DATABASE DEVELOPMENT FOR POWER HOLDING COMPANY OF NIGERIA (PHCN) TRANSFORMERS CAPABILITY UTILIZATION (CASE STUDY BARNAWA FEEDER AREA OF KADUNA STATE)

BY

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M. TECH/SSSE/917/2003/2004

A THESIS SUBMITTED TO
THE POSTGRADUATE SCHOOL,
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA,
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF MASTER OF
TECHNOLOGY (M.TECH.) IN REMOTE SENSING
APLLLICATIONS. DEPARTMENT OF GEOGRAPHY
SCHOOL OF SCIENCE AND SCIENCE EDUCATION
FEDERAL UNIVERSITY OF TECHNOLOGY,
P.M.B. 65, MINNA,-NIGERIA.

JUNE, 2005

CERTIFICATION

This thesis titled **DATABASE DEVELOPMENT FOR POWER HOLDING COMPANY OF NIGERIA (PHCN) TRANSFORMERS CAPABILITY UTILIZATION BY SADA MUHAMMAD (M.TECH / SSSE/ 2003/2004/917)** meets the regulations governing the award of the degree of M.Tech of the federal university of technology, Minna and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This work is dedicated to my parents, without whose blessings and continued support this would not have been possible.

ACKNOWLEDGEMENT

It gives me great pleasure to express my appreciation of the assistance so generously rendered to me by all those who helped in completing this course and project in time.

I am very grateful to my supervisor Prof. Adefolalu for his guidance, patience, keen interest, cooperation and constructive criticism in all stages of the project.

I express my deep sense of gratitude to Dr. M. T. Usman [H.O.D] , Dr. Halilu, Dr. Apollonia, Mal. Salihu and other staff of the department for the assistance rendered at all stages of the traiing course. I owe my sincere gratitude to Dr. P., S. Akinyeye for his kind consideration. I shall always remain indebted for the invaluable assistance, affectionate behaviour and hospitality which I have received from my colleagues: Yahanasu Aliyu, Asmau Buhari, Alhaji Lateef, Magaji Abu, Murtala Musa and Aminu Ambaya throughout the training. Amon9g others that deserved a giant appreciation for their financial and moral support are: Alhaji Iro, Lawal, Bashir, Shehu and Lawal Ahmad. I am forever grateful for your kind contribution towards my academic endeavour.

It is hard to forget the assistance and moral support provided to me by my mother Hajiya Hafsatu Dardau, my uncle Alhaji Sani Danmusa and other members of the family. I wish to express my affection and sincere thanks to my brothers and sisters: Aliyu, Yusuf, Sani, Hadiza, Maryama, Asiya and Umar. My friends: Aliyu Yar'adua, Lawal Ibrahim, Tayab Aliyu, Daura Abba, Usman Moh'd Dan Bauchi and Hauwa'u A. for their encouragement and heartily support to do this course.

ABSTRACT

This study examines the potentials of GIS as a decision support tool towards enhanced decision process in power supply with particular reference to capacity utilization of transformers in Barnawa area of Kaduna metropolis, Nigeria. SPOT satellite imagery, Existing maps and GPS technology were used to design and create spatial database for the Barnawa PHCN (Power Holding Company of Nigeria) feeder area. The database was created in a vector-data model using a relational database structure of the ArcView GIS. This spatial database was subjected to queries, overlay operations and Network analyses required to make decisions on transformers maintenance, monitoring and management. From the created database it is possible for the PHCN management to effectively monitor the use of their transformers. Based on this possibility, recommendations were made. These include the establishment of a GIS unit within the PHCN.

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ACRONYMS

1.	AM/FM	-	Automated Mapping and Facility Management
2.	CAD	-	Computer Aided Design
3.	CADD	-	Computer Aided Design and Draughting
4.	CCN	–	Cable Company Network
5.	CES	-	College of Environmental Studies
6.	DBF	-	Data Base Format
7.	DSS	-	Decision Support System
8.	DTM	-	Digital Terrain Model
9.	ESRI	-	Environmental System Research Institute
10.	GIS	-	Geographic Information System
11.	GPS	-	Global Positioning System
12.	KV	-	Kilovolts
13.	KVA	-	Kilovolts Amp.
14.	MEDORA	-	Mediterranean Opportunities for Rural Areas
15.	MTS	-	Mobil Telephone System
16.	MW	-	Megawalts
17.	NEPA	-	National Electric Power Authority
18.	PHCN	-	Power Holding Company of Nigeria
19.	PTT	-	Post, Telegram and Telephone
20.	TIN	-	Triangulated Irregular Network
21.	UIS	-	Utility Information System
22.	UNTL	-	United Nigeria Textile Limited

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

Electricity is vital to a nation's economic and social well being. It plays so large a role in the development process of the modern world that it would be difficult to imagine life without it. And so today's planning methods for electric utilities must be improved to meet the challenges of increasing costs of services and capitals, new operating methods and increased regulatory pressures.

In Nigeria, responsibility for electricity supply is vested under the auspices of Power Holding Company of Nigeria [PHCN], formerly National Electric Power Authority [NEPA]. Its services include generation, transmission and distribution. The distribution stage, which is the stage that connects the company to the customers, involves the use of high-tension transformers distributed all over the country. These transformers step down high-tension current for use by individual customers. Erratic power supplies have been attributed to overloading, poor maintenance and inadequate protection of the transformers. These problems persist because the decision-makers lack comprehensive, up-to-date and accurate information on the resources they manage.

On the ground techniques for collecting data and the manual techniques for synthesizing information are costly and time consuming or even inaccurate. The PHCN decision makers need adequate information on the locations, capacities, areas of coverage, type of use and amount of load for each of their transformers. With this information, decision makers can readily determining areas of need for new or additional transformers.

Remote sensing and Geographic Information Systems [GIS] are complementary technologies that are used to solve spatial problems. Remote sensing collects data while GIS manages the amount and diversity of data needed for decision making.

This research is intended to look at the appropriateness of GIS as a support tool for effective management and monitoring of PHCN transformers utilization in Barnawa feeder area of Kaduna metropolis in Kaduna State. In this study area, the transformers are supplied with current from PHCN railway power station with 132KV/33KV. The source for the PHCN railway power station is the 330KV/132KV located at Mando, which is in turn linked to the National Control Centre at Osogbo, Oyo State. The PHCN railway power station, which receives an input of 132KV and has an output of 33KV, is being stepped down at Kakuri injection bus-station. This Bus-station is further stepped down into three feeders- UNTL, Rural and Arewa feeders. The Arewa feeder has an input of 32KV with output of 11KV. It is also stepped down into four sub-feeders. These feeders are Nassarawa, Nortex, Kakuri and Barnawa. Barnawa, the study area has about 47 sub-stations or transformers, among which there are 39 public and 8 dedicated transformers.

1.2 PROBLEM STATEMENT

PHCN locates transformers in different parts of the country in order to supply electric power to individuals and organizations. Each transformer has its area of coverage within which it provides electricity. In Barnawa, there are about 40 of such transformers with different capacities spatially distributed. These transformers are prone to abuses of all sorts ranging from over loading, illegal connections and disconnection. Another form of abuse is that of a customer connecting two different transformers. All these abuses contribute to inefficiencies of transformers leading to erratic power supply. However, these abuses are possibly, because of the following:-

a. Sometimes it is difficult for PHCN officials to readily determine rate of power consumption in an area.
b. They also do not know the general use to which a particular transformer is put.
c. Customers on their part find it difficult to know which transformer they are attached to, as well as its capacity.
d. Intending customers also do not readily know which transformer in an area can accommodate additional demand.

1,3 AIMS AND OBJECTIVES

AIM

The aim of this study is to develop spatial database for PHCN transformers in Barnawa feeder area for a more effective management and monitoring of the transformers capacity utilization.

OBJECTIVES

a. To develop spatial database for PHCN transformers in Barnawa feeder area.

b. To produce the digital map of Barnawa showing locations of transformers, their capacities and areas of coverage's.

c. To carry out some basic GIS analysis such as network analysis, overlay operations and spatial quarries.

d. To demonstrate the robustness of the database for management and monitoring of transformers capacity utilization.

1.4 JUSTIFICATION

Electricity is one of the utilities that provide common 'good' to individuals and organizations. This common good is not a product that can be bought off the shelve but to be delivered directly under centralised control through transmission network. The centralised control for this utility in Nigeria is done by PHCN. The PHCN require adequate information on the services they provide. This information is commonly referred to as Utility Information System [UIS], deals with the planning, maintenance and mapping of such services.

With UIS, PHCN officials can easily determine overloaded transformers as well as the caliber of customers in an area. Caliber of customers helps to determine what capacity of transformer to provide in an area. Customers on their part will benefit from this spatial information by readily knowing which transformers service them and its capacity/area of coverage. Intending customers can also determine which transformers to be connected to and if congested, what capacity of transformer to be requested for.

1.5 SCOPE AND LIMITATIONS

The research focuses on the development of a database for PHCN transformers' capacity utilization in Barnawa feeder area, a suburb of Kaduna metropolis. The research area is delineated by latitudes 10^0 27' 00" N, 10^0 29' 45" and longitudes 7^0 25' 00" E, 7^0 27' 00E.

This study will look into the possible ways of checking all abuses of PHCN transformers such as overloading, illegal connections and disconnection through the use of GIS spatial database. The spatial database will provide information about the locations, capacities, areas of coverage's, caliber of customers and age of each transformer using GIS technique. The data will be obtained from remotely sensed imagery and existing maps.

Since GIS is a tool for managing and monitoring spatially distributed information, the spatial database will consist of layers of information. This will enable GIS operations to be performed on the database. These operations are means of carrying out effective and efficient management and monitoring of the various transformers. The limitations of this research are the high cost of data required, processing them into information as well as the cost of movements and other contingencies.

1.6 DESCRIPTION OF THE STUDY AREA

1.6.1 Geographic Location and Population

Barnawa, a suburb of Kaduna metropolis is located between latitudes 10^0 27' 00" N, 10^0 29' 45" and longitudes 7^0 25' 00" E, 7^0 27' 00E. With an areal extent of about 20. 87km^2, it lies on the southern part of Kaduna with about 6km to the city centre. The research area shares boundary with Narayi to the east, Kakuri to the West, Ungwan Television to the south and River Kaduna to the north. The population estimate of Barnawa according to the 2002 projected population by National Population commission is about 179,599.

1.6.2 Landuse

Before now, Barnawa was only known for having residential quarters for civil servants and individuals. However, there has been increase in population over the last decade resulting into the emergence of other landuse such as commercial, institutions, small-scale industries and religious. Of all these, commercial activities are prominent as can be seen with the numerous shopping complexes and malls scattered all over the area.

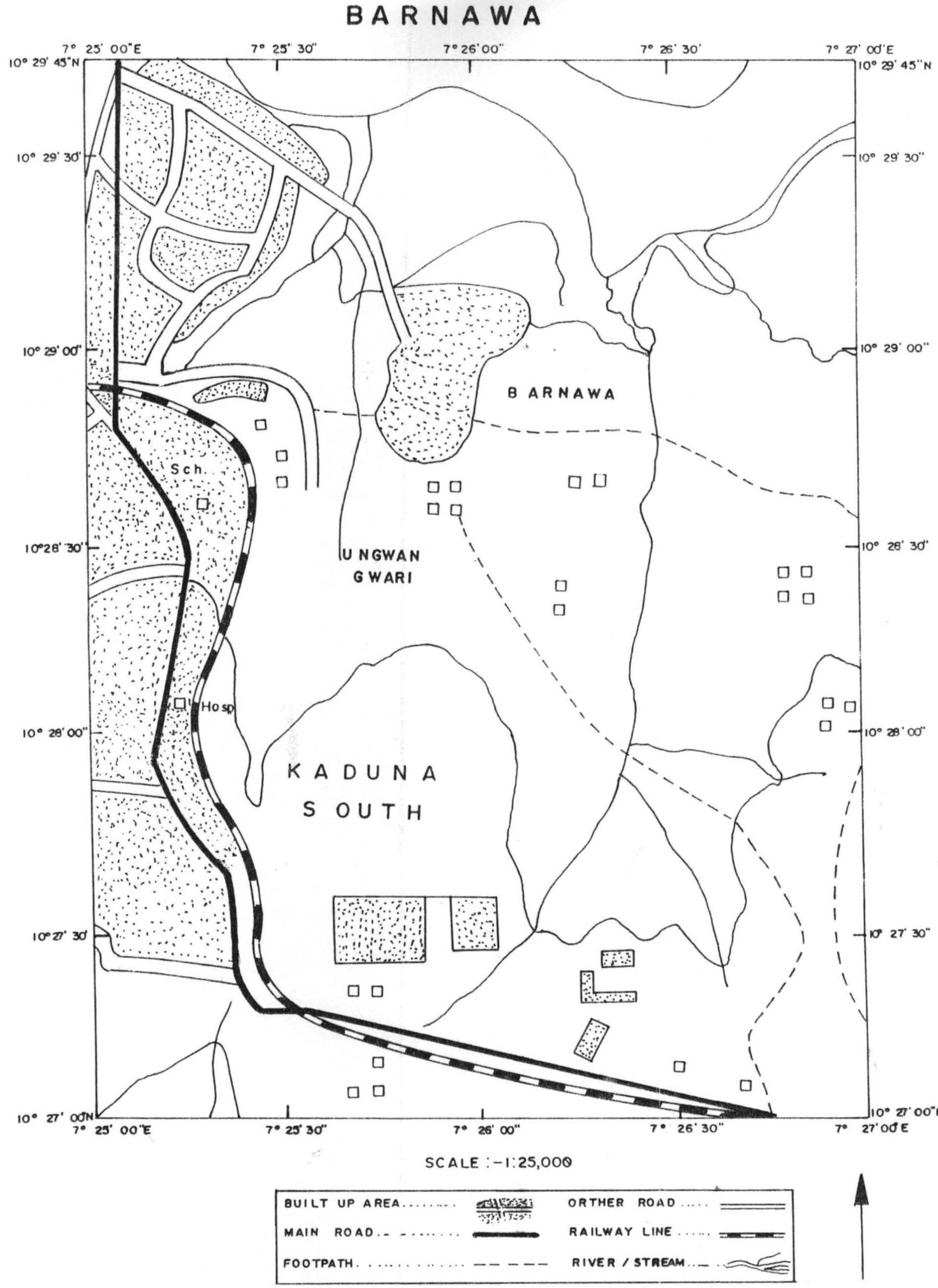

FIG. 1:1 BARNAWA FEEDER AREA

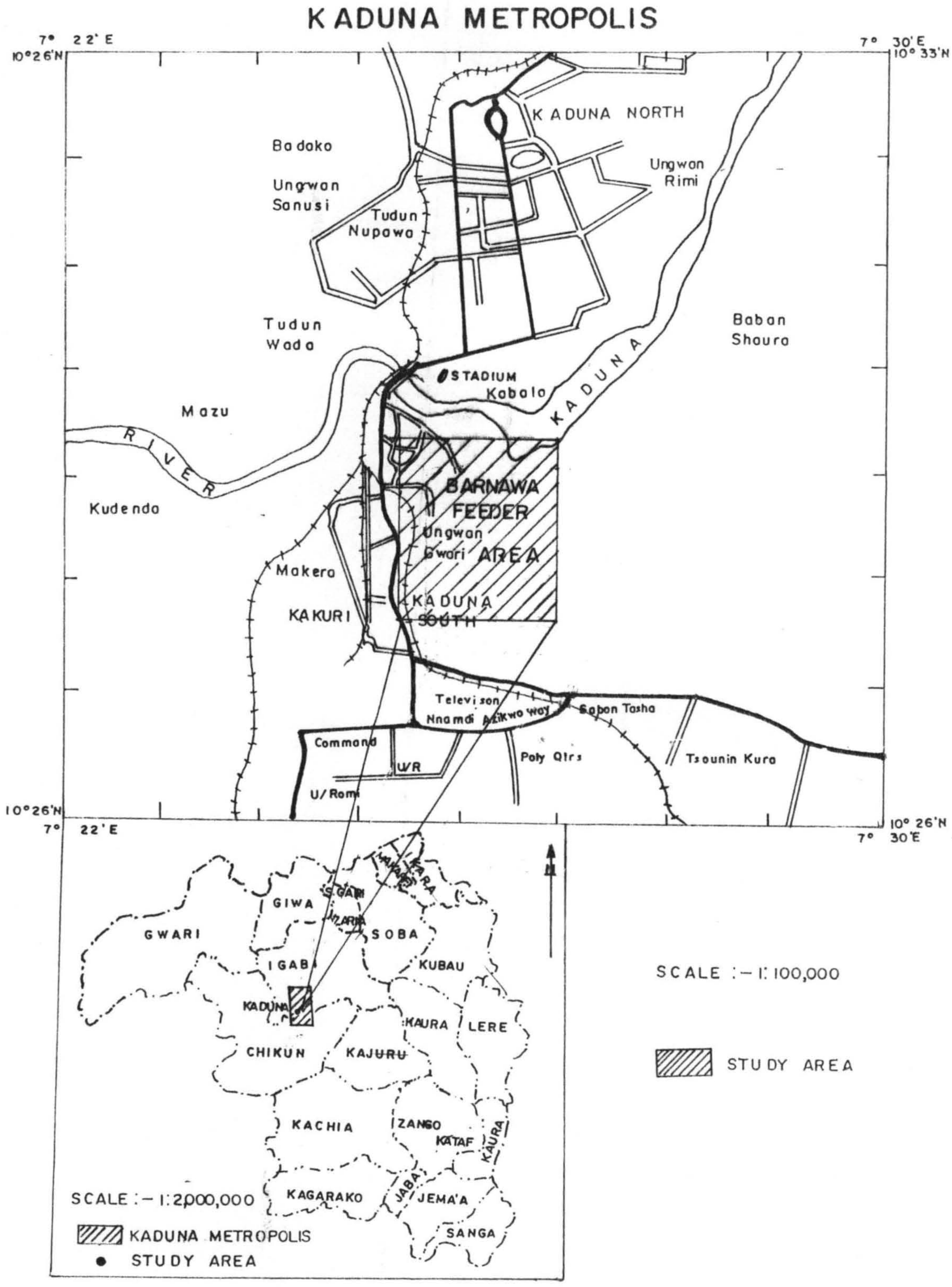

FIG. 1·2 MAP OF KADUNA METROPOLIS SHOWING THE STUDY AREA

1.6.3 Temperature

Barnawa, within Kaduna metropolis experiences a typical tropical continental climate with distinct seasonal regimes oscillating between cool to hot dry and humid to wet. This seasonality is pronounced with cool to hot dry season being longer than the rainy season.

1.6.4 Drainage Pattern

River Kaduna is the main river that cut across Kaduna metropolis. The river bounds the research area to the north. Apart from this river, there are streams in the area. These streams channel their water into river Kaduna. The rivers and streams are rich sources of sand, granite rock and clay that are usually exploited for constructions

.

1.6.5. Topography

The topography of Barnawa area can be described as flat terrain with some valleys housing rivers and streams scattered all over the area. The rocks can be found around Narayi area with altitude of about 560m. Aside from this rocky area, the remaining part has been tampered with by urban development.

1.6.6. Geology

The bedrock geology is predominantly metamorphic rocks of the Nigerian Basement Complex consisting of biotite gneisses and older granites. Deep chemical weathering and fluvial erosion, influenced by the bio – climatic nature of the environment, have developed the characteristic high undulating plains with subdued interfluves.

1.6.7. **Soil 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 richer in kaolinitic clay and organic matter, very heavy and poorly drained characteristics of vertisols.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

2.1 Power Holding Company of Nigeria [PHCN]

National Electric Power Authority [NEPA] now known as Power Holding Company of Nigeria [PHCN] was established through decree No. 24 of 1st April, 1972. NEPA was then formed as a result of the amalgamation of Niger Dam Authority and Electricity Corporation Nigeria to enhance better coordination and economic system of electricity supply for all parts of the federation.

Since its inception, NEPA, now PHCN has had eight major generating power stations located strategically nationwide. These generating power stations are of two types i.e Hydro and thermal. The Hydro power stations are located in Kainji, Jebba, and Shiroro (all in Niger state). While the thermal plants are located in Ogande-Delta State, Afam-River State, Ughelli-Delta State, Ijora and Egbin in Lagos State.

Beside these major generating power stations, there are power plants installed to improve the company's services. The power plants include the hydro electric power plant at the mambilla Plateau and the thermal power plants at Abuja, Kaduna and Zungeru.

All these power stations/plants are connected to the National control centre, Osogbo, Oyo State. This centre obtains power generated from the hydro and thermal power stations in the country and re-distributes same to the various zonal power stations across the country. The zonal power stations make use of transformers that step down current in order to be useable by customers.

The power stations have installed capacity of 6000mw. But the available electricity is put at about 3000mw. Power Holding Company of Nigeria has three main categories of customers, namely residential, commercial and industrial customers. The residential customers include domestic customers who use their premises and electricity therin strictly for residential purposes. Commercial customers are customers that use their premises for purposes other than residential or factory for manufacturing goods. While the industrial customers use theirs purely, for heavy industrial purposes. All these categories of customers have different types of meter for billing attached.

There are three types of meter for billing provided by PHCN for usage by their customers. These are:-

a. Single phase meter - for residential customers.

b. Three phase meter - for commercial and small scale industrialists.

c. Maximum demand meter - for big-time industrialist and commercialist with demand exceeding 45KVA.

The electric power sector reform bill, 2005 was signed into law on the 11th of March, 2005 in attempt to improve electric power supply in the country. This bill seeks to "provide for the formation of companies to take over the functions, assets, liabilities and staff of NEPA, develop competitive electricity markets, establish the Nigerian electricity regulatory commission, provide for the licensing and regulations of the generations, transmission, distribution and supply of electricity, enforce such matters as performance standards, common nights and obligation, provide for the determination of tariffs and provide for matters connected with a incidental to the fore going. This reform bill gave birth to the new Power Holding Company of Nigeria [PHCN].

2.2 CONCEPTS OF REMOTE SENSING AND GIS

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 radio waves as the means of detecting and measuring target characteristics. This explanation is in line with Okhimanhe's [1999] definition of remote sensing. She described 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 a means of sensors which detect and record electromagnetic energy".

Furthermore, Aronoff [1993] described remote sensing as the art and science of obtaining information from a distance about objects 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 analysis techniques to generate useful information. This is corroborated by Adeniran [1999] who succinctly described remote sensing as "the Science and Technology of recording and analysing the characteristics of earthly phenomena by airborne and space base platforms to assist in inventorisation, mapping and monitoring of earths resources. From both explanations, it can be deduced that Remote Sensing obtains information by "detecting and recording electromagnetic energy reflected/emitted by objects' [Aronoff, 1993].

However, "inventorying, mapping and monitoring of earth's resources [Adeniran, 1999] can be carried out through the integration of remotely sensed data into GIS, which provides the capabilities for mapping, management and analysis of spatial information. And this information obtained from remotely sensed data are not only effective when used with a GIS, but the GIS can also be used to improve the accuracy of remotely sensed data analysis [Aronoff, 1993].

Remote Sensing and GIS are both tools for managing spatially distributed information in large quantities and at various scales. They both provide a systemic and synthetic view of spatial information [Ehlers, 1989] as well as increase the capabilities of human decision makers and planners to grasp relationships at larger scale and in more complex settings than hitherto has been possible [Jones,1997].

In a nutshell, remote sensing and GIS show great promise for the "integration of a wide variety of spatial information as a support to tasks such as urban and regional planning, natural resource management, utilities planning etc"

[Aronoff, 1993]. This is also corroborated by Sobunde [1996] who said remote sensing is significantly upgraded with GIS technique. According to him, remote sensing data integrated with computer aided drawing [CAD] and GPS, and viewed through a GIS platform is finding rapidly increasing application globally. GIS is an organised collection of computer hardware, software, geographic data and personnel designed to effectively capture, store, update, manipulate, analyse and display all forms of geographically referenced data [ESRI, 1990]. Hence, a GIS permits spatial analyses of data and also capable of linking data from different sets. It accepts large volumes of spatial data derived from a variety of sources [Ehlers, 1989].

In a broader term, 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 one organises 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 has been able to give GIS its full composition thereby describing it as a technology that "has provided an exciting potential for geographic information to be used more systematically and by a greater diversity of disciplines than ever before" [Aronoff, 1993]. And this technology 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 time and space [Jones 1997].

One major part of a GIS is the ability to overlay various layers of spatially referenced data. [Ehlers 1989]. This allows the user to determine graphically and analytically how structures and objects interact with each other. GIS can be seen as a computerized system that facilitate the phases of data entry, data analysis and data representation especially in cases when we are dealing with geo-referenced data [Odedare, 1999].

Major application areas of GIS, according to ERDAS,[1997] include site selection, natural resource management, petroleum exploration, mission planning, change detection, urban planning, task assessment and planing, traffic engineering and facilities management. Facilities management include that of electric supply. However, the crux of the matter is that GIS uses database to carryout its analysis. Spatial database is a unique characteristic of GIS, which along with other features make GIS different from other information systems [Ayeni, 2001].

2.3 DATABASE DEVELOPMENT

The database is at the centre of the GIS. It can be seen providing the fuel for the GIS. The tasks of finding, creating, assembling and integrating geo-referenced data may collectively be termed as database development. Fabiyi [2001] described database as a logical collection of inter-related information, managed and stored as a unit. He further said that a GIS database involves data about the spatial location and shape of geographic features recorded as points, lines, areas, pixels, grid cells or TINS as well as their attributes.

Spatial data are earth-related data about the features on the earth surface. They are represented with point, line and polygon. They can also be divided into two types based on procedure of capturing them which are vector and raster data. The attribute data is the characteristics of a geographic feature described by numbers or characters, typically stored in tabular format and linked to the feature.

Furthermore, database services and computer network make available a great variety of information services. A database system is essentially computerized record keeping system that "stores representation of spatial phenomena in the real world to be used in a GIS" [Judd, 2005]. The system allows:-

a. Adding files to database

b. Inserting new data into existing files.

c. Retrieving data

d. Updating data

e. Selection of data from existing ones.

f. Removing/deleting existing files from database.

g. data integration and processing.

2.4 UTILITY DATABASE

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]. The application areas include natural resource management, petroleum explorations, change detection, urban and regional planning, utilities planning and management. [ERDAS, 1997].

Utility can be described as infrastructure that provides common "good" to individuals or organization or both. This common "good" is very often a basic need for people or the economy and therefore companies providing the product are often under public control e.g government [Adeniran, 1999]. The common "good" is not a product that can be bought or acquired in separate units at a shop. Water and electricity are delivered directly to the customer using a transportation network.

Utility information systems [UIS] are a subset of urban land information, planning and maintenance of services such as supply of water and electricity. UIS can be regarded as a special type of GIS which is very important for the sustainable development of urban areas.

Spatial database is always referred to as the heart of GIS. And with a proper database structure, attributes of components of a particular utility can be retrieved form the database, and also a query can be made on the database to select certain parts of the utility networks. [Kufoniyi, 1999].

Den Haan [1990] described the importance of utility information systems in Netherlands. He said the length of all networks in Netherlands is about 1,040,000 km, valued at about 30 milliard guilders and the cost of replacement is estimated at 125 to 150 milliard guilders. According to him, because of the high economic values, it is very important to manage and maintain these vital networks. And to do this, more and more information is needed quicker and in more detail as planning and control of urban facilities become more complicated and increases in demand. He further said, detail registration of facilities is needed for:-

a. Utility system management [maintenance and distribution].

b. Planning of utility networks.

c. Management of subsoil for safety and maintenance of roads.

d. Coordination/monitoring of activities [permits].

Furthermore, Ayeni [2001] in his own submission stressed the economic importance of spatial database. He said that the Earth summit of 1992 held in Brazil greatly increased the global awareness of the inter-relationship between earth resources, environment and development. He further submitted that GIS databases provide the information [data] which are crucial to economic development such as spatial database for population, agriculture, tourism, mineral resources, utilities and for various levels of administrative units.

Route mapping is playing an increasingly important role in creating a database for railway asset management. Judd [2005] described the use of railway asset management database for the State of Victoria, USA. He said it serves as train simulators. It predicts the behaviour of the train. It also serves as layout for vehicle navigation system. The author also said the first task in the route mapping was to establish the location and orientation of the mapping platform as it moves along the track. With this determined, track-side features can be located from stereo-images acquired via modern digital progressive scan cameras. He further said that gyroscopes and traveled distance meters were integrated with the GPS to ensure that the location is continuous.

The telecommunication industry is currently witnessing fundamental changes. These changes are as a result of the term “telecoms” being broadened to include the “information management infrastructure to back up operational and decision support systems” [Jolley, 1995]. The information here is being managed by GIS to determine “what” data is added to “where and “when”. It is therefore clear that the information used in the operation and decision support of the telecoms network and consumer base is naturally supported by GIS technology and this will eventually extend its root to every function within the organization [Judd, 1995]. To corroborate Judd [1995], Ansary [1995] in his paper titled “GIS; A major aid to telecoms planning”, cited two UK based telecommunication companies [10NICA and Philip telecoms] as having used GIS technology as an essential tool for designing their network in order to be able to meet the needs of the competitive market while keeping the costly exercise of mounting extensive field operations to a minimum. He said the companies made use of GIS radio planning tools which enable field exercise to be limited to the task of collecting sample results thereby obtaining an intuitive and interactive graphic user interface which enabled those operators to concentrate on the planning task rather than background technology. The author further highlighted the geographic data required as including DTM, vector representation of buildings/urban area, woodland and water areas, and demographic traffic data. He however, concluded his write-up by saying "given the diverse engineering requirements; the architecture of the GIS tool must readily lend itself to customization".

The Head of telecommunications services at CCN Group in UK, Fuller [1995] wrote that cables operators are avid users of GIS for network-build planning. He said, in the Leeds Cable Franchise for instance, there are approximately 290,000 premises, and so the engineering implications for road digging and cable laying are significant. Build planning is not only a question of topography and property density, it also requires permission from the relevant authorities. Based on this, he then hinted that GIS can help cable companies to communicate with this relevant authority by providing the means to share geographic data.

Besides engineering implications, Fuller [1995] said the effectiveness of sales and marketing efforts within a geographically defined territory such as cable Franchise depends on knowledge of potential customers in an area. And for this, he said, a database has to be provided to include census, electoral roll, credit, UK post office and neighborhood descriptions of individual post codes. This database will assist "sales force to target those households most likely to want to buy cable services", he asserted.

In line with the above assertion, Baumann [1995] stated: "European telecommunication companies are eagerly embracing GIS technology as they discover that it can be used as an enterprise-wide, cross-disciplinary tool for tasks as diverse as demand forecasting and system design". He said GIS is the technology that is being used to prepare them of the information age. The author cited different GIS projects the EU has sponsored to facilitate implementation. The projects are.

a. The Mediterranean Opportunities for Rural Areas [MEDORA] project where GIS is used to assess the telemetric requirements of rural areas in Europe. Its data sources include national databases, NUTSIII boundaries from Eurostat [Europe's Statistical Agency] and CORINE data which provides locations of ports and airports.

b. Geophore is another GIS project sponsored by EU. The project developed a system which automatically displays the direct route to a caller's location. The system uses ARC/INFO GIS to display the relevant map and determines the optimum route between caller and service.

c. TELZIS is the name given to the third GIS project for the Republic of Croatia's Post, Telegram and Telephone [PTT] organizations. The author said, by using a combination of GIS products that are seamlessly integrated with the ARC/INFO core, TELZIS unifies the various standards developed in the different PTT offices in Croatia. Baumann [1995] concluded that GIS technology is sure to play a major role in the growth of the telecommunications industry as the use of telecom-related applications expands and competition among the more traditional telecom companies increases.

British Telecommunications [BT] is one of the oldest and largest telecom companies in the world. Mitchell [1995] said BT's effort to stay ahead in the market has driven the privatised enterprise to implement a significantly different approach to GIS. He further said that BT was creating the largest spatial data management system in the telecom industry. According to him, BT inherited a legacy of plant networks spread throughout the British Isles and further a field, and it "has to know exactly what is out there", so as to enable the company to anticipate or respond faster to new business opportunities, and to maintain and develop the network more efficiently. The author listed the data requirements to include the capture of network attributes, the entities that defines the network and entering just one occurrence of any attribute which describes a particular part of the network. He further said that, all these data world be held in one cooperate or native database from which network topology would be generated. Mitchell [1995] concluded that "the database would have to be powerful enough to cope with the magnitude of data to be handled by the system.

Furthermore, the mobile telephone system is an emerging industry in Nigeria. Olaofe and Nosa [2001] opined that "GIS has been identified as an integral tool for spearheading its development within the country". They supported their opinion with a research on Mobile Telephone System [MTS], where they discovered that GIS can be used to arrive at even and adequate spacing between cell sites. It can also be used to determine the best cell sites as well as the provision of services along well travelled corridor. For their research, they acquired an accurate model of the terrain/elevation and the classified coverage of landuse to determine the varying signal attenuation levels in urban areas, parks, forest and grasslands. Olaofe and Nosa [2001] further said that competition for the mobile telephone services is getting stronger and the company that can provide the best services has a significant advantage. The optimal location of the cell site is critical.

GIS is a tool that is quickly becoming a valuable management asset to many water utilities. Simply used as a spatial database, GIS can greatly assist in various modeling application through the development of automated tools for constructing and maintaining reliable hydraulic network models of water distribution systems. Ennis (2006) in his paper titled "Improved Water Distribution System Modeling and Management Using Map Object" chronicled a comprehensive Decision Support System (H2OMAP) for use in the effective management of water distribution systems. He said "The software systems link on advanced hydraulic network simulator with GIS technology for spatial database management, graphical display and analysis of result" Ennis (2006) further said that the graphical interface is developed using Map Objects technology and it provided an information structured framework for network model construction analysis and result presentation. In conclusion, he said the resulting software offered a virtual environment to assist decision makers in formulating, evaluating and screening competing management strategies

Chang et al [1992] also described a project on water supply and distribution system in their paper titled "GIS Application Development for Utility Infrastructure Systems". The project covered a service area of over 2400km^2 with population of about 6 million. They said the entire area was covered by 260 maps provided by several government agencies. They further said that the initial work was divided into several major tasks and they include the digitisation of maps into computer aided design and drafting [CADD] system, provision of an up-to- date database in the computer model so that the model would realistically represent the existing water distribution system, and the development of computer programs o link various forms of information together to a common coordinate system. The author also listed the types of data acquired as input to the project to include maps covering the service area, piping layout, right of way and property ownership, pipelines and utilities crossings, hydraulic network model nodal points, piping attributes and names of water users with water use records. The essence of this project was to develop a GIS application programme for water distribution analysis. And for this, they concluded that a major effort in developing a meaningful GIS application package is the establishment of a proper database.

Since electricity is distributed over space, and it's a utility that performs common "good" to individuals and organizations, an intelligent GIS database can be used to monitor, manage and make decisions on its activities. Den Haan [1990] said "for maintenance and repairs, it is important to have data on the location of cables and conduits, the type of material they are made of and of course the relative danger involved e.g. in the case of high voltage electricity". These information are also needed by the owner/administrators of roads or land under which the networks are lying. To come up with these information, Den Haan [1990] listed the data of conduits, switches and valves, production and consumption. And he said these data are necessary to determine the capacity of the network or to analyse changes in tension when the network is extended.

Den Haan [1990] further hinted that another category of data needed is that on the customer which includes name, address, consumption and payment. He said analysis of this data is also useful to predict consumption so that the system can be expanded or redesigned to meet future needs.

Electrical distribution planning engineers use methods that address the spatial nature of a distribution system to achieve an orderly and economic plan for expansion of the system and to continually assess the effect of a change on the plan. Cook [1995] in his article addressed a single application, electric distribution system planning implemented across multiple AM/FM/GIS and analysis software system. He identified and analysed the application requirements, portability, integratability and functionality of combinations of AM/FM/GIS and analysis software systems. He further opined that "by tightly integrating systems, using remote sensing database access and object oriented programming techniques for improved portability of functions, an optimal design can be developed. By implementing GIS technology, Budapest electricity network has been able to cut cost while improving service. Alverson [1995] in his paper said "four years into the development of a network GIS, operations at the Budapest Electricity Supply Company Limited, which serves some 2 million customers in and around Budapest are showing both improved efficiency and savings". He further said that to achieve the company's main goal of cutting costs, they had to have a map base on which to build a truly integrated information system.

In the article "Using GIS in electricity management" El Hassan (2006) described how Electricity of Lebanon (EDL) found GIS invaluable for evaluating system reliability and capacity, tracking down power loss and managing revenue collection in a country that had suffered from the effects of 17 years of war. He further said that EDL designed Geographic Information Systems Electricity of Lebanon (GISEL) and this made it possible for the utility to direct rebuilding of damaged or destroyed delivery infrastructure, test the reconstructed network and identify losses due to pirated electricity and defective metering equipment.

Also on EDL, Pertot (2006) said there is a growing demand to back EDL in its struggle to crack down on illegal network connections, collect its outstanding bills and fight maladministration. He further said that to achieve a quantum leap for this worn out sector, a GISEL Distribution Operation Support (GISEL - DOS) project has been inaugurated. According to him, this project has resulted in improving EDL's image as an organisation pioneering in information technology and provided on added value for its asset management. Pertot (2006) concluded by asserting that GIS system has become a paramount means for EDL to provide a better customer services and boost revenues.

In Nigeria, it has often been rightly said that NEPA, now PHCN may have run out of concrete ideas in solving the perennial epileptic power supply in the country, especially with the fact that the country generates more power than it requires meeting the demand of its customers. It is instructive to note that the eight power stations, when working at full capacity produces about twice the electricity requirement of the nation and that of its customers, nay Niger, Benin Republic and Chad etc.

With the excess in power generation, one begins to wonder where the problem bedecking the nation's main source of electricity lies and why Nigeria and its economy will continue to suffer in the midst of plenty. Many have argued that the nation would have developed technologically than this, but for erratic power supply. However, erratic power supply has been attributed to overloading and poor maintenance culture. Many are also traceable to poor voltage distribution network, inadequate protection of the transformers and most importantly poor quality of cable used by the company. Of interest to this researcher is the inadequate protection of transformers.

Remote sensing and geographic information systems can help decision makers to minimize the problems associated with on-the-ground technique for collecting data and manual technique for synthesizing information. Igbokwe and Enengini (2006) in their paper titled "GIS in management of Electricity Distribution Network: A case study of Onitsha North LGA Anambra State, Nigeria". In the paper, they presented the use of Geographic information system in management of Electricity Distribution facilities by developing an automated system for PHCN in Onitsha North LGA. To do this, they collected administrative / street and electricity distribution network maps from relevant agencies from which electricity distribution faculties spatial database was designed and created using relational database model approach. The writers further described their tasks to involve converting paper maps to digital format through scanning, sending raster images to Auto CAD Map R2 environment for geo-referencing and on - screen vectorisation, editing the drawing and exporting then to Arcview 3.2a environment and linking the graphics with the created spatial database. They also tested the developed system by carrying out a number of GIS operations and analyses, and the results obtained were displayed in graphics and tables. In their conclusion, the writers said "It was ascertained from the results that GIS is a competent and effective fool for managing electricity distribution network".

From the foregoing, public agencies and private industries have been using GIS for automated mapping, facility operation and management and future planning. The popularity of GIS utilization is growing at a rapid pace because it is an effective and versatile tool when supported by proper implementation programme. A good database is accessible for easy editing, permitting changes to be made and analyses yielding sound decisions.

CHAPTER THREE

METHODOLOGY

3.1 PREAMBLE

3.1.1 INFORMATION LAYERS

GIS is probably best known for its ability to build map layers and evaluate the relationship between them. These relationships can be assessed from both mathematical [logical] and graphic [visual] perspectives. The data for this research study are stored in layers to include:-

a. Rivers

b. Roads

c. Transformer locations

d. Transformers area of coverages

e. Important features [Hotels, Shopping Complex, Hospitals and PHCN Office)

f. Barnawa feeder area [Administrative Boundary]

3.1.2 SYSTEM SELECTION

The hardware and software listed below were used for data processing, manipulation/analysis and presentation of information.

Hardware

a. Scanner

b. Computer hardware memory on widows 4528 Ram, 32MB HDD 4.2GB

c. 14 inch colour monitor

Software

a. Arc-view GIS

b. AutoCAD 2000

C ERDAS Imagine

3.2 DATA SOURCES

SPOT Satellite Imagery, Existing maps, GPS, PHCN, and Field observations

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

3.2.2 Existing maps

a. The topographic map of part of Kaduna at scale 1:12,500.

b. The street guide of Kaduna metropolis at scale 1:25,000

c. Cadastral maps of CES, Mamman Kantagora Estate, Living Faith Church at scale 1:1000.

3.2.3 Power Holding Company of Nigeria [PHCN]

This is the company vested with the responsibility of generating, transmitting and distributing electricity in Nigeria. They were consulted to obtain the details of the transformers that are spatially distributed in Barnawa feeder area. The details include the number of transformers, their areas of coverage, capacities, makes, years of installation and etc.

3.2.4 Field Observation and Measurement

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 information that plays 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 were obtained through ground truthing and GPS readings.

The existences of the various transformers were ascertained as well as their areas of coverages. For areas of coverage, the names of the roads were cross checked with those on the existing maps. Where there is conflict, it as resolved and where a road has no name, it was given an identification mark.

Global Positioning System (GPS) was used to obtain the positional data of each of the transformers. It was also used to obtain the planimetric measurement of some new roads that were not shown on the maps obtained.

3.3 DATA ACQUISITION/CAPTURE

3.3.1 Image Interpretation

A.INTERPRETATION KEY

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

TABLE 3.1 INTERPRETATION KEYS FOR SPOT XS BAND.

S/NO	FEATURES	TONE/COLOUR	TEXTURE	SIZE	SHAPE	PATTERN	ASSOCIATION
1.	Railway	Dark grey	Medium	Fixed	Long Straight	Linear	Cultivated or Uncultivated
2.	Roads	Dark grey	Fine	Variable or Uniform	Straight with sharp bends	Linear	Buildings and Barren lands
4.	Rivers and streams	Dark grey	Fine	Variable	Variable	Linear	Cultivated and Settlement
5.	Residential	Bright White to dull blue with patches	Medium	Variable	Variable	Regular	A group of houses

B. ON- SCREEN VISUAL INTERPRETATION

Based on the interpretation keys develo above, the on-screen visual interpretation was performed to obtain three la ERDAS IMAGINE. The three layers were obtained separately through t mbined operations of data acquisition [interpretation] and data capture [d n].

In on-screen digitizing, vector data in the "Viewer" with a mouse using the displayed image as a referen ata are then written to a vector layer. The layers created from thi e for communication network, water features and important features such as shopping complexes, markets, hotel, schools, mosques and churches.

3.3.2 Editing

Having completed data capture in ERDAS IMAGINE system, the various digitizing errors were identified and corrected in ArcView system software. Since ERDAS IMAGINE and ArcView are compatible softwares, all the coverage created in ERDAS IMAGINE were opened in ArcView without re-writing 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, they were accordingly corrected

3.3.3 Existing maps

a. Scanning Process

The instrument for this exercise is called scanner and it was used to capture the relevant portions of the various existing maps. The result of the scanned map was a raster image and it was saved in a JPEG format.

b. On-screen digitizing

After scanning the source maps, the on-screen digitizing technique was applied to convert the raster image to vector using AutoCAD 2000. To do this layer were first created to reflect all the map elements. The created layers were those of roads, rivers, transformers locations, transformers area of coverages, important features and the boundary of Barnawa feeder area. Each of these layers was eventually populated with their various map data using the scanned image as a guide.

Three created layers, (road, river and important features) were then overlaid on the three layers created from the satellite imagery respectively.

3.3.4 GPS Readings and Field Results Entry

The GPS readings obtained for the locations of the transformers were plotted out using the same reference system with the digitized maps to check their locations. The location data formed a layer. Also the new roads were plotted onto the digitized maps thereby joining the details on such layer. The field observation mainly yielded areas of coverage's for each transformer. This was translated into a layer of the spatial database

.

3.4 DATABASE DESIGN

After necessary data acquisition/capture for this study, the design and creation of the database which forms a powerful tool for GIS application, must be handled carefully. The design of the database was carried out in phase. The sequence was as systematic as described by Kufoniyi, [1999]. It involved the following ordered steps:-

a. Articulation of reality of the application

b. Translation of reality to a conceptual model.

c. Translation of such model to a logical design.

d. The physical design.

3.4.1 View of Reality

This is the mental abstraction of the reality of a particular application or group of applications. In this study, the PHCN transformers were focused upon as the reality in the application. Therefore, the data pertaining to those transformers were extracted within the study area. The data include the:-

a. Locations of transformers

b. Number of transformers.

c. The installed capacity.

d. The age

e. The area of coverage

f. Roads within are of coverage

g. Average utilization / consumption.

3.4.2 Conceptual Design

This phase was achieved through the representation of the concept of reality. The reality in this study was viewed according to the needs, the phenomena of interest identified, relevant characteristics described and the relationship of the objects to each other in space mapped. To represent this view of reality, the vector data modeling approach as the representation schema was adopted. This was because all the spatial objects of interest have distinct boundaries of which precise location and extent can be determined in vector model. The attributes of the various layers as conceptualized, are as follow:

a. Node d – X-Coord, Y-Coord and Node-id

b. Landuse – X-Coord, Y-Coord, P-name, P-use and P-id

c. Roads – R-name, R-length, R-class B-node, E-node and R-id

d. Rivers -- Riv-name, Riv-id, B-node, E-node and Riv-length.

e. Transloc – X-Coord, Y-Coord, Age, Capacity and T-id

f. Transcov – Perimeter, Area, Roads and TC-id.

3.4.3 Logical Design

Here, the conceptual data model was designed to reflect the recording of the data in a computer system. There are several methods of data structure, from which the relational data structure was chosen for this study. The relational data structure involved forming tables that contain items of data called field. The objects, here formed the rows while the attributes formed the column.

Node - Node-ID, X- Coord, Y- Coord

Roads- R-ID, R-Name, R-Length, B-Node, E-Node class

Rivers- Riv-ID, Riv-Name, Riv- Length, E-Node, B-Node

Landuse- L-ID, L-Use- L-Name, landuse area

Transloc- T-ID, X- coord, Y-coord, Capacity.

Transcov- T-ID, area of coverage, perimeter of coverage, age, roads

Important F - P-ID, X-coord, Y-coord, P-Name, P-Use,

Table 3.2 Node entity and its attributes

Attribute name	**Description**
Node – ID	Node identifier
X – coord	Easting
Y – coord	Northing

Table 3:3 Roads and their attributes

Attribute name	**Description**
R – ID	Road identifier
Class	Type of road
R – name	Name of road
R- length	Length of roads
B – node	Beginning of a road
E – node	End of a road

Table 3.4 Rivers and their attributes

Attribute name	Description
Riv-ID	River identifier
Riv- Name	Name of river
Length	Length of river
E-node	End of river
B-node	Beginning of river

Table 3.5 important features and their attributes

Attribute name	Description
P – ID	Feature identifier
P-name	Name of feature
P-use	Function/use

Table 3.6 Landuse and their attributes

Attribute name	Description
L-ID	Landuse identifier
L-name	Name of landuse
L-Area	Area of landuse
L-use	Landuse

Table 3.7 Transloc and their attributes

Attribute name	Description
T-ID	Transformers identifier
X- Coord	Easting
Y – Coord	Northing
Capacity	Capacity

Table 3.8 Transcov and their attributes

Attribute name	Description
T-ID	Transformers identifier
Area of coverage	Area of coverage
Age	Date of installation
Perimeter of coverage	Perimeter of coverage
Roads serviced	Roads serviced

3.4.4 Physical design

This is concerned with the representation of the data structure in the format of the implementation software. For this study ArcView GIS database software was chosen. And the tables below show the attributes and their data types as they were being used in the software.

Table 3.9 Node . DBF

Attribute name	**Data type**
Node – ID	Number [410]
EA	Number [12,3]
AN	Number [123]

Table 3.10: Road. DBF

Attribute name	**Data type**
R- ID	Number [4,0]
R-class	Char. [10,0]
R- name	Char. [20,0]
Length	Number [5,3]
Bnode	Number [4,0]
E node	Number [4,0]

Table 3.11 Rivers DBF

Attribute name	**Data type**
Riv – ID	Number [2,0]
Riv-Name	Char [20,0]
Riv- Length	Number [3,2]
B node	Number [4,0]
E node	Number [4,0]

Table 3.12 landuse DBF

Attribute name	Data type
L- ID	Number [2,0]
L –Use	Char [10,0]
Name	Char [20,0]
Area	Number [7, 3]

Table 3.13 Important features. DBF

Attribute name	Data type
P – ID	Number [2,0]
P – name	Char [20,0]
P – Use	Char [20,0]

Table 3.14 Transloc. DBF

Attribute name	Data type
T – ID	Number [3,0]
X-coord	Number [12,3]
Y – coord	Number [12,3]
Capacity	Char [6,0]

Table 3.15 Transcov. DBF

Attribute name	Data type
T-ID	Number [3,0]
Area of coverage	Number [6,3]
Perimeter "	Number [4,3]
Roads serviced	Char [20,0]
Age	Number [8,0]

3.5 DATABASE CREATION

This is the storage of graphics and attributes data in the database. This will enable spatial analyses, queries and other GIS operations. Along with the analogue maps converted to digital maps earlier, attributes tables were also created to develop a database for the study.

3.5.1 Creating Attribute Tables

This involves creating attribute tables for the features in the various layers earlier created. For each layer, the tables were created by selecting "create table" from the "file menu" along with the name of the layer. This displays the attribute tables that were created automatically by the computer. In which case the computer-yielded attribute tables from the graphics and so their domains are the same.

Thereafter, columns were added to the table with each column having a domain of appropriate data types. Since it is possible to copy statistical data from the system's generated table, data such as areas, perimeter, coordinates were copied and pasted in the relevant table created. This made populating the table faster. Beside the data from the systems generated table, the created table were populated with the attribute data earlier gathered from the social survey and printed materials. The tables were linked to the graphics using the primary keys as the field keys.

3.6 INFORMATION PRESENTATION

3.6.1 INFORMATION LAYERS

With the design and creation of database for use by PHCN to monitor and manage their step-down transformers, GIS technology permits the display of graphics according to themes. The themes for this study are in layers which were generated at the capture stage. These layers are those of rivers, roads, transformer location, transformers areas of coverages and important features.

3.6.1.1 RIVERS

Two classes of rivers were digitized. These are broad rivers and streams. Area symbol was used to represent the broad river while the streams are in single lines. They are given in blue colour (see fig .3.8)

3.6.1.2 ROADS/RAILWAY

Double line symbol was used for roads while single, dissected line symbol was used to represent railway lines. The two of them are in black colour since they are man-made features. [Fig. 3.9]

3.6.1.3 TRANSFORMERS LOCATION

This layer uses point symbol to represent each locations of transformer in the Barnawa PHCN feeder area. Along with the points, the capacities are indicated. [Fig. 3.10]

3.6.1.4 TRANSFORMER AREAS OF COVERAGES

Based on the data obtained from the PHCN, the area of coverage for each transformer was carefully delineated. Dashes with dots in between were used to represent these boundaries. For Barnawa feeder area boundary itself, dashes with plus in between was used. [Fig. 3.11]

3.6.1.5 LANDUSE

Important features such as commercial centers, schools and hospitals were selected to form a layer. Area/ symbols were used for those with appreciable area extent while point symbols were used for others. [Fig. 3.12]

Fig 3.8 Vector Layer showing rivers

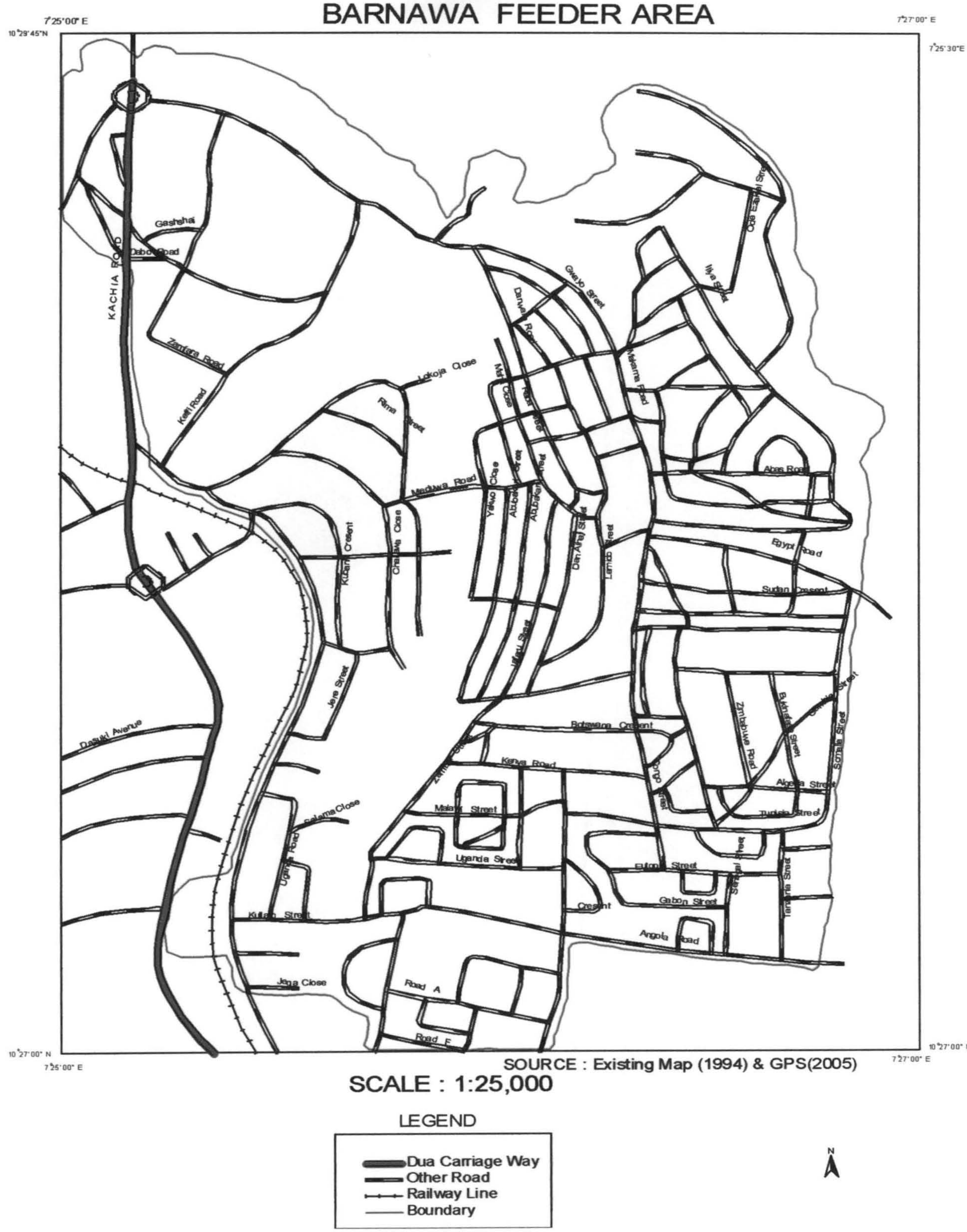

Fig 3.9 Vector Layer showing road network

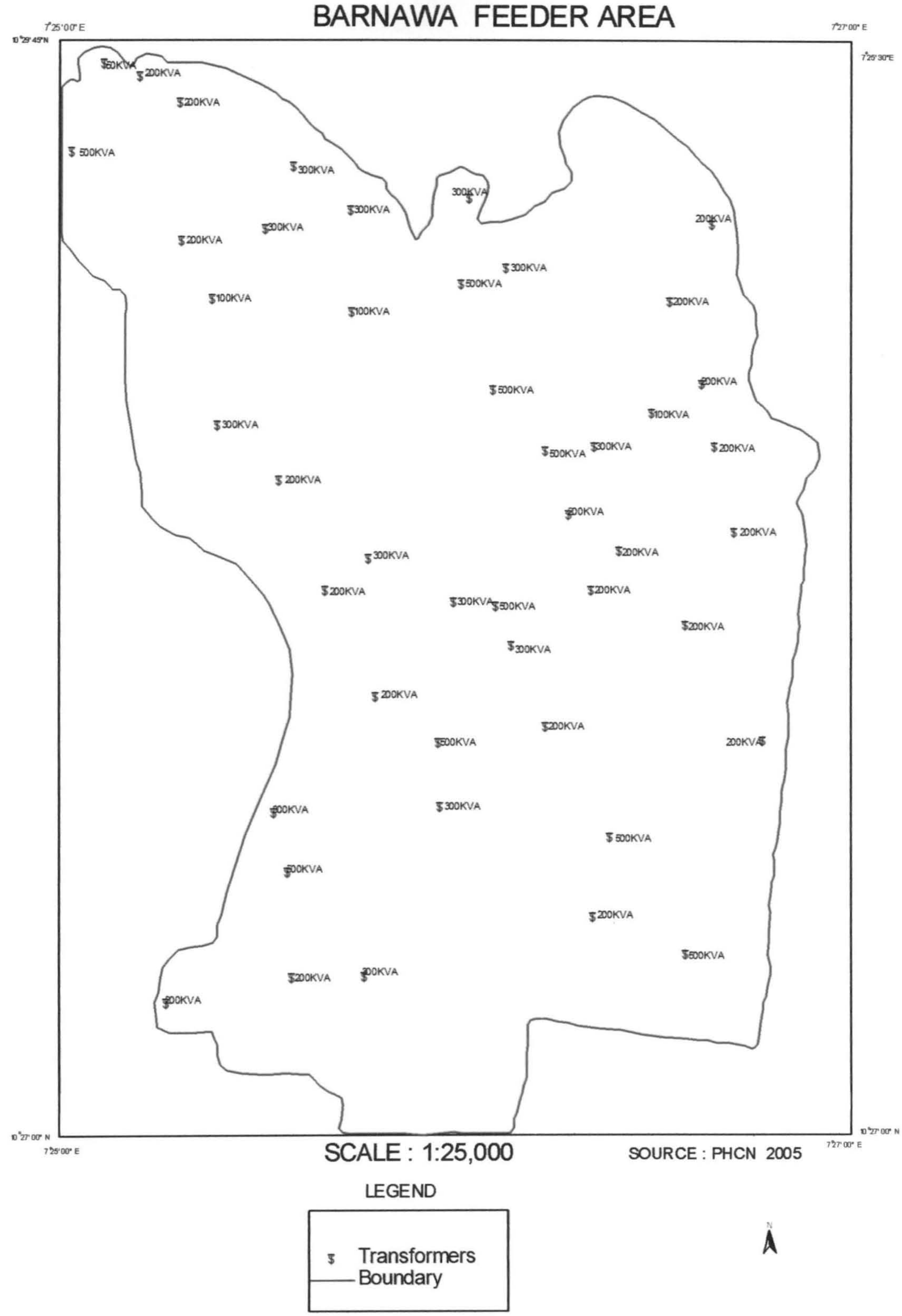

Fig 3.10 Vector Layer showing location of Transformer

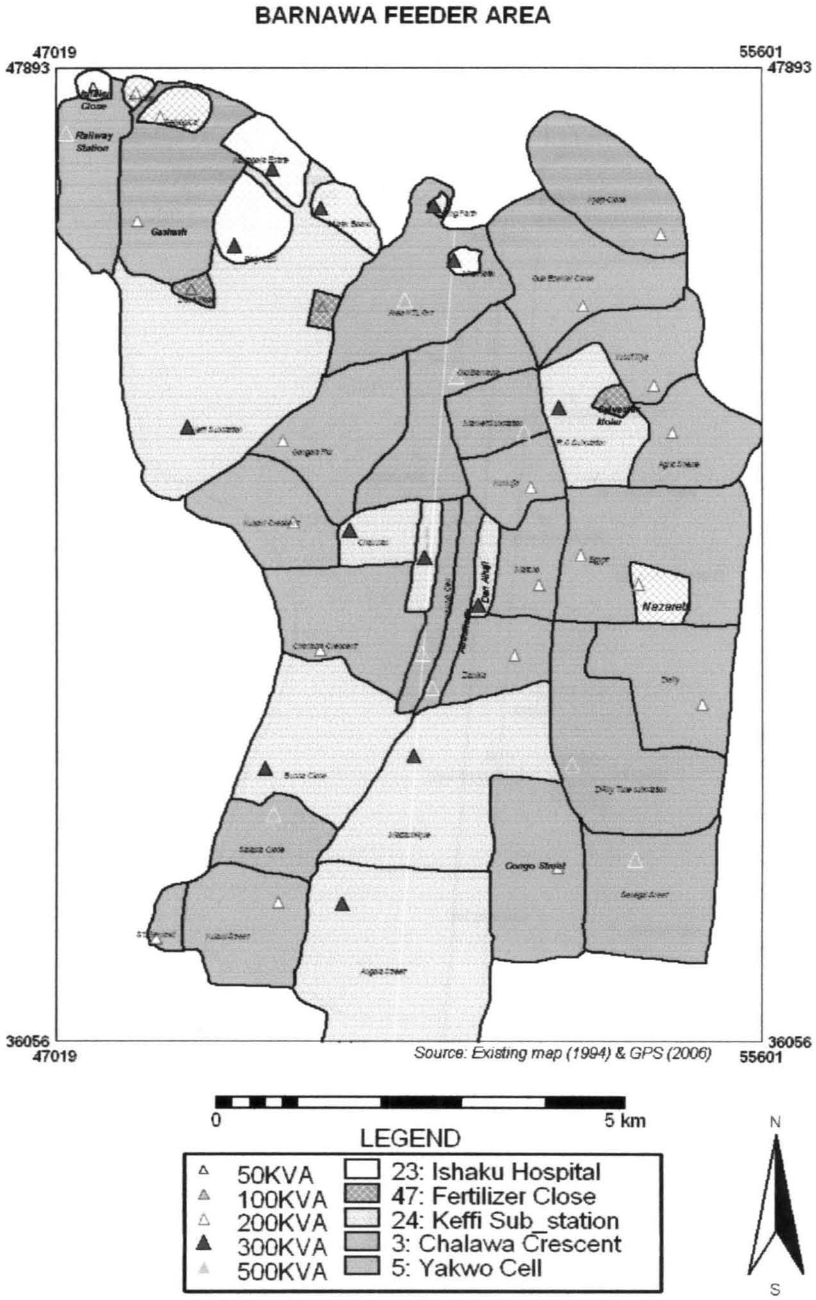

Fig 3.11Vector Layer showing transformers area of coverage

3.6.2 MAP COMPOSITE

In ArcView , 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. To compose the thematic map, a layout was created to combine all ArcView project components such as views, legends, scale bars, north arrow and other graphics to form a single output document. All these project components were annotated to give comprehensive meaning to all the elements. At the end, a thematic map of Barnawa PHCN feeder area showing all the transformers therein was composed and this is shown in fig. 3.13

Fig 3.13Vector Layer showing composite map

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 SPATIAL ANALYSIS

For this study, analyses were carried out using the spatial quarry, overlay operations and network analysis.

4.1.1 SPATIAL QUERY

This study was subjected to a number of spatial queries to answer questions on "what" and "where" through query by location or by attributes.

a. Query by location:-

Arcview GIS software allows the retrieval of information by selective search and a display is made on the seven. Thus, the generic question "what is where" can by answered by querying the database. For instance, the attributes of a transformer was queried by mouse pointing to the particular transformer and double clicking the mouse to display all the attributes of the transformer such as its capacity, area of coverage, date of installation etc. (See Fig. 4.1)

b. Query by attributes

This query poses questions to the attributes of the spatial data in the database tables to determine "where is what?" In this wise, the database was queried to know the location of Salama Street from the road attribute table. (See fig. 4.2).

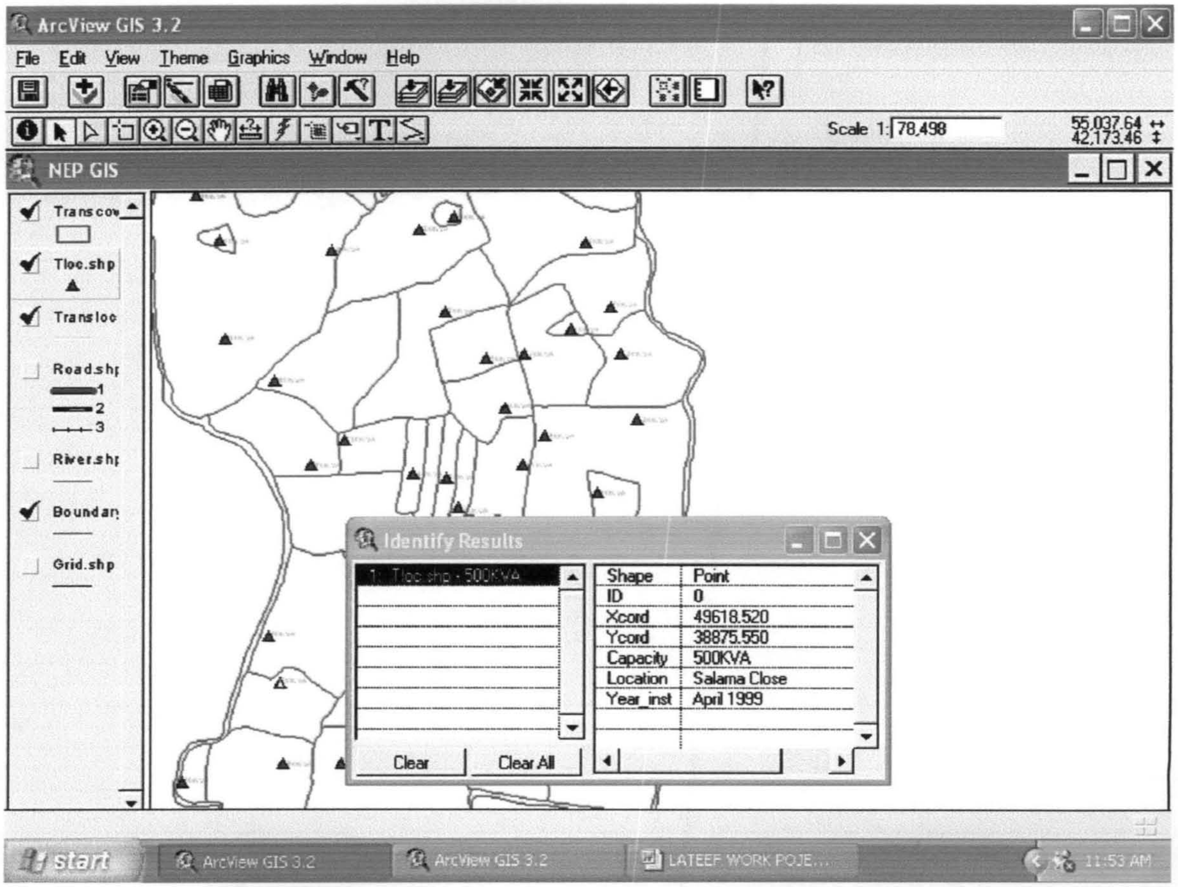

Fig. 4.1 Spatial query showing the attributes of a transformer

4.1.2 OVERLAY OPERATIONS

It should be noted that the spatial queries performed above are on single layers. Another set of analyses performed in this study involved the combination of several layers. These types of analyses are referred to as overlay operations. In these operations, new maps were created on the basis of multiple layers.

The overlay operations performed in this study involved the overlaying of "transloc layer" on the "road layer" to determine the locations of the various transformers in relation to the roads. This operation yielded a new map [fig. 4. 3].

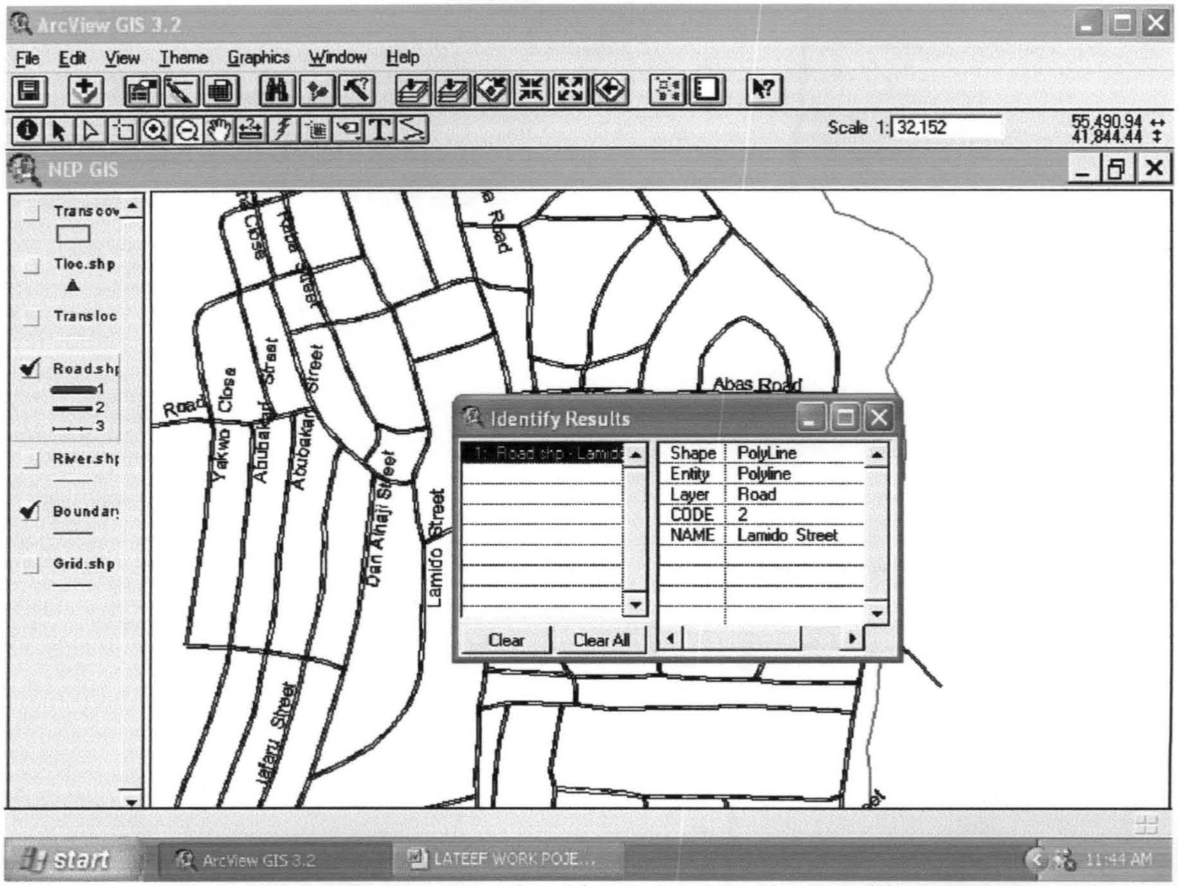

Fig. 4.2 Spatial query showing highlighted road – Lamido Street

Furthermore, the "transcov layer" was overlaid on the new map created above. In this case, a new map was also created to determine the areas of coverages of the various transformers as well as the roads within these areas of coverages. (See fig. 4.4)

Fig. 4. 3 Result of Map Overlay (Roads and Transformer Locations)

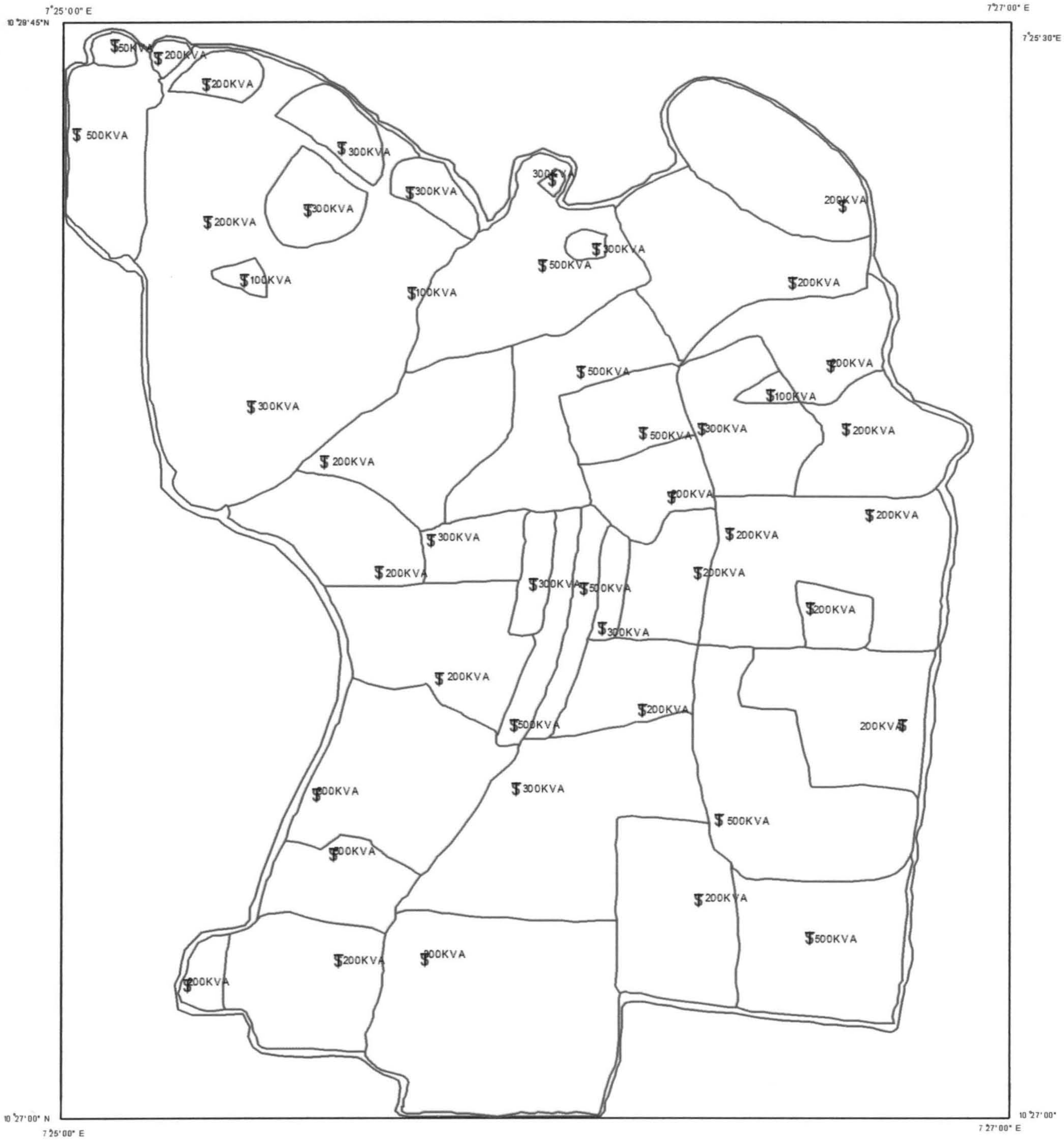

Fig 4.4 Result of Map Overlay (Transformer Locations and Areas of Coverage)

4.1.3 NETWORK ANALYSIS

There are different types of network analysis operations, of importance to this study is the network partitioning, which assigns network elements to different locations based on pre-defined criteria.

The trace function in the network analysis was applied to determine which roads are being served by a particular transformer. (See fig. 4.5) or which transformer supplies electricity to people on a particular road (Fig. 4.6).

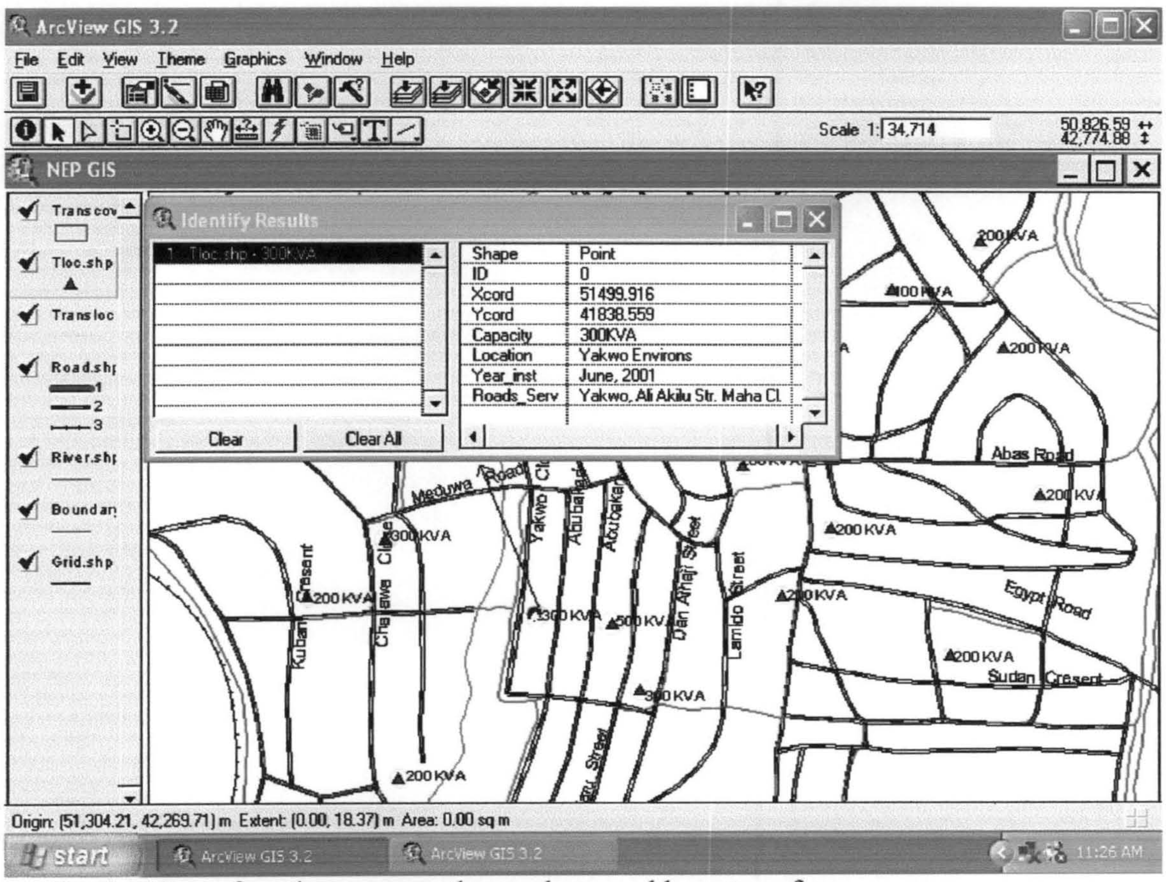

Fig. 4.5 Trace function to trace the roads served by a transformer

The trace operation determines which portion of the network is connected to a point based on certain pre-defined criteria. This is an important function in much application. For this study, the problem of electricity outage is cited. In the hierarchical electricity network, several customers are fed from a single transformer and there are several of these transformers in the network. When an outage situation occurs, the first task is to identify which transformer causes the outage. The trace function of GIS network analysis was applied here to trace the transformer.

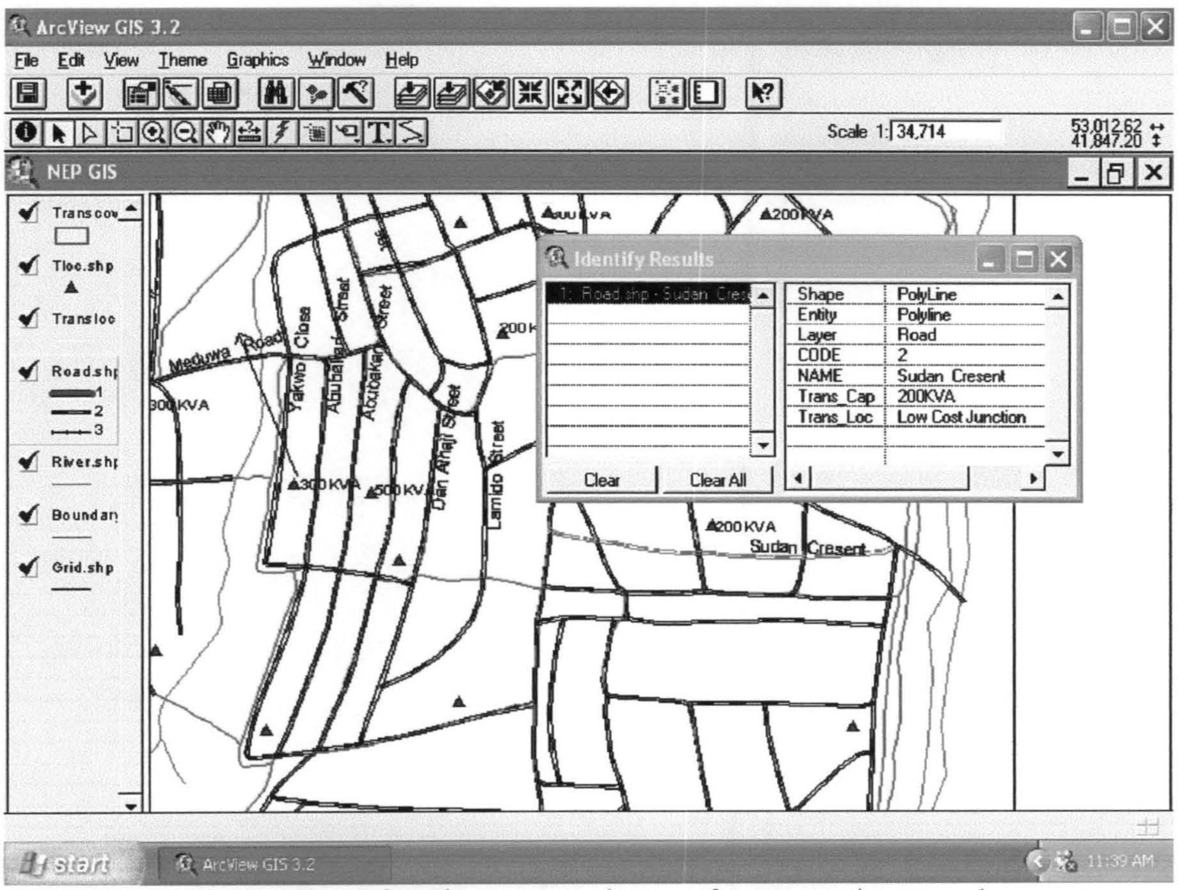

Fig. 4.6 Trace function to trace the transformer serving a road.

4.2 DISCUSSION OF RESULTS

This study involves the development of database for PHCH transformers in Barnawa Area of Kaduna metropolis. The database so created was used to perform various GIS analysis in order to determine the appropriateness of GIS as a support toll for effective management and monitoring of the utilization of these transformers.

The first set of analysis carried out were spatial queries where the database was subjected to query by location and query by attributes. With these queries, information can easily be retrieved.

Overlay operation is another GIS analysis that was carried. Different layers were super-imposed on each other to make new maps. The overlay operation afforded the opportunity to determine various activities within a particular location. For instance, with this overlay operation, the transformer capacity, type of landuse and the roads within an area can be determined.

The last set of analyses carried out were the network analyses where the trace operation was performed. This is important to PHCH management because most often, they are faced with the problem of tracing faults or determining those that are directly affected by a particular fault. The database was subjected to these analyses so as to address this aforementioned problem. In the network analyses, roads serviced by a particular transformer were determined and also determined was the transformer which supplies electricity to people on a particular road.

The three sets of analyses are generally central to the effective management and monitoring of PHCH transformers' capacity utilization. These analyses can individually or collectively be used to:

a. Determine power consumption in an area.
b. Locate troubled transformer and also the affected area.
c. Determine the capacity of transformer required in an area.
d. As a base to update the database.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY

The primary aim of this research was to design and create a robust spatial database for use by Power Holding Company of Nigeria PHCN] in the monitoring and management of their step down transformers. This research was borne out of the need for finding a lasting solution to the problem of erratic power supply in Nigeria.

Since the transformers are distributed all over the country to supply electricity to their customers, their locations and distribution network can be assessed through geographic information systems. To carry out this research, a sample area was chosen to demonstrate the effectiveness of GIS in assisting the management of PHCN to eradicate power outage in Nigeria. The sample area is Barnawa PHCN feeder area with an area of 20. 87km^2. The study area has 46 transformers with capacities ranging from 100KVA to 500KVA.

SPOT satellite imagery (1994), existing maps of Kaduna metropolis and GPS technology were the major sources of data for this research. The maps were scanned and screen digitized along with the satellite imagery to create layers of information depending on the theme. The GPS technology was used to obtain the planimetric data of the transformers. Areas of transformers coverages and dates of installation were also collected from the PHCN.

With the data acquired and captured in the computer system, spatial database was designed and created. Because of its flexibility, the relational database structure was used to develop the database. The database contained information in the form that can be used to answer user's problems. A link was established between the database and input that provided answers in the form of a map, table or figure.

To demonstrate the effectiveness of this spatial database, spatial analyses were performed on it. Spatial query, overlay operation and network analysis are the various levels of analyses carried out in this study. The results of the analysis revealed that this is possible to monitor, maintain and manage the PHCN transformers through the adoption of GIS technology.

5.2 CONCLUSION

The study has effectively demonstrated that GIS technology can be employed as a decision support tool for monitoring and management of PHCN transformers capacity utilization. With the spatial database created for the utility information system, PHCN officials can readily determine areas of need for new or additional transformers. They can also monitor the use to avoid overloading, illegal connection and disconnection.

Even though the employment of GIS is not an end in itself but a means to an end, it will go a long way in providing the solution to the problems of erratic power supply in the country.

5.3 RECOMMENDATION

Geographic information system [GIS] as a decision support tool is inevitable n planning, monitoring and management of the environment and its resources to improve socio-economic well-being of the people. Based on the findings of this study, the following recommendations are considered as appropriate here:-

a. GIS technology should be implemented at all level and sectors of government and private sectors in Nigeria.

b. Since the robustness of a spatial database depends on the quality of the data that was used as input, it is pertinent to make comprehensive data available and affordable.

c. An enlarged database should be developed to accommodate all the facilities of Power Holding Company of Nigeria.

d. A GIS unit should be created within the PHCN if presently not in existence.

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APPENDIX 1

PHCN TRANSFORMERS IN BARNAWA FEEDER AREA

	S/no	**Capacity**
1.	Gongola road	200KVA
2.	Kubani street	200KVA
3.	Chalawa crescent	200KVA
4.	Chairman substation	300KVA
5.	Yakwo cell	500 KVA
6.	Yakwo close	300 KVA
7.	Abdulkadri street	500 KVA
8.	Dantiner hotel	100 KVA [MD]
9.	Dan Alhaji	300 KVA
10.	Lamido street	200 KVA
11.	Zambia street	200 KVA
12.	Market substation	500 KVA
13.	Old Barnawa substation	500 KVA
14.	Area KTL Qtr	500 KVA
15.	Dan Alhaji releif S/S	200 KVA
16.	MIA Hotel	300 KVA [MD]
17.	Living Faith	300 KVA [MD]
18.	Water Board	300 KVA [MD]
19.	Kontagora Estate	300 KVA [MD]
20.	Poly [CES]	300 KVA [MD]
21.	Solid minerals	200 KVA [MD]
22.	All States Bank	200 KVA [MD]
23.	Isaku Hospital	50 KVA [MD]
24.	Keffi Substation	300 KVA
25.	Dabo road	100 KVA [MD]

26.	Gashashai	200 KVA
27.	Railway Station	500 KVA
28.	R. G. substation	300
29.	Sylester Idoku	100 [MD]
30.	Kiya I	200 KVA
31.	Iya U	200 KVA
32.	Ode Ezekiel street	200 KVA
33.	Shehu-Abbas	200 KVA
34.	Met- Oho	200 KVA
35.	Agric scheme	200 KVA
36.	Egypt	200 KVA
37.	Daily	200 KVA
38.	Daily time substation	500 KVA
39.	Cingo street	200 KVA
40.	Senegal	200 KVA
41.	Mosambigue street	300 KVA
42.	Bussa close	300 KVA
43.	Salama close	500 KVA
44.	Kulami	200 KVA
45.	St. Gerald	200 KVA
46.	Angola street	300 KVA
47.	Fertilizer close	100 MD

Source of data: PHCN Kakuri District