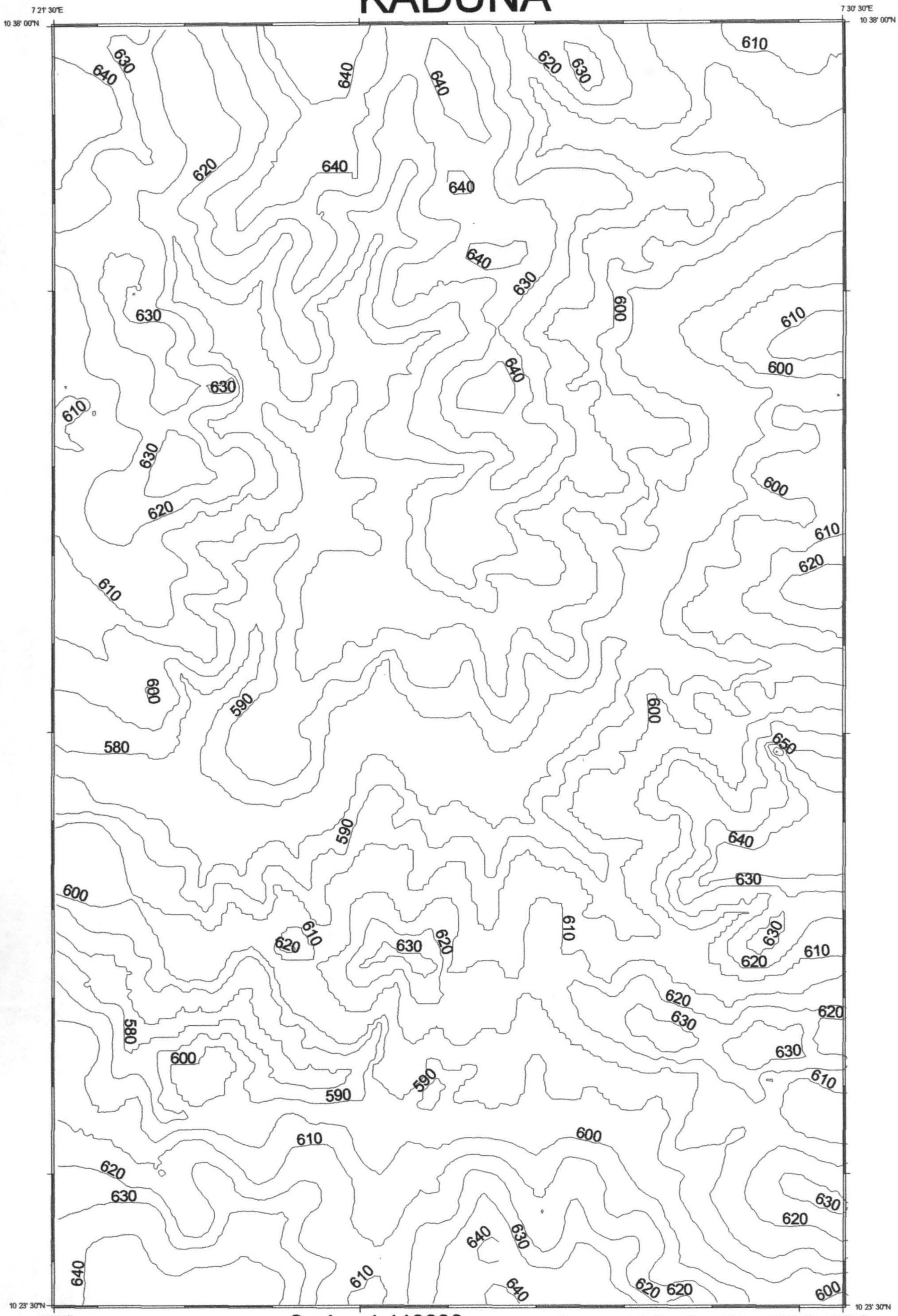
Relief Representation

Computer manipulation of elevation data opens up great possibilities for studying the geometry of land surfaces in relation to physical factors such as climate, vegetation, soil and geology. Therefore, understanding of the relationships between land surface geometry and these physical factors will help us to make more informed land use decisions. Contour lines, DTM, DEM, Slope map and Aspect map are the various method of relief representations that can be obtained from computer manipulation of elevation data.

CONTOUR LINES: From the GPS obtained height information, contour lines at 10m (Fig. 4.1) and15m (Fig. 4.2) contour intervals were generated and shown in brown colour.

DTM: Another method of representing relief is Digital Terrain Model (DTM). DTM may be defined as a digital representation of the terrain relief [earth's surface] suitable for computer processing. It is a discrete expression of terrain surface in a data array, consisting of a group of planimetric coordinates [x, y] and the elevations of the ground points [z]. A DTM can be in the regular grid form or it can be represented with irregular points. In addition to x, y, & z coordinates of a set of selected surface points, it also includes appropriate computer programmes that

KADUNA



Scale:- 1:110000

Source: Existing Topo Map (1972) & GPS Point 2004

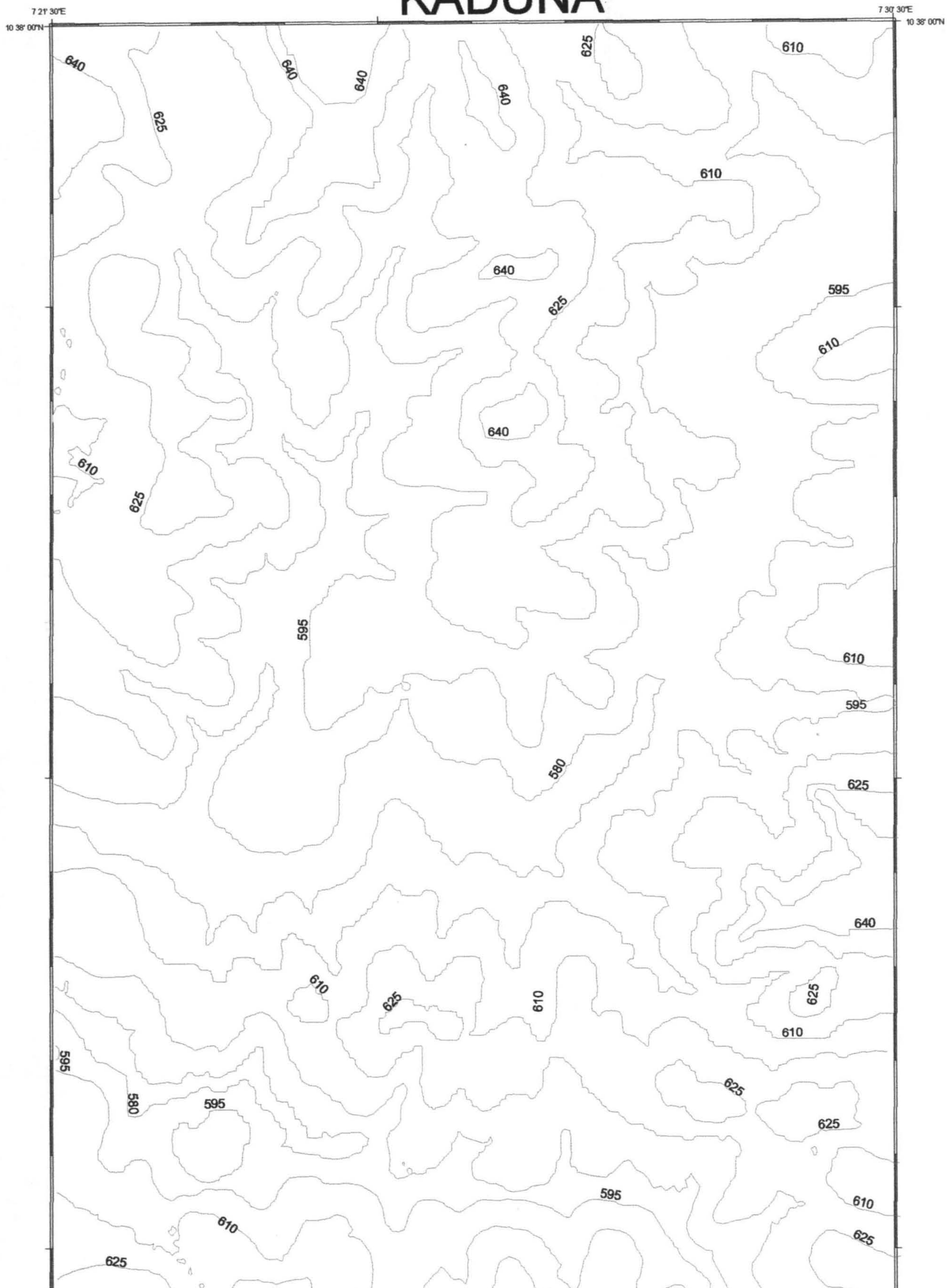
LEGEND

Contours of Point.shp
Contours Interval = 10m

N

Fig. 4.1 Vector Layer Showing Relief Representation (10m)

KADUNA



Scale:- 1:110000

Source: Existing Topo Map (1972) & GPS Points (2004)

LEGEND

Contours of Point.shp
Contours Interval = 15m

N

Fig. 4. 2 Vector Layer Showing Relief Representation (15m)

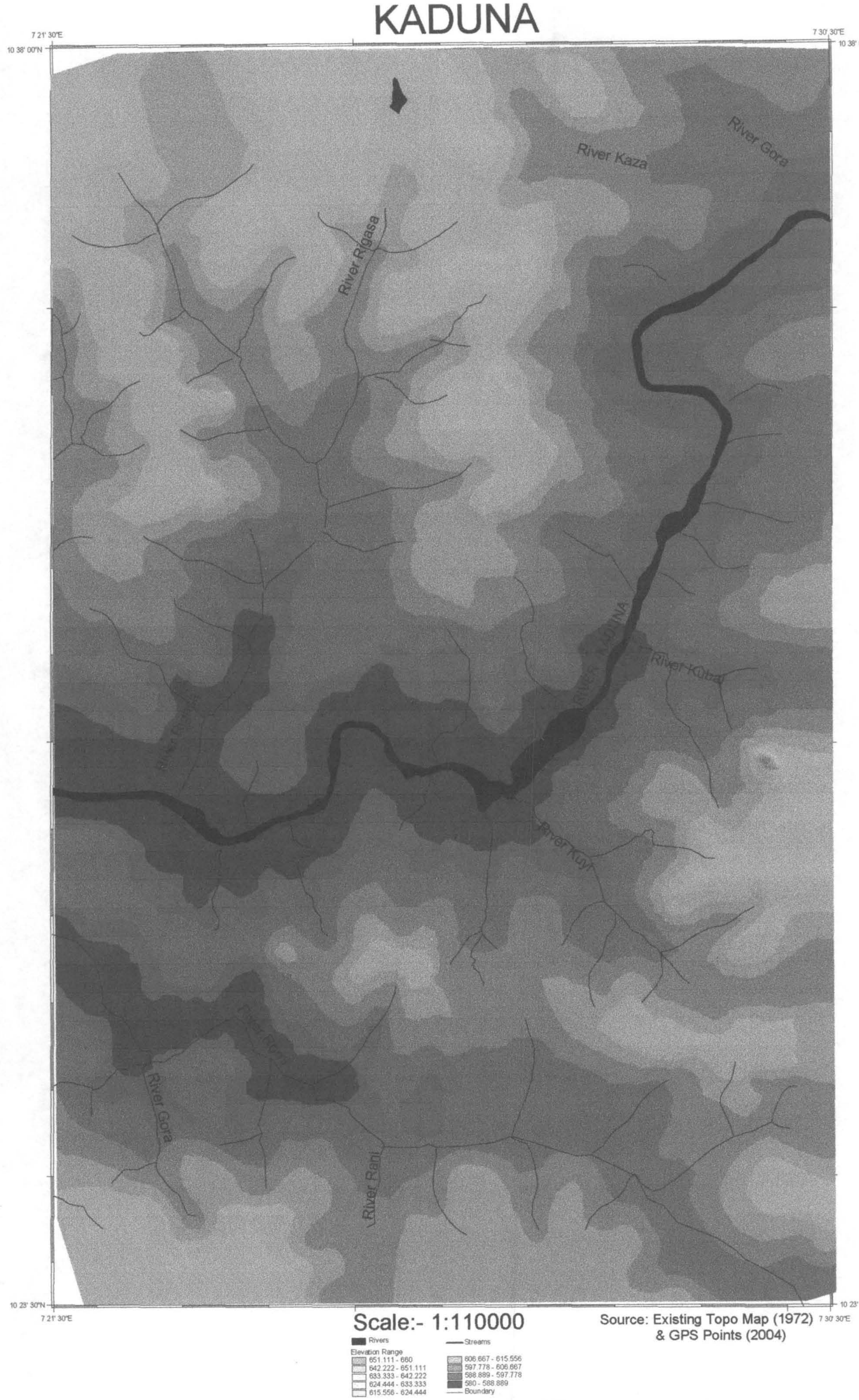


Fig 4.3 Digital Terrain Model (DTM)

KADUNA

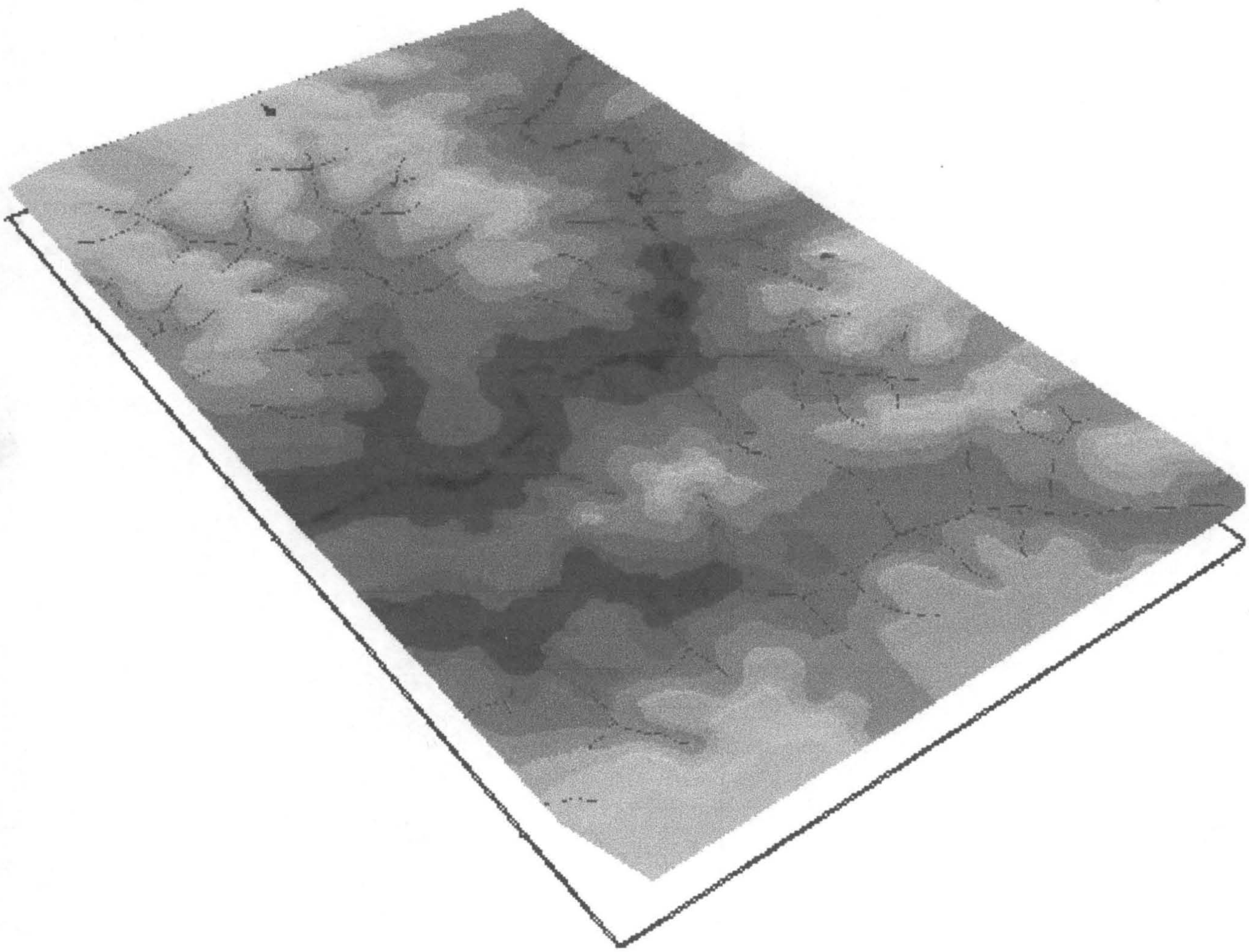


FIG. 4·4 DEM—DIGITAL ELEVATION MODEL

Fig 4.5 Aspect Map

are needed for interpolation, computation of earthwork volumes and other data manipulation. The DTM for this study is shown in fig. 4.3.

DEM: Similar to DTM, Digital Elevation Model (DEM) shows the perspective view of the terrain. Fig. 4.4 shows the DEM of the terrain surface of the study area.

ASPECT MAP: Slope azimuth or aspect is the direction, which a surface faces, usually expressed in degrees (0-360) or as compass bearing (N, NE, E, SE, S, SW, W & NW). Aspect is an important characteristic of hill slopes because of its effect on solar illumination, and coastlines because of its relationship to prevailing wind direction, which can affect shoreline erosion. Fig. 4.5 is Aspect of Kaduna as obtained from the manipulation of the elevation data.

Roads / Railway

For road/railway layer different patterns of lines symbols were used to represent different classes of roads. Major roads were shown in red while others along with railways were shown in black. There are two colours combined here i.e. the red and black colours, and are shown in fig. 4.6

Hydrographic Features

Two classes of water features were digitized. These are broad rivers and Streams. Areal symbol was used to represent broad river while the streams are in single lines. They are in blue colour and are shown in fig. 4.7

Built – Up Areas

Built-up areas cumulatively represent the extent of Kaduna. In this case, the actual shape was maintained since this an area feature. It is given gray patterns and can be seen in fig. 4. 8

Vegetation

The last layer is vegetation. Abstract symbol of point nature was chosen to represent vegetated area in green colour. This layer covers all undeveloped areas as can be seen in fig. 4. 9.

4.1.2 Map Composition

In Arc-View, map composition involves creating the required frames or map elements, adding other graphics such as title or neat lines, and arranging everything on the page until the format desired is achieved. Layout design and annotations are the major activities in map composition.

Layout Design

Several tools exist to help in placing map elements in a layout. These tools were effectively utilised in this research study. To compose the map, a layout was created to combine all Arc View project

KADUNA

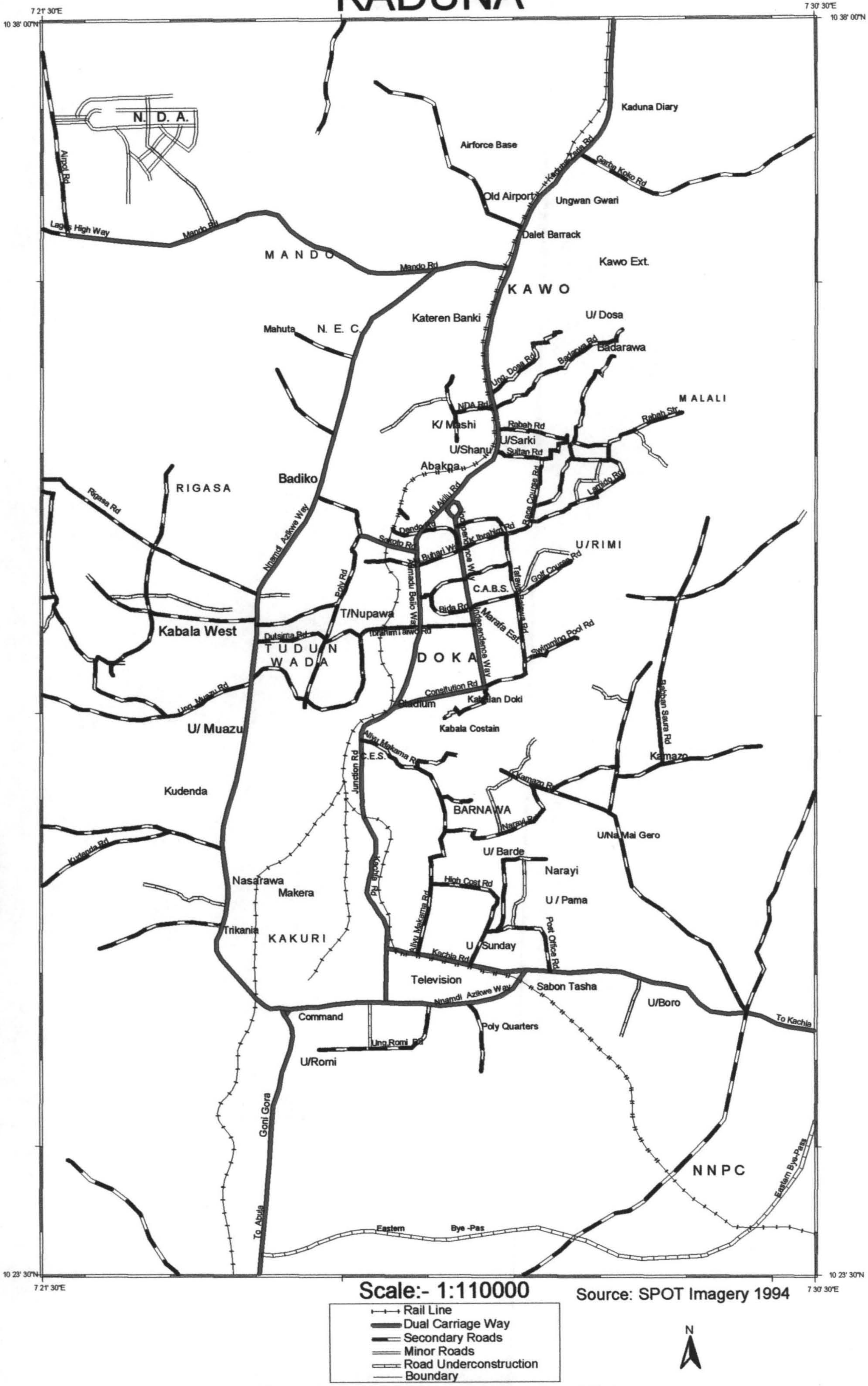


Fig. 4.6 Vector Layer Showing Road Network

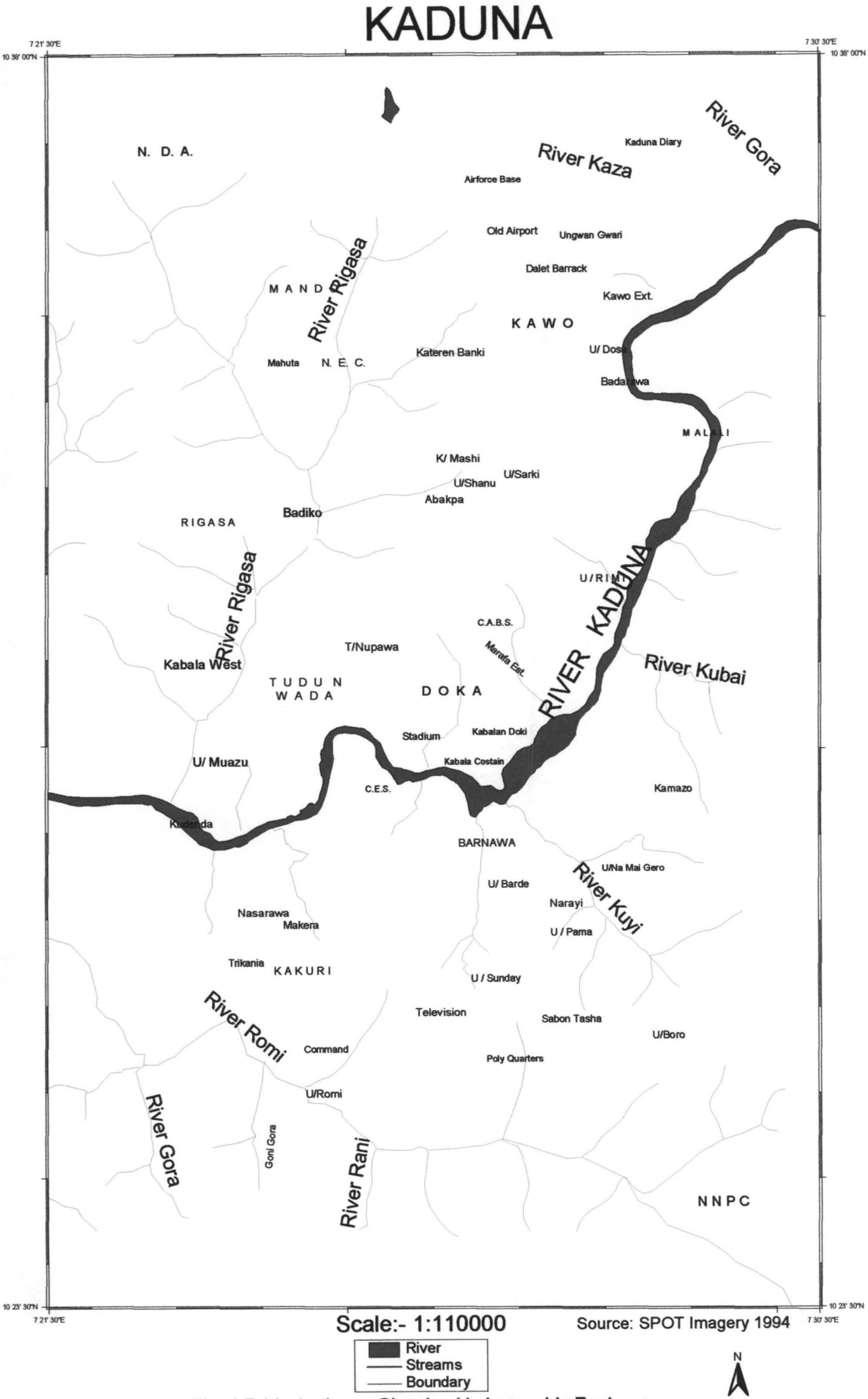
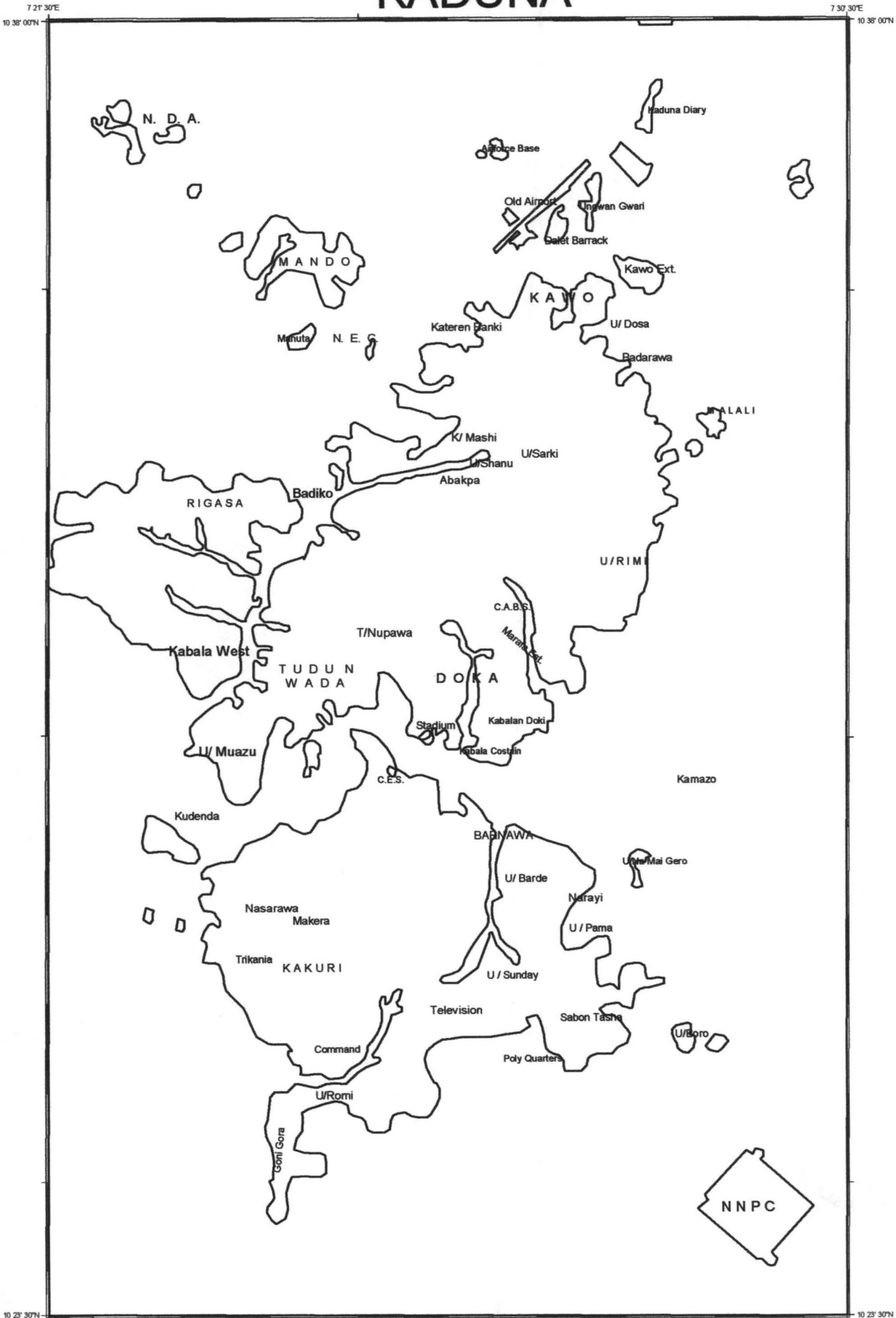


Fig 4.7 Vector Layer Showing Hydrographic Features

KADUNA



Scale:- 1:110000

Source: Spot Imagery 1994

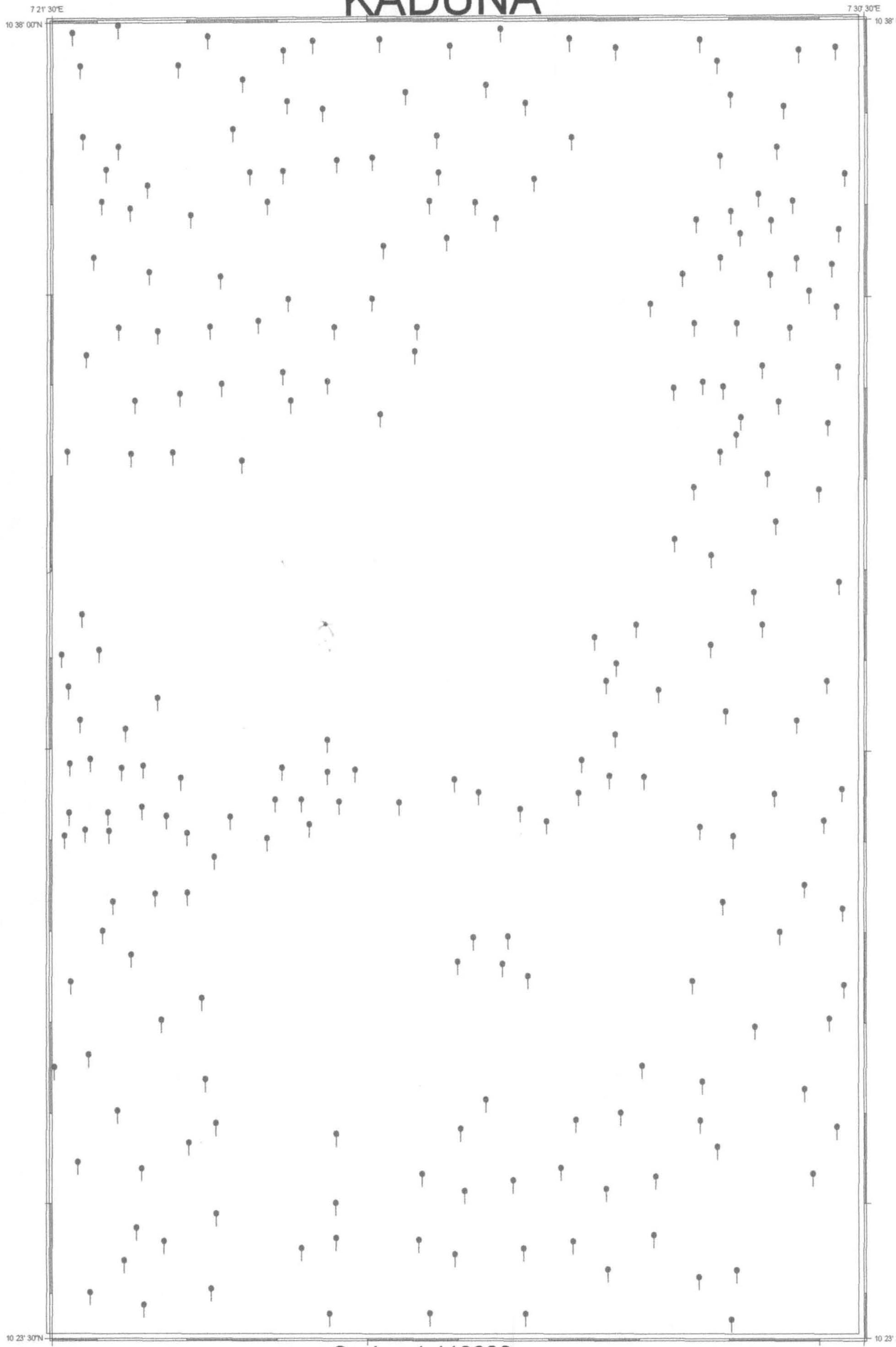
LEGEND

—— Built_up.shp

N

Fig. 4.8 Vector Layer Showing Built-up Areas

KADUNA



Scale:- 1:110000

Source: SPOT Imagery 1994

LEGEND

Vegetation

N

Layer Showing Vegetated Area

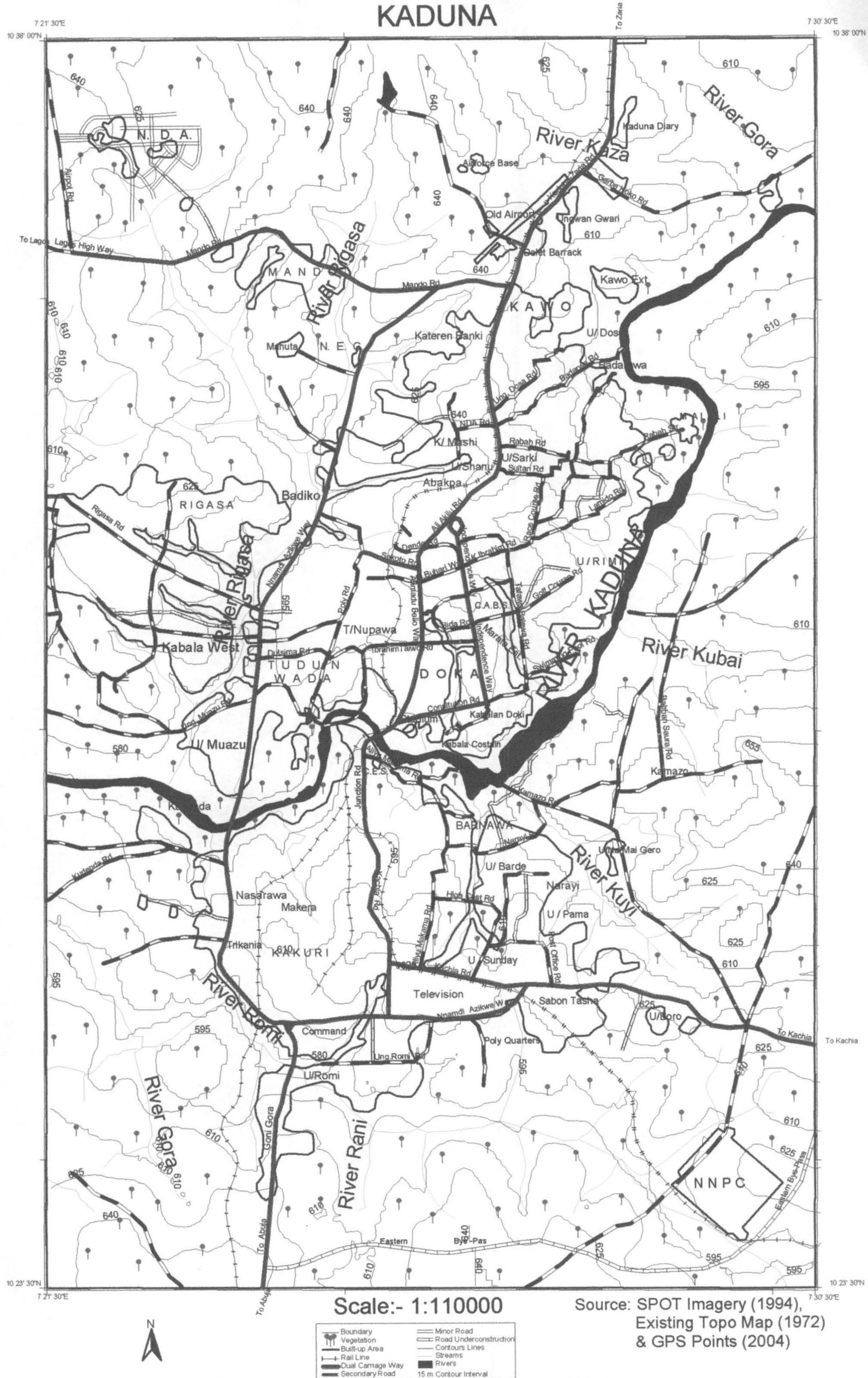


Fig. 4. 10 Composite Topographic Map of Kaduna

components such as views, legend, scale bars, north arrow, and other graphics to form a single output document.

To create the layout, layout icon in the project window was prompted to select "New" in order to create a default layout, thereby defining the graphic page, which corresponded to the format desired for the final output. On the graphic page, the map elements were added and linked to the Arc View project components. To give visual balance, these map elements were moved around with the graphic page.

Annotations

A map is much than just an image on a background. Since a map is a form of communication, it must convey information that may not be obvious by looking at the image. Therefore, maps usually contain several annotations elements to explain the graphic features on the map. The annotation elements added on the map for this research work include neatlines, tick marks, graticules, north arrow, legends and label.

Finally, a composed topographic map of Kaduna and Environs is shown in fig. 4.10.

4.2 ***Analysis***

There are three different forms of analysis in this research work, and they are based on the formulated hypothesis stated in chapter one of this thesis. The analyses are predicated on area change determination, database and cost implication.

4.2.1 *Change Detection*

The change detection here is obtained through comparison between the area extent of Kaduna as at 1965 and that of 1994 (fig. 4.11).

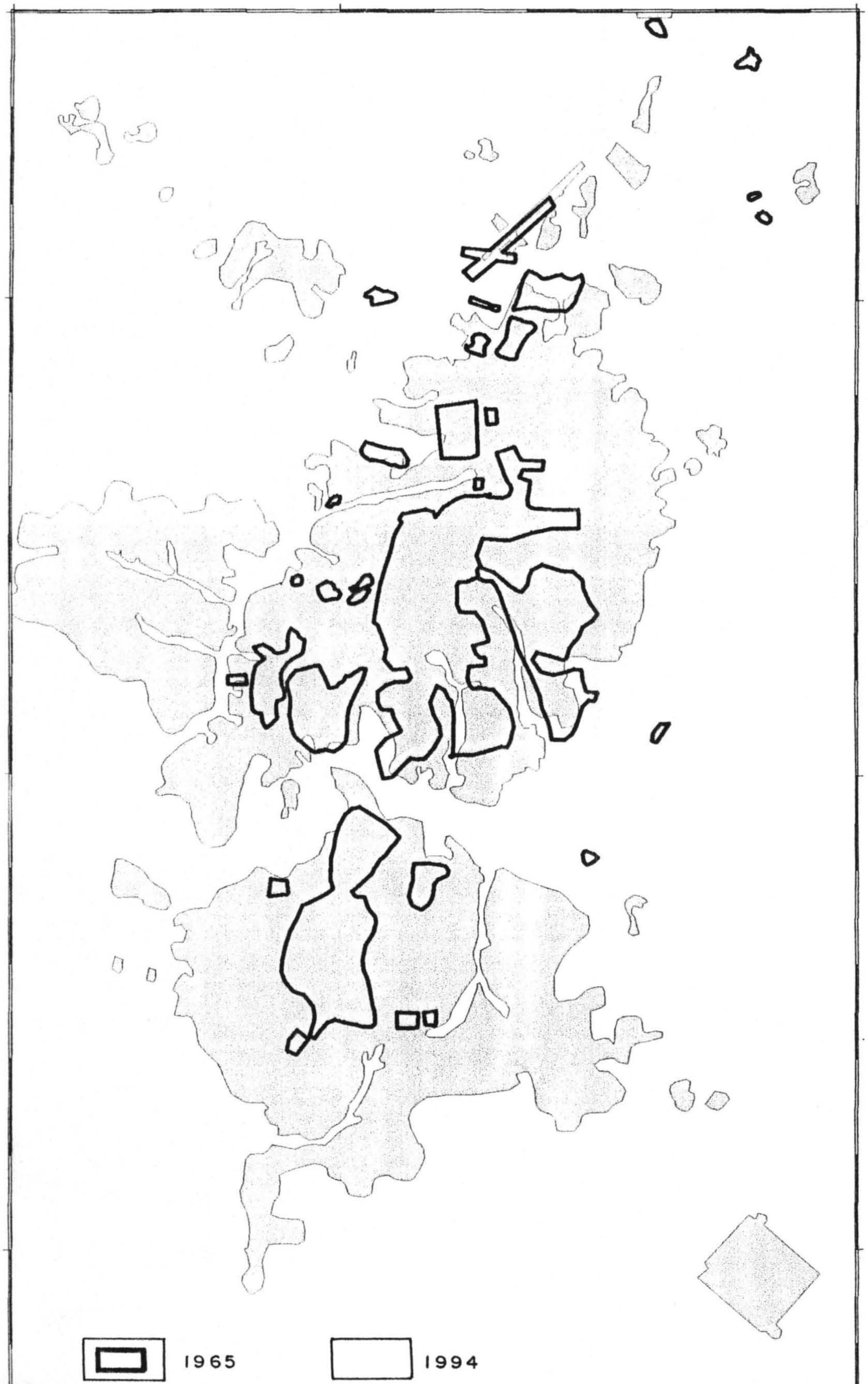
Table 4.1 built-up area extents of 1965 and 1994

	1965	1994	Difference	%
Total area	25.916km^2	117.863km^2	91.947km^2	354%
Perimeter	107km	255km	148km	138
Polygons	35	33	2	

The total area of Kaduna as at 1965 was 25.916km^2, while in 1994 it was 117. 863km^2, which shows a percentage, increase of 354% over a period of 29 years. Table 4.1 gives the figures for the two periods. On this table, it can easily be deduced that a significant amount of change has occurred from 1965 to 1994. The change, which implies growth on the developmental structure of the town, is large enough to necessitate re-mapping.

4.2.2 *Database*

The tasks of finding, creating, assembling and integrating data are collectively referred to as database development. Database is essentially a computerized record keeping system i.e. an electronic



Source : Existing Map (1965) & Spot XS.(1994) SCALE :- 1 : 115,000

Figure 4.-11- Vector Layer showing Comparison Between Built-up Areas of 1965, and 1994.

filing cabinet. Specific information could be located and queried for in the database with ease. The database is at the center of geographic information system (GIS). Infect, it can be seen as providing the fuel for the GIS. A database has both spatial and attribute data. The spatial data is the geographic feature while the attribute data describe the characteristics of that feature. In this research work, Database was developed for all the generated layers. For instance, the road layer has the different classes of roads as spatial data, while the name type, length class of road as the attribute data.

Also hydrographic features have streams and river as the spatial data, while the properties, such as length, name and type are referred to as attribute data.

With this types of information processed into computer systems, up dating becomes easier. To up date does not require condemnations of the entire work, instead only the affected part will be up dated in terms of omission or addition

The computerized data handling method makes manipulation, sorting, reformatting, storage, and retrieval a lot easier and stress-free. This is an edge over the conventional way i.e. manual filing system in which stored data or information could be cumbersome to retrieve in time of need.

4.2.3. Cost Implication

Cost consideration for any project is a crucial issue. The determination of the cost implication assists in choosing the most cost-effective means of carrying out a project. The cost implication in this research study is being looked at using three mapping techniques i.e. Land surveying, Photogrammetry and Remote Sensing.

(a) *Land Surveying*

The bill of quantities for direct field cost of topographic mapping produced by the Nigerian Institution of Surveyors (NIS) in their Scale of Fees (2002) revealed that fees for topographic survey can be obtained using the following procedure: -

Up to $1000m^2$ = N62, 000

1 ha = N162, 000

The next ha and above = N62, 000/ha

This costing involves recce, clearing, pegging, levelling, QC and data processing, plotting and draughting, report and printing

Going by the above procedure, the topographic mapping of Kaduna and environs with total area of $450km^2$ can be estimated to cost: -

@ N62, 000/ha

$450km^2$ = 45,000ha

45,000ha = 45,000 x N62, 000

= N2, 790,000,000

(b) *Photogrammetry*

For this mapping technique, aerial photograph is used. And so, over an area of $450Km^2$, about 12 strips are required to produce 420 photographs with 408 models. The NIS (2002) Scale of Fees propounded the cost estimate as follows: -

i. Aerial photos @ N15, 000/photo = 420 N15, 000=N6, 300,000

ii. Provision of basic ground controls = N50, 000

iii. 2 sets of contact prints = N600x840=N504, 000

iv. 1 set of diapositives = N2000x420=N840, 000

v. Aero triangulation = N2, 800,000

vi. Stereo compilation, = N700x408=N2, 856,000

vii. Field completion survey = 100,000

viii. Cartographic fair drawing = 50,000

ix. Printing & report= N50, 000

Total = N13, 550,000

(c) *Remote Sensing*

This is the aspect where computer system is used to process satellite imagery in order to obtain digital information. To effectively carry out the topographic mapping of Kaduna using remotely sensed data, the following cost estimate can be incurred: -

i. Procurement of SPOT satellite imagery (orthorectified) @ \$3200/scene. (A SPOT imagery scene is 60km x 60km.) Only a scene is required to cover the research area of 450km^2 @ N130/\$ = N130x3200 = N416, 000

ii. Acquisition of computer system

Hardware = N250, 000

Software = N200, 000

N450, 000

iii. Establishment of ground controls = N50, 000

iv. Image pre-processing = N10, 000

v. Image interpretation = N10, 000/layer =N50, 000

vi. Generation of DEM = N20, 000

vii. Ground truthing and field completion = N100, 000

viii. Map composition (cartographic design) = N20, 000

ix. Printing & report = N50, 000

Total = N1, 166,000

From the cost implications enumerated above, it can easily be deduced that the use of remotely sensed data for topographic mapping is cost effective in that it is cheaper than the other two methods.

The various levels of analyses carried out in this research study have proven that the use of remotely sensed data is the most beneficial in the production, use and updating of maps.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 ***Summary***

The research examines the applicability of SPOT XS satellite and GPS data within the GIS technique in updating topographic maps of Kaduna urban area. The research was borne out of the need for constant mapping and the identification of the problem hindering this assertion. The problem of unavailability of up-to-date maps caused by the costly, labourious and time consuming nature of the land surveying and Photogrammetry methods of mapping necessitated this research into an alternative that will solve the problem associated with these conventional methods.

To carry out this study, SPOT XS satellite imagery of 1994, existing map of Kaduna and environs (1965) and GPS readings were obtained. These data were individually processed to yield information and later combined for analyses. The SPOT XS satellite imagery was used to generate the layers of the topographic map, the GPS gave the relief information, while the existing maps provided the supportive information. The layers of information generated have both spatial and attribute databases which can be manipulated at will.

To buttress the choice of remote sensing technique, previous studies were looked into from all over the world including Nigeria where a lot of people and organizations have at one time or the other used remotely sensed data in carrying out topographic mapping of an area of interest.

The results obtained vary considerably. In general, it was found out that: (i) Remote sensing technique is the most suitable for monitoring and evaluating changes.

(ii) The use of computer database will facilitate updating, access to data and data manipulation / analyses.

(iii) It is much more cost effective to use R/S and GIS techniques in updating maps.

The results of these analyses were in favour of Remote Sensing technology, which means the technology is the most suitable for topographic map updating.

5.2 Conclusion

This study is predicated on the use of SPOT XS satellite GPS data in updating Topographic map of Kaduna and environs within the framework GIS. From the study, the following conclusions were drawn:

(a) SPOT XS can be used to update all elements of topographic maps of Kaduna and environs.

(b) GPS data can be used to support the updating process.

(c) GIS technique enables map data to be plotted faster and with greater precisions than is possible using manual methods.

(d) GIS technique, also provides the opportunity to interact with graphic displays while carrying out updating, manipulation and analyses of data.

(e) Finally, the use of remotely sensed data is an alternative to the much tedious, labourious, very costly and time consuming classical methods such as Land surveying and Photogrammetry.

5.3 Recommendation

It is a common knowledge that mapping is the bedrock of all types of development. Exploration, exploitation, planning and management of natural resources, and the provision and distribution of infrastructures, can be systematic, effective and efficient through the use of comprehensive and up to date maps. Remote sensing technology offers an effective basis for map production. It is preferred to the conventional method because of its timeliness and cost-effective nature. Based on the findings of this study, the following recommendations are considered as appropriate here:

a. The use of remotely sensed data should be adopted for topographic mapping.

b. High-resolution satellite imageries (1m and above) should be made available and easily affordable.

c. Government should take mapping policy seriously by allocating more funds for mapping.

d. Remote sensing techniques should be used to compile geographic database for the entire country.

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