GIS MAPPING OF ELECTRICAL NET DISTRIBUTION TRANSFORMERS IN SAMARU BUSINESS UNIT, KADUNA STATE, NIGERIA

BY

Ibrahim TIJJANI
P16PSPG8301
(M.Sc REMOTE SENSING AND GIS)

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

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL MANAGEMENT,
FACULTY OF PHYSICAL SCIENCES,
AHMADU BELLO UNIVERSITY,
ZARIA, NIGERIA

OCTOBER, 2021

DECLARATION

I hereby declare that this dissertation was written by me and that is a record of my own research work. I declare that this research work has not been submitted in any form or format for any degree at any level known to me. All sources of publication and related reports cited in the investigation have been identified and referenced accordingly

Ibrahim TIJJANI	…………………………..	……………………
Name	Signature	Date

CERTIFICATION

The dissertation titled GIS mapping of electrical distribution transformers in Samaru business unit, Zaria, Kaduna state, Nigeria was written by Ibrahim TIJJANI, meets the regulation governing the award of Master of Science Degree in Remote Sensing and GIS in Ahmadu Bello University and is approved for its contribution to knowledge and literacy presentation.

Dr. B.Akpu Chairman, Supervisory Team	……………………… Signature	………………… Date
Dr.N.D Jeb Member, Supervisory Team	……………………… Signature	………………… Date
Dr.S.Abbas Head of Department	……………………… Signature	………………… Date
Prof. SaniAbdullahi Dean Postgraduate School	……………………… Signature	………………… Date

DEDICATION

I dedicate this to my late father AlhajiTijjaniBukar and my mother HajiyaMaimuna for their unwavering support and motivation throughout my education.

ACKNOWLEDGEMENTS

I wish to express my profound gratitude to Almighty Allah who taught man how to read and revealed to him what was previously unknown for the gift of life, wisdom, understanding and known throughout this programme.

I express my sincere gratitude to my supervisors Dr. B. Akpu and Dr N.D. Jeb, whose advice, guidance and constructive critics made this work possible despite all their tight schedules. Thank you for all attention and encouragement. May almighty empower you in knowledge and health so as to impact and inspired more. My appreciation also goes to my parent for their assistance towards my education and smooth completion of this work and also my family members who supported and encouraged me towards the success of this work like Musa, Muhammed, Annas and my lovely wife Aziza. I also wish to thank the lecturers of the Department of Geography for their valuable advice and assistance which enabled me to put this project together as coherently as possible. Prof I.J Musa, Prof M.M. Mamman, Dr O. Adefila, Dr. R.O Yusuf, Dr S. Abbas, Mal I. Garba, Dr M. Jamil the Coordinator and the entire staff Department.

I am grateful to the members of staff of Kaduna Electricity Distribution Company for helping me acquire materials for this study. Finally, my sincere gratitude goes to staff and fellow students in the department of Geography, Ahmadu Bello University Zaria for their assistance.

I also acknowledge the contributions of my good friend and colleague MurtalaDahiruAbdullahi for his constructive criticism and motivation. Other people worth mention are SalisuKasimu, Muhammed Ibrahim, AminuAliyuDanraka, MuharazumMuhammed, Faiza Musa and Amadu Marcus among others. To my friends at home AbubakarSadiqNuhu, Awwal Ibrahim, Ahmed TjjaniAbdulkarim, KabiruZubairu and MuhammedKabiru I say thank you all for the well wish.

I am equally grateful to my course mates especially Isa Adamu, Maharazu, Shuaibu and Badarudeen. I also acknowledge the goodwill of MuhammedKabir, Umar Zakariyya and BabangidaAbdullahi.

Lastly to everyone who contributed in one way or another whom I leave out not because I did not appreciate but due to time and space limitation. I say thank you all, May Allah bless. Even though I appreciate people's contribution, I remain responsible for all my mistakes, omission or misjudgment found therein.

ABSTRACT

The absence of up-to-date information on electricity distribution facilities and that of development is hindering effective power supply. This study applied geospatial techniques to analyze the distribution of transformers in Samaru business unit, Zaria, Kaduna State. Names and addresses of transformers were obtained from Kaduna Electricity Distribution Company Zaria business area. Global positioning system (GPS) Garmin 78c5x was used to capture the geographic coordinates of transformers in the area. Google earth pro 4.0 and electricity distribution maps were obtained. Geodatabase was created and query analysis was carried out. Buffer zones of 600meters were constructed around the electricity distribution transformers to determine the proximity of electricity distribution transformers to the customer. The findings revealed that there were 84 electricity distribution transformers in the study area, of which 53.6% were general public electricity distribution transformers, while 46.4% were owned by private organizations or individuals. The 500 kva and 300 kva electricity distribution transformers were mostly used for public purposes, while the 50 kva were dedicated electricity distribution transformers. About 94.0% of electricity distribution transformers were connected to the distribution network. The findings further shows that Hanwa unit had the highest percentage (60%) of electricity distribution transformers that were not connected while Samaru and Palladan units accounted for 20% each. Samaru unit has the highest concentration of electricity distribution transformers (33.3%) and 100kva transformers accounted for the highest percentage (32.1%). However the proximity analyses conducted indicated that the voltage drop in power supply is experienced the farther the customer is connected to the electricity distribution transformer. The KAEDCO should provide more electricity distribution transformers for the

developing areas like Zango, Palladan, Layin-zomo, so as meet up with the demand of growing population and development taken place in the study area to enhance electricity supply.

TABLE OF CONTENTS

CHAPTER THREE: THE STUDY AREA AND METHODOLOGY

CHAPTER FOUR: RESULTS AND DISCUSSION

LIST OF FIGURES

Figure Page

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Generally, electricity describes supply of electric current. This involves generation, transmission and distribution of the electric current to consumers.Electricity is an aspect of the utility sector that is very essential to the smooth meaningful development and running of the affairs of any society. It supports the economy and promotes the well-being of individuals (Emengini, 2004).

Energy plays the most vital role in the economic growth, progress, and development, as well as poverty eradication and security of any nation. Uninterrupted energy supply is a vital issue for all countries today. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible, and environmentally friendly (Oyedepo, 2012). Energy is an important factor in all the sectors of any country's economy. The standard of living of a given country can be directly related to the per capita energy consumption (Oyedepo, 2012).

Man depends on electricity for basic needs such as food processing, water supply and treatment, shelter provision, communication, employment and health care. Those needs are served by structures for food preservation, water treatment, heat and light, phone service, internet, offices, factories, hospitals and emergency response, to name a few (Alawiye, 2011). One could easily agree that the population growth is fueling the growth in electricity demand. The developing world is rapidly catching up with the lifestyle of the industrialized world, through the electrification of everything which increases the dominance of electricity as the preferred form of energy. Several developments have driven electricity into every aspect of our lives, most notably motors, microprocessor, microwave and now another massive change is about to begin: the switch to electric transportation (Berst and Michael, 2008).

In recent years, electricity supply has become very significant owing to the seeming indispensable role it plays in every facet of our daily lives. Absence of electricity for long periods causes discomfort and hampers productivity. It is also a known fact that electricity consumption has become a parameter by which the standard of living as well as the level of industrialization of nations is measured (Muhammad, 2005).

Electricity's rapid rise to dominance as a source of industrial power was based on a number of compelling advantages. First and foremost, electricity could be packaged in almost any size. In terms of availability, future prospects for electricity appear to be reassuring. In the industrial world electricity is already widely available at prices that are typically lower in real terms than they were twenty years ago (Joskow, 1997). The demand for energy in this particular form is further reinforced by its energy saving role, as well as its labour saving features that have been neglected. Moreover, the many possibilities for building "environmentally friendly" new technologies on electrical foundations appear likely to enhance the demand for electricity (Alawiye, 2011).

Rosenberg (1998) observed that electric power is properly considered as a key element of the so called Second Industrial Revolution, having considered agriculture to be the first industrial revolution, modern industrial societies are commonly described as energy intensive, which is, perfectly accurate. A central feature of industrial development over the past two decades is that it has been characterized by a growth in the amount of energy utilization per worker, or per person.

Ayodele (2004) has indirectly re-echoed that the electricity consumption is positively related to economic growth and that the former is a cause factor of the latter. This means that electricity consumption has diverse impact in a range of socio economic activities and consequentially the living standards of Nigerians.

The essence of electricity in a nation is one so pertinent that generating sets is owned by most Nigerians. In August 2000, 2400MW of electricity was being generated by diesel and petrol generating sets (Electric Power Sector Implementation Committee, EPIC 2004). This shows that electricity is not only important for fuelling economic activities and growth but it is also necessary for the attainment of sustained comfort.

Just like in India, the electricity sector in Nigeria is presently characterized by chronic power shortages and poor power quality supply. With an approximated installed capacity of 6000MW (EPIC, 2004), it was stated that the country consumes about half its capacity. With an increased population coupled with diversification of economic activities, energy demand is rising but yet, electricity supply is relatively stagnant. It is therefore obvious that electricity demand is way above its supply (Odulare and Okonko, 2009).

The inefficiency as well as inadequate facilities to boost electricity supply has also been a major cause of the increasing gap between demand and supply of electricity. This could be due to the fact that there are only nine working generating stations in Nigeria (3hydro and 6 thermal) (EPIC, 2004). Out of the approximated 6000MW installed capacity in Nigeria, not more than 4500MW is ever produced (EPIC, 2004). This is due to poor maintenance, fluctuation in water levels powering the hydro plants and the loss of electricity in transmission. It could also be due to the 80MW export of electricity each to the Republics of Niger and Benin (Odulare and Okonkwo, 2009).

According to Donald (2013), electrical power distribution includes all parts of an electric utility system between bulk power sources and consumers services entrance equipment. Distribution is the act of conveying electrical power from transmission end to the end user. In Nigeria, the transmitted voltages which are 330KV and 132KV are further stepped down to 33KV and 11KV which is further stepped down to the distribution substation that steps down the voltages to 415 volts that is available for usage. The electrical power that is used by every household appliance is derived from the voltage of 415V in collaboration with neutral to produce an average voltage of 220 volts.

A mainly urban utility may have less than 50 ft of distribution circuit for each customer. A rural utility can have over 300 ft of primary circuit per customer. Several entities may own distribution systems: municipal governments, state agencies, federal agencies, rural cooperatives, or investor-owned utilities. In addition, large industrial facilities often need their own distribution systems. While there are some differences in approaches by each of these types of entities, the engineering issues are similar for all (Short, 2004).

With the aid of GIS, variety of information can be better organized on a computer system linking the database to an output map. Emengini (2004) noted that knowledge about physical assets of the enterprise is necessary to make strategic and operational decisions. Thus, to take wise decisions vital to the operations, growth and management of electricity distribution facilities, information must be collected and analyzed to its full extent. Such information contributes not only to efficient services, but also to the operation and maintenance of assets, and to the sensible planning of extensions and new works.

GIS can effectively be used to manage and monitor information on the distribution of electricity to end-users including information describing their spatial and non-spatial attributes such as geographical location and electricity use. The selection of appropriate and cost-effective technology is the key to improving the distribution systems with their extensive conductors and installations. The selected technology should also be able to cater for future demand scenarios and to provide optimal solutions and not simply confined to analyzing the present needs. The GIS technology allows for periodic updating and monitoring and the GIS mapping of the Electrical Network and Consumer Database helps in the way of improved load management, loss reduction, better revenue realization, asset and work management and possibly better consumer relationships (Tripta, 2005).

According to Shot (2004) distribution transformer has lower ratings like 11 KV, 6.6 KV, 3.3 KV, 440 V and 230 V. They are rated less than 200 MVA and used in the distribution network to provide voltage transformation in the power system by stepping down the voltage level where the electrical energy is distributed and utilized at the consumer end. The primary coil of the distribution transformer is wound by enamel coated copper or aluminum wire. A thick ribbon of aluminum and copper is used to make secondary of the transformer which is high current, low voltage winding. Resin impregnated paper and oil is used for the insulation purpose. The oil in the transformer is used for Cooling, Insulating the windings protecting from the moisture(Harlow, 2004).

The situation is not different in Samaru business unit which comprises of some parts ofZaria and Sabon-Gari LGAs. Mortimore (1970) maintains that education is the major urban industry in Zaria. With these institutions the population of Zaria comprises of different classes of people ranging from students, health workers, civil servant, businessmen and security personnel. These people have high demand for power supply for their day to day activities. Akus (2011) observed that Zaria receives just about 10 to 25 Kwh per day instead of 70 Kwh required. With the inadequate power supply, population growth and increased commercial/industrial activities, the situation is most alarming. The power industry is expected to keep track of the electrical facilities (poles, circuits, power lines and transformers) involved in the distribution of energy to the end-users.

1.2 Statement of the Research Problem

The creation, updating, general maintenance and management of electricity distribution network in terms of spatial data and non-spatial data are herculean tasks. The voluminous nature of data involved for proper record keeping is indeed cumbersome and cannot be effectively handled and managed by the traditional system of record keeping. The analogue system means acceptance of inflexibility resulting from data storage in fixed forms and formats. The system becomes less useful for many purposes and is rarely updated because of cost implication. Maps are easily displaced or destroyed because many different people at different locations use them (Emengini, 2004).

The distribution network has experienced very rapid growth especially with progressive rural electrification policy of the Federal Government. Most urban centers are developing very fast and power demand is on the increase. Caven (1998) opined that residential areas in some cities have suddenly been transformed into commercial centers thereby overloading the existing power supply facilities. The high cost of distribution materials has limited the ability of the Authority to cope as most urban planning and developments are carried out with prior information to the Authority to plan and provide the requisite electricity supply information.

The rapid increase in population in Zaria is fueling the demand for electricity. This scenario has also put excessive pressure on the available facility, this is more so because the current electricity distribution transformer were made to serve a lesser number of users compared to what is available at the moment. The presence of many users of the electricity facility is a sign of over use of the facilities thus leading to shortage and outage of electricity (Global Environment Fund, 2008).

The rapid increase in population of Samaru business unit has brought the expansion of settlement in the area, which has raised the demand for electricity in the study area, thus leading to the extension of the electricity distribution network. Therefore, the absence of up to date information on electricity distribution transformers and that of development and growing concern over environmental issues is hindering effective power supply in the study area.

Emengini (2004) used GIS in management of electricity distribution in Onitsha North Local Government Area. The findings of the study showed the locations of electricity distribution facilities. The electricity distribution transformers on ground such as 11kv line, power transformer, distribution transformer, transmission station etc. The study also showed selected distribution transformers with capacity 15mva along old market were displayed. The results demonstrated some of the capabilities of GIS in handing and managing electricity distribution spatial data.

Osakpolor and Dare-Alao (2014) assessed the Geospatial Modeling of Electricity Distribution Network in Ife central Local Government Area. The study focused on the generation of a geospatial model for electricity consumers and facilities to provide better understanding towards effective distribution and conservation of electricity. The finding shows the capability of spatially enabled information system (GIS) in understanding the spatial relationships among electricity distribution facilities and consumer demand.

A number of studies have been carried out on public power supply and consumption in Zaria urban area and its environs. For example Bawa (2005), Nom (2012), Ladigbolu (2010) andAkus (2011) examined the Spatio-temporal variation in public electricity supply and demand in Zaria. The findings revealed that Zaria area requires about 70mw of electricity but only about 10mw was received. The result also reveals that electricity supply has been progressively declining over the years. Year 2005 had the highest units supplied with 28.2% of the electricity supplied over the period and followed by 2006 with 27.8%. Year 2007 and 2008 have 25.9% and 18.1% respectively. This revealed that variations in supply and demand are not only affected by time and space, but population growth, vandalism and poor attitude to work will lead to the variation in electricity supply (Akus, 2011).

Ladigbolu (2010) investigated the effects of power failure on small scale business in Sabon-Gari area of Zaria. The study also showed that 34% of the businesses depend solely on power from Power Holding Company of Nigeria while 64% are able to provide backups in form of generators to serve as coping strategy. The study revealed that some areas experience power outages more than other areas and this has effects on their income for instance Lagos Street experiences 12 hours power supply while Club Street experiences power supply availability for 3-4 hours per day.The study further revealed that works stops completely for those businesses that do not have generators and those with generators experiences a reduction in work as high cost of service scare some people away and for some, power outages make their products to spoil Ladigbolu (2010).

In view of the above previous studies, it is clear that they all focused in measuring the public power supply, consumption and cost of electric power shortages in Nigeria but none to the best of my knowledge have been carried out on the GIS mapping of electricity distribution transformers in Samaru business unit. This is the reason why this research on GIS mapping of electricity distribution transformers is been carried out, with a view to determine their efficiency and optimality.

This study intends to answer the following research questions:

1. Where are the electricity distribution transformers in the study area?
2. What are the characteristics of the electricity distribution transformers?
3. What are the capacity and present state of the electricity distribution transformers in the area?
4. How close are the electricity distribution transformers to the customers?
5. What is the amount of electricity supplied to customers in the study area

1.3 Aim and Objectives

The aim of the study is to apply geospatial technique in the mapping of electricity distribution transformers in Samaru business unit. The specific objectives of the study are to:

i. identify and map the electricity distribution transformers in the study area.
ii. create a geodatabase for the electricity distribution transformers in the study area

iii. examine the characteristics of the electricity distribution transformers in the study area

iv. determine the proximity of electricity distribution transformers to consumersin the area.

v. to determine the amount of power supplied in the study area.

1.4 Scope of the Study

The spatial extent of this research covers Samaru business unit of KAEDCO,is a subsidiary of Zaria Business Area. The area includes; some parts of Hanwa, Kwangila, Palladan, Zango, Samaru, Danmagaji and some part of Wusasa. The study analyzed the electricity distribution transformers in Samaru business unit. The study considered the locationelectricity distribution transformers (11kva transformers). The temporal extent of the study covered electricity distribution facilities as at 2016.

1.5 Significance of the Study

Electricity is an essential commodity for human beings. It plays an important role in the overall growth and development of a nation. In this era of industrialization, electricity is the heart of industrialization and economic development. Energy is the basic necessity for the economic development of a country.

Based on the aforementioned, a research of this nature is significant as it seek to provide an empirical data and information about the electricity distribution facilities. Efficient functioning of the generated power cannot be achieved without proper record keeping and monitoring of the transmission and distribution network system.

Emengini (2004) noted that knowledge about physical assets of the enterprise is necessary to make strategic and operational decisions. Thus, to make wise decisions vital to the operations, growth and management of electricity distribution transformers, information must be collected; such information contributes not only to efficient services, but also to the operation and maintenance of assets, and to the sensible planning of extensions and new works. The application of GIS in electricity distribution network in Zaria area will provide large volume of data which could be used for electricity distribution planning and management in the study area in particular.

This study is necessary because electricity as an aspect of utility sector is very essential in the smooth and meaningful development of the society. It supports the economy and promotes the well-being of individuals. Efficient functioning of this utility is of paramount importance for the sustenance of its growth.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 Introduction

The literature review comprises of conceptual framework in understanding electricity, database, and geodatabase, historical background of electricity in Nigeria, related literatures and GIS in electricity distribution system. Each of the section was further subdivided into subheadings and review was done under subheadings.

2.2 Conceptual Issues

2.2.1 Electricity

According Ayobowale (2011) electricity is a fundamental form of energy observable in positive and negative forms that occurs naturally (as in lightning) or is produced (as in a generator) and that is expressed in terms of the movement and interaction of electrons. It could therefore be said to be an electric current The Energy Information Administration (EIA, 2009) views Electricity as the flow of electrical power or charge. It is a secondary energy source which means that we get it from the conversion of other sources of energy, like coal, natural gas, oil, nuclear power and other natural sources, which are called primary sources. The energy sources we use to make electricity can be renewable or non-renewable, but electricity itself is neither renewable nor non-renewable.

Electricity is a basic part of nature and it is one of our most widely used forms of energy. Many cities and towns were built alongside waterfalls (a primary source of mechanical energy) that turned water wheels to perform work. Before electricity generation began over

100 years ago, houses were lit with kerosene lamps, food was cooled in iceboxes, and rooms were warmed by wood-burning or coal-burning stoves. Beginning with Benjamin Franklin's experiment with a kite one stormy night in Philadelphia, the principles of electricity gradually became understood. Thomas Edison helped change everyone's life -- he perfected his invention -- the electric light bulb. Prior to 1879, direct current (DC) electricity had been used in arc lights for outdoor lighting. In the late-1800s, Nikola Tesla pioneered the generation, transmission, and use of alternating current (AC) electricity, which can be transmitted over much greater distances than direct current. Tesla's inventions used electricity to bring indoor lighting to our homes and to power industrial machines.(EIA, 2009).

2.2.1.1 Types of Electricity

The two basic types of electricity are static electricity and current electricity. The history of static electricity ways back to 16th century when the Greeks discovered that electric charge can be generated by rubbing amber with the piece of cloth. This explains the definition of static electricity well. Thus static electricity is a friction produced as a result of rubbing two objects. While current electricity is a complex process. In simple words the movement of electrons along an electric charge is known as current electricity. Current electricity is of vital importance because it gave rise to the discovery of modern electric equipments. Static electricity apparently is of no use. However it serves the purpose of friction and helps in holding objects together (Solar Power Potentials, 2017).

(a) Static Electricity

Static electricity is generated when an object containing excess of electrons transfers them to positively charged objects. As a result an electric field is emerged which causes the effects of repulsion or spark. Static electric charge is produced when two objects are rubbed together and pulled apart. Object which has excess of negative or positive charge produces static electricity. Electric current can be more simply described as flow of electrons (Solar Power Potentials,2017).

(b) Current Electricity

Current electricity is measured in amperes. So far there is no specific unit for measuring static electricity. Current electricity requires a conductor so that the electrons can flow and travel easily. Copper wire is the most widely used form of a conductor. Current electricity can be generated in many ways. It can be generated with the simple chemical reaction taking place in a battery. Current electricity can also be generated from the electric generators. Electric generators transform the various forms energy like chemical and mechanical energy into electric current. Electric current is further divided into two forms as direct current and alternate current. Direct current is the direct flow of electrons or a direct chemical reaction like the one taking place in battery. Whereas indirect current is one present in the electric sockets and plugs. Direct current is the one which cannot be controlled or stopped or in which the ions move in one same direction. However the indirect current is the one whose circuit is further broken down into on and off phases or in which the electrically charged ions randomly move in opposite directions. Alternating current is used for transferring electricity to homes and buildings. Current electricity is a manufactured product. Because it is generated from the energy sources like coal, oil, hydraulic pressure and many other sources. When we separate opposite charges static current is produced. However when the opposite charges flow or move in opposite direction electric current is produced(Elert, 2017).

Both forms of electricity produce power. Static electricity produces the power to hold objects. While current electricity generates the power to operate or run electric devices. Electric energy is the flow of electrons and protons, and static electricity and current electricity are the portions of electricity. Current electricity can be generated from various other energy sources such as nuclear energy, wind and water pressures etc. this electric current generated as a result has helped us improve our lifestyle. Electricity has made our lives easier. Our survival without the energy sources from which we generate electric current further has become impossible now. The transfer of electrons produces a small electric current every time they move (Solar Power Potentials, 2017).

2.2 .2 Transformers

A transformer is an electrical apparatus designed to convert alternating current from one voltage to another. It can be designed to "step up" or "step down" voltages and works on the magnetic induction principle. A transformer has no moving parts and is a completely static solid state device, which insures, under normal operating conditions, a long and trouble-free life. It consists, in its simplest form, of two or more coils of insulated wire wound on a laminated steel core. When voltage is introduced to one coil, called the primary, it magnetizes the iron core. A voltage is then induced in the other coil, called the secondary or output coil. The change of voltage (or voltage ratio) between the primary and secondary depends on the turns ratio of the two coils (Shot, 2004).

2.2.2.1 Types of transformer

There are various types of transformer used in the electrical power system for different purposes, like generation, distribution and transmission and utilization of electrical power. The different types of transformer are Step up and Step down Transformer, Power Transformer, Distribution Transformer, Instrument transformer comprising current and Potential Transformer, Single phase and Three phase transformer, Auto transformer, etc.

(a) Step up and Step down Transformer

This type of transformer is categorized on the basis of a number of turns in the primary and secondary windings and the induced emf. Step up transformer transforms a low voltage, high current AC into a high voltage, low current AC system. In this type of transformer the number of turns in the secondary winding is greater than the number of turns in the primary winding. If ($V_2 > V_1$) the voltage is raised on the output side and is known as Step up transformer (AAB, 2004).

Step down transformer converts a high primary voltage associated with the low current into a low voltage, high current. With this type of transformer, the number of turns in the primary winding is greater than the number of turns in the secondary winding. If ($V_2 < V_1$) the voltage level is lowered on the output side and is known as Step down transformer (Winder, 2004).

(b) Instrument Transformer

They are generally known as an isolation transformer. Instrument transformer is an electrical device used to transform current as well as voltage level. The most common use of instrument transformer is to safely isolate the secondary winding when the primary has high voltage and high current supply so that the measuring instrument, energy meters or relays which are connected to the secondary side of the transformer will not get damaged. The instrument transformer is further divided into two types i.e. Current Transformer (CT) and Potential Transformer (PT) (AAB, 2004)

(c) Current Transformer

The current transformer is used for measuring and also for the protection. When the current in the circuit is high to apply directly to the measuring instrument, the current transformer is used to transform the high current into the desired value of the current required in the circuit.

The primary winding of the current transformer is connected in series to the main supply and the various measuring instruments like ammeter, voltmeter, wattmeter or protective relay coil. They have accurate, current ratio and phase relation to enable the meter accurately on the secondary side. The term ratio has a great significance in CT (Shot, 2004).

(d) Potential Transformer

The potential transformer is also called the voltage transformer. The primary winding is connected across the High voltage line whose voltage is to be measured, and all the measuring instruments and meters are connected to the secondary side of the transformer. The main function of the Potential transformer is to step down the voltage level to a safe limit or value. The primary winding of the potential transformer is earthed or grounded as a safety point.

(e) Single Phase Transformer

A single phase Transformer is a static device, works on the principle of Faraday’s law of mutual Induction. At a constant level of frequency and variation of voltage level, the transformer transfers AC power from one circuit to the other circuit. There are two types of windings in the transformer. The winding to which AC supply is given is termed as Primary winding and in the secondary winding, the load is connected (Electrical Technology 2012).

(f) *Three Phase Transformer*

If the three single phase transformer is taken and connected together with all the three primary winding connected to each other as one and all the three secondary windings to each other, forming as one secondary winding, the transformer is said to behave as three phase transformer, that means a bank of three single phase transformer connected together which acts as a three-phase transformer (Harlow, 2004).

Three phase supply is mainly used for electric power generation, transmission and distribution for industrial purpose. It is less costly to assemble three single phase transformer to form three-phase transformer than to purchase one single three-phase transformer. The three-phase transformer connection can be done by Star (Wye) and Delta (Mesh) type (Electrical Technology 2012).

(g) *Power Transformer*

The power transformers are used in the transmission networks of higher voltages. The ratings of the power transformer are as follows 400 KV, 200 KV, 110 KV, 66 KV, 33 KV. They are mainly rated above 200 MVA. Mainly installed at the generating stations and transmission substations. They are designed for maximum efficiency of 100%. They are larger in size as compared to distribution transformer (AAB, 2004).

At a very high voltage, the power cannot be distributed to the consumer directly, so the power is stepped down to the desired level with the help of step-down power transformer. The transformer is not loaded fully hence the core loss takes place for the whole day, but the copper loss is based on the load cycle of the distribution network. If the power transformer is connected in the transmission network, the load fluctuation will be very less as they are not connected at the consumer end directly, but if connected to the distribution network there will be fluctuations in the load.

The transformer is loaded for 24 hours at transmission station, thus, the core and copper loss will occur for the whole day. The power transformer is cost effective when the power is generated at low voltage levels. If the level of voltage is raised, then the current of the power transformer is reduced, resulting in I^2R losses and the voltage regulation is also increased (Winder 2004).

(h) Distribution Transformer

According to Shot (2004) this type of transformer has lower ratings like 11 KV, 6.6 KV, 3.3 KV, 440 V and 230 V. They are rated less than 200 MVA and used in the distribution network to provide voltage transformation in the power system by stepping down the voltage level where the electrical energy is distributed and utilized at the consumer end. The primary coil of the distribution transformer is wound by enamel coated copper or aluminum wire. A thick ribbon of aluminum and copper is used to make secondary of the transformer which is high current, low voltage winding. Resin impregnated paper and oil is used for the insulation purpose. The oil in the transformer is used for Cooling, Insulating the windings protecting from the moisture(Harlow, 2004).

The pole type distribution transformer is self-protected. It is equipped with a lightning arrester, a weak-link or protective-link expulsion-type fuse (installed under oil in the transformer tank), a secondary circuit breaker, and a warning light. The transformer primary bushing conductor is connected to one phase of the three-phase primary circuit through a partial-range current-limiting fuse. The transformer tank is grounded and connected to the primary and secondary common-neutral ground wire. The self-protected transformer contains a core and coils, a primary fuse mounted on the bottom of the primary bushing, a secondary terminal block, and a low-voltage circuit breaker. (AAB, 2004).

Conventional overhead transformers are also available. The key component distinguishing the conventional transformer from the self-protected transformer is the lack of internal fusing in the conventional model. An external fuse/cutout combination is mounted between the distribution primary and the conventional transformer.

Pad-mounted transformers are used with underground systems. Three-phase padmounted transformers are used for commercial installation and single-phase pad-mounted transformers are used for underground residential installations.

Vault-type distribution transformers are installed for commercial customers where adequate space is not available for pad-mounted transformers. The vault-type transformer may be installed in a vault under a sidewalk or in a building. They are often used in underground electric network areas. Submersible single-phase distribution transformers are used in some underground systems installed in residential areas. Corrosion problems and the high cost of installation have minimized the use of submersible transformers (Harlow, 2004).

- The distribution transformer less than 33 KV is used in industries and 440, 220 V is used for the domestic purpose. It is smaller in size, easy to install and has low magnetic losses and is not always loaded fully. As it does not work for constant load throughout 24 hours as in the daytime its load is at its peak, and during the night hours it is very lightly loaded thus the efficiency depends on load cycle and is calculated as

All Day Efficiency. The distribution transformers are designed for maximum efficiency of 60 to 70%.Distribution transformer are Use in

- Used in pumping stations where the voltage level is below 33 KV
- Power supply for the overhead wires railways electrified with AC
- In urban areas, many houses are fed with single phase distribution transformer and in rural areas; it may be possible that one house requires one single transformer depends upon the loads.
- Multiple distribution transformers are used for Industrial and commercial areas.
- Used in wind farms where the electrical energy is generated by the windmills. There it is used as a power collector to connect the substations which are away from the wind energy generation system.

(i) Public electricity distribution transformers

Public electricity distribution transformers are the electricity distribution transformers that were installed in the area from which the distribution of electric power can be accessed by the general public, which are found in all parts of the study areas like Samaru, Wusasa, Palladan, Kwangila areas etc, these electricity distribution transformers are managed by Kaduna Electricity Distribution Company (KEADCO). They are in-charge of service and maintenance of the transformers.

(j) Dedicated Transformers

Dedicated electricity distribution transformers are those transformers installed to meet up with the power distribution needs of some certain organizations, industries and individuals. Majority of the dedicated transformers are pole mounted transformer because they are of low capacities ranging from 50kva to 100kva with very few 300kva to 500kva, depending on the electric power demand of the organization or household. The dedicated electricity distribution transformers are purchased by an organization or individual. These transformers are in the premises of the clients and also maintained and serviced by engineers that work in these places except a few which are maintained and service by KEADCO. These transformers last longer due to proper maintenance. The dedicated electricity distribution transformers are mostly used by banks, hotels, communication mask, organizations and some few residential buildings.

2.2.3Geodatabase

Many scholars have defined Database differently, the more the advancement in technology, the more comprehensive and meaningful the definition. Burroughs (1986) defines database as a method for structuring data in the form of sets of records or tuples so that relationships between different entities and attributes can be used for data access and transformation. Longley, Goodchild, Maguire, and Rhind (1999) define a data base as a large, computerized collection of structured data. But according to (Longley, Goodchild, Maguire, and Rhind. 2005) a database can be view as an integrated set of data on a particular subject. Geographic databases are simply databases containing geographic data for a particular area and subject.

Reddy (2008) describes a spatial database as a collection of entities, some of which have a permanent location on some global and dimensional space. Regina and Leo (2011) refer spatial database as a database that defines special data types for geometric objects and allow you to store geometric data (usually of a geographic nature) in regular database tables. While Bakker (2012) is of the opinion that a database is a large computerized collection of structured data. The data is structured in tables, one such table is called relation and relationships connect tables into structure. This definition adds more value to that of Longley *et al* (2005).

Longley *et al* (2005) stated that the database approach to storing geographic data offers a number of advantages over traditional file-base datasets as follows:

i. Assembling all data at a single location reduces redundancy.

ii. Maintenance cost decreases because of better organization and reduces data duplication.

iii. Allocations becomes interdependent so that multiple applications can use the same data and can evolve separately over time

iv. User knowledge can be transferred between applications more easily because the database remains constant.

v. Data sharing is facilitated and a corporate view of data can be provide to all managers and users.

vi. Security and standards for data and data access can be established and enforced.

vii. Better suited to managing large numbers of concurrent users working with vast amount of data.

Management of GIS database consists of storing a variety of data categorized under two types, entity (spatial data) and attribute (aspatial) data in a way that permits s to retrieve or display any combinations of these data after and analysis manipulation. In order to perform these operations, the computer is able to store, locate, retrieve, analyze and manipulate raw data derived from a number of sources by using representational file structures. In other words, each graphical identity must be stored explicitly, along with it attributes, so that, we can retrieve and select the correct combinations of entities and attributes in a reasonable time GIS database comprise spatial or entity or graphical database, non spatial or attribute database, and linkage mechanism for their topology, to show the relationship between the spatial and attribute data for further analysis (Reddy, 2008)

Longley, Goodchild, Maguire, and Rhind (2005); asserted that in-spite of the technical elegance of Object Database Management Systems (ODBMS), they have not proven to be as commercially successful as some predicted. This is largely because of the massive installed base of RDBMS and the fact that RDBMS vendors have now added many of the important ODBMS capabilities to their standard RDBMS soft ware systems to create hybrid object-relational DBMS (ODBMS). A Geodatabase/ORDBMS can be thought of as an RDBMS engine with an extensibility framework for handling objects. They can handle both the data describing what an object is (object attributes such as color, size and age) and the behavior that determines what an object does (object methods or functions such as drawing instructions, query interfaces, and interpolation algorithms) and these can be managed and stored together as an integrated whole. The ideal geographic ORDBMS is one that has been extended to support geographic object types and functions through the addition of the following:

1. A query parser: The engine used to interpret SQL queries is extended to deal with geographic types and functions.
2. A query optimizer: The software query optimizer is able to handle geographic queries efficiently
3. A query language: The query language is able to handle geographic types (e.g., points, lines and polygons) and functions (e.g., select polygons that touch each other).

4. Indexing services: The standard uni-dimensional DBMS data index service is extended to support multidimensional (i.e., x, y, z coordinates) geographic data types.
5. Storage management: The large volume of geographic records with different sizes (especially geometric and topological relationships) is accommodated though a specialized storage structures.
6. Transaction services: Standard DBMS are designed to handle short (sub-second) transactions and are extended to deal with the long transactions common in many geographic applications.
7. Replication: Services for replication databases are extended to deal with geographic types, and problems of reconciling changes made by distributed users.

2.2.3.1 *Type of Geodatabases*

There are three different categories of Geodatabases, namely: personal, file and ArcSDE. We will discuss each category in the following subsection:

(a) Personal Geodatabases

The single user database is also known as personal Geodatabases. These kinds of Geodatabases are using MS Access to store the spatial information. There are some limitations applied to this type: In case of file storage maximum size bounded to only 2 GB Supported only for windows platform (Shubham 2012).

(b) File Geodatabases

This type of Geodatabase also supports single user editing. This kind of Geodatabases is using a normal file structure to store the spatial information. The file extension should be".mdb" format. There are some limitations applied to this type: - In case of file storage maximum size of 1 TB / Table (Burrough and McDonnell 1998).

(c) ArcSDEGeodatabases

This database is built on top of RDBMS system (Figure 1.3). This is also called ArcSDE. This kind of database is used to provide a multiuser environment via providing central spatial data storage location. This database has access control for individual user, backup and recovery option. These all features make this database more scalable. Even though it has many advantages over other types but still got some limitations such as, it's not platform independent, different software versions have different platform (windows, Linux, Mac) mapping.

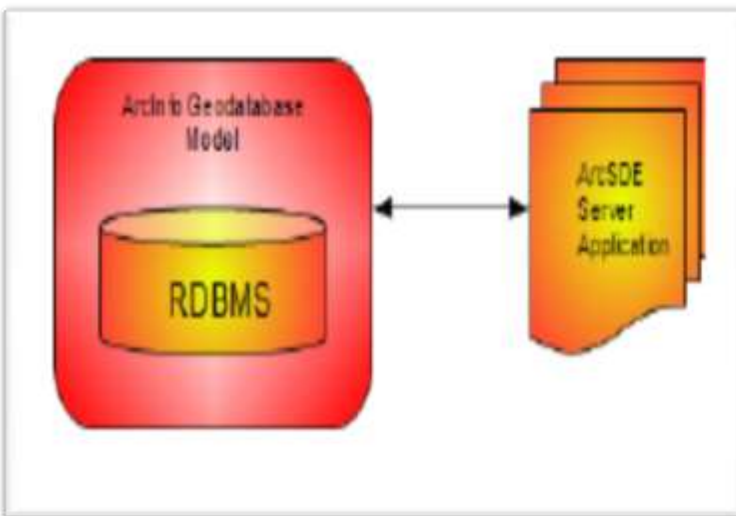

Figure 2.1: High level of Architecture

(d) Advantages of Employing a Geodatabase Structure in GIS Data Management

There are numerous advantages to structuring GIS data in a geodatabase environment. Some of the most important of concern the structure of GIS data. Vector data including points, lines and polygons are typically stored in shapefiles referred to as feature classes. A geodatabase allows for the creation of feature data sets that enable coordinated relationships among feature classes. If a feature class representing artifact points is moved, the subsequent artifact polygon and line feature classes are also moved, ensuring their continued relationship. Another advantage of using a geodatabase structure is that it allows for the creation of domains. A domain assigns valid values or ranges for the attribute table that forms part of the information contained within a feature class, helping to reduce errors in data entry by eliminating invalid entries. It also reduces data entry time by creating a series of drop-down menus.

The construction of a geodatabase similarly has advantages for future research. The structure of a geodatabase with its domain settings in place mirrors the data-dictionary structure used by Trimble GPS receivers and survey units including Total-Stations. Since GPS and survey data are recorded in a format directly translated into a GIS file, these files can be incorporated into the geodatabase. Finally, a geodatabase relaxes the system requirements needed to run GIS software on a computer. The geodatabase is one system file, and the GIS software, no matter what is asked of it, only has to access one file, freeing up system resources.

2.2.4.6 Geodatabase Datasets

Shubbam (2012) concurred that Geodatabase has three different kinds of datasets use in the management of geographic information. Creating and developing these data sets are the primary need to design and build a Geodatabase. Users have to start first with these datasets designs later on the user also add the advance features in the Geodatabase such as topology and network design. The storage of the Geodatabase has both the schema, set of rules for every datasets, and a table like storage for spatial attribute and data. These datasets are table basics, feature class basic, and raster basics (Shubham, 2012).

2.2.6.1 Table Basics

Following are the types used to hold and manage information about attributes in the Geodatabases

i. Numbers: It holds the numeric values like short integers, long integers, float and double. Text: Collection of alphanumeric values.
ii. Date: Holds time and date related values.
iii. BLOBs: This data types stands for Binary large objects and used to store images.
iv. Global Identifiers: This is used to manage the relationship for data management, versioning, updates and replication. It is a registry style string consisting of 36 characters enclosed in curly brackets and these strings uniquely identifies a feature or a table row within and across Geodatabase.

2.2.6.2Feature class basics

Feature classes hold the homogenous collection of the same features, where each feature has same spatial representation like points, lines and polygons with a similar set of attribute column. For example a point is representing some specific location, a line feature class representing roads lines. Points, lines, polygons and annotations are the most commonly used feature classes used in Geodatabases. Along with these feature classes Vector features for representing geographic object with vector geometry are frequently used for representing discrete boundaries like walls, streets and rivers. In simple words we can say that a feature is simply an object which holds the graphical representation and which we typically a collection of point, line and polygon. The following are the features classes used to hold the graphicalrepresentation of an object:

1. Points: This class is used to represent features that are very small (such as a GPS observation).
2. Lines: This class is used to represent shape and location of geographic objects ExampleStreet lines and streams, or we can use this class to represent those graphical objects which have length but no area.
3. Polygons: This class is used to represent shape and location of geographic objects example. States, countries and land use zone etc.
4. Annotation: This is used to show some descriptive properties of geographic objects. This class is responsible for text rendering for graphical objects.
5. Dimensions: This class is used to show the length and distance of graphical objects. Exampleto indicate distance between two entities.
6. Multi points: This class used to represent the features which are composed of more than one point.
7. Multi patches: This feature class is used to represent the outer surface of geographical objects that occupy some area or volume in 3-D space. Representation of simple objects (triangles and cubes) to complex objects (Isosurface and buildings).

2.2.6.3 Raster basics

Raster datasets display geographic elements by dividing the space into discrete square or rectangular cells in the grid. Every cell has a value that is used to represent some characteristic of that location as shown in Figure 1.4. Raster datasets are commonly used for representing imagery, digital models and other different areas. Often raster are used as a way to represent points, line and polygon features. In the example below, you can see how a series of polygons would be represented as a raster dataset. Rasters are interesting for at least two reasons: first, they can be used to represent all geographic information (features, images and surfaces) and second, they have a rich set of analytic Geo processing operators. Therefore, in addition to being a universal data type for holding imagery in GIS, rasters are also heavily used to represent features enabling all geographic objects to be used in raster-based modeling and analysis.

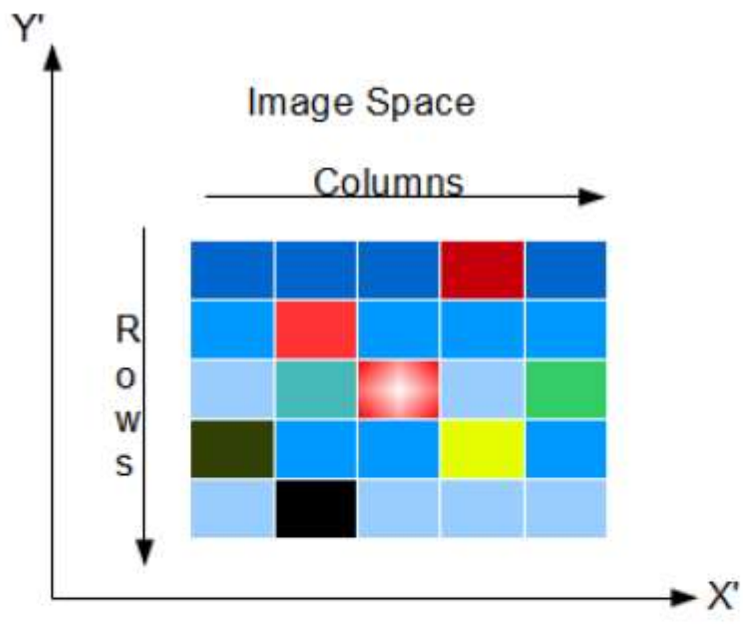

Figure 2.2: .Raster Representation in Geodatabase
Source: Shubham (2012)

2.2.6 History of electricity in Nigeria

The history of electricity in Nigeria dates back to 1896 when electricity was first produced in Lagos, 15 years after its introduction in England. In 1946, the Nigerian Government Electricity Undertaking was established under the jurisdiction of the Public Works Department to take over the responsibility of electricity supply in Lagos. From 1898 when the first generating power plant was established in Lagos until 1950, the pattern of electricity development was in the form of individual electricity power undertaking scattered all over the towns. Other bodies like Native Authorities and Nigerian Electricity Supply Company had licenses to produce electricity in some locations in Nigeria.(Oluwatiyin, Oluwasegen and Alabi, 2015).

In order to integrate electricity power development and make it effective, the then colonial Government passed the Electricity Corporation of Nigeria Ordinance. With this ordinance in place, the electricity department and all those undertakings which were controlled by Native Authorities came under one body. The Electricity Corporation of Nigeria was established as a statutory public Corporation in 1951. The company took over power generation projects of the government which was carried out through the Public Works Department and from four Native authorities. There was another body known as Niger Dams Authority established by an act of parliament 33 as an autonomous entity and charged with the provision of hydro power; and also to construct and maintain dams and other works on the river Niger and elsewhere generating electricity by means of water power, improving navigation and promoting fish brines and irrigation (Ayobowale, 2011).

ECN was mainly responsible for distribution and sales while NDA was to build and run generating stations and transmission lines. The ECN and the NDA were merged to become National Electric Power Authority with effect from the 1st of April 1972. The integration of the ECN and NDA was expected to result in more effective utilization of the human, financial and other resources available to the electricity supply industry throughout the country. NEPA then became the virtual sole provider of electricity in the country (Folorunso and Oluwa, 2014).

The statutory function of the NEPA was to develop and maintain an efficient coordinate and economical system of electricity supply throughout the federation. The decree further states that the monopoly of all commercial electric supply shall be enjoyed by NEPA to the exclusion of all other organizations. This however does not prevent private individuals who wish to buy and run thermal plants for domestic use from doing so (Ayobowale, 2011).

The National Electric Power Authority (NEPA) has a total installed capacity of about 4500 MW, but the daily generating capability was only 2700 MW due to frequent failures caused by the age of the power plants, lack of spare parts and maintenance, and scarcity of skilled labour. Over 29% of the electricity is generated with fuel oil, 29% from hydropower, over 26% from gas turbines, and over 15% from oil gas. Since inception of NEPA, the authority expanded annually in order to meet the ever increasing demand of its customers. Unfortunately, majority of Nigerians had no access to electricity and the supply to those provided was not regular.

Despite the problems faced by NEPA, the Authority played an effective role in the nation's socio-economic development thereby steering Nigeria into a greater industrial society. For several years, despite consistent perceived cash investment by the Federal Government, power outages have been the standard for the Nigerian populace and were seen as normal by the citizens of the country (Ayobowale, 2011).

Many rural households lack electricity service while some urban households rely on fuel wood for cooking. They only used an electric boiling ring to boil small amounts of water quickly because of the irregularity of power supplies. The need to establish a substitute for NEPA was recognized to be urgent as a result of the many impending conditions under which NEPA was expected to operate in order to meet national demand (Chudi, 2011).

However, the journey to the privatization of NEPA started when the National Council on Privatization empowered a 23-member Electric Sector Reform Implementation Committee to develop guidelines to promote the policy goals of total liberalization, competition and private sector led growth of electricity sector. The ERIC set out the Electric Power Policy statement, which is to ensure that, Nigeria has an Electric Power Industry that can meet the needs of its citizens in the 21st century.

The electric power sector reform was perfected in a bill signed into law on 11th March 2005. The Electric Power Sector Reform Act 2005 gives legal backing to the reform activities, which includes, restructuring and eventual privatization of NEPA. The main ingredients of the reform are deregulation, commercialization, free market economy etc. It is aimed at improving the overall efficiency through restructuring electric power private sector participation and competition, which is a major driver of the nation's economy, through improved customer satisfaction and reduced tariff. The implementation of the power reform bill kicked off with the incorporation of the initial holding company, called Power Holding Company of Nigeria on the 31st of May, 2005 (Electric Power Sector Reform Act 2005).

With the return of civil rule in 1999, the federal government embarked on power sector reform. This culminated in the Electric Power Sector Reform (EPSR) Act 2005. This is contained in a Federal Government of Nigeria Gazette and it stipulates the reforms in the electricity power sector and how they are to be implemented. The Power Sector Reform was embarked upon on March, 2005 due to the inadequate supply of electricity, high demands and issues with bills. The main goal of the reform is to accomplish full deregulation of the Electricity Supply Industry (ESI) in two years after its implementation. The objectives include making electricity generation and supply available to consumers, making the sector investor-friendly and dismantling NEPA’s monopoly. This was achieved through the passage of the Electric Power Sector Reform (EPSR) Act which came into being on the 11th of March, 2005.

The reasons given for the reform include: introduction of competition in the industry as a means of improving industry efficiency that will result in providing lower energy prices to end users, lack of price transparency in utility operations hence consumers and regulators demand price transparency and declaration of cross subsidies among different users, like many other public owned institutions, corruption, inefficiency and managerial incompetence prevailed and the electricity industry showed inconsistent policy direction and lack of strategy framework for its sustainable development, policy decisions by past government in the ESI were based on political or administrative interest instead of efficient resource allocation and cost recovery necessary for economic development and the strategic energy policy for the country was never implemented (Okobolo and Ismail, 2013).

The Act repealed the earlier law establishing NEPA; consequently, the Power Holding Company of Nigeria, (PHCN) was set up and charged with the responsibility of providing power supply. It also restructured the power sector from a vertically integrated structure into eighteen unbundled autonomous companies comprising one transmission company called TransCo, six generation companies known as GenCos and eleven distribution companies-DisCos respectively. The Act focused on the liberalization and privatization of the sole power provider-PHCN while introducing Independent Power Producers IPPs. The EPSR Act nurtures a wholesome market stating with a single buyer of electricity produced by PHCN and the IPPs for onward sale to the eleven DisCos that would also be offered for sale. Eventually the single model would be discarded for a bilateral contract model with suppliers and buyers free to contract between themselves (Electric Power Sector Reform Act 2005).

The Act further provides for the establishment of the Nigeria Electricity Regulatory Commission (NERC) which is charged with the following: (Inugonam, 2009).

- Regulate tariffs and quality service
- Oversee the activities of the industry for efficiency.
- Institutional and enforcement of the regulating regime.
- Licensing of Generation, Distribution, Transmission and Trading companies that result from the unbundling of NEPA.
- Legislative authority to include special conditions in licenses.
- Provision relating to public policy interest in relation to fuel supply, environmental laws, energy conservation, management of scarce resources, promotion of efficient energy, promotion of renewable energy and publication of reports and statistics.
- Providing a legal basis with necessary enabling provisions for establishing, changing, enforcing and regulating technical rules, market rules and standards.

In November, 2005 Nigeria Electricity Regulatory Commission was inaugurated and took full responsibility. Other aspects of the reform provided for the management of the Rural Electrification Agency (REA), the National Electric Liability Management Company (NELMCO) which is a special purpose entity created to manage the residential assets and liability of the defunct NEPA after privatization of the unbundled companies. The Act also provided for the establishment of a Power Consumer Assistance Fund (POLAF) to subsidize under privileged electricity consumers (Ulocha, 1998).

However, in spite of these efforts, the problem of the power sector continues until November, 2013 when PHCN was formerly handed to the new investors.

2.3 Literature Review

2.3.1 GIS and Electricity Facility Management

Wanjohi (2016) appraised the GIS-Based power transformer‘s planning and location in Kiringaya west sub-country Kenya. The study focused on the distribution of power transformers and production of a map showing potential locations for installing new transformers to provide enough spatial coverage with planned energy allocations and minimized distribution losses. The findings show that 55% of the study area is efficiently covered by the existing transformers leaving out 45% of the area uncovered. The result also shows that if the current medium voltage network in the area is maximized, 29% more of the area would be uncovered by the existing transformers and 20% would require extension of the medium voltage network. The study further revealed that 7% of the forest cover was excluded. Electrical distribution system has a spatial dimension to it, which calls for the need of GIS. The Geographical Information System can handle both spatial as well as non-spatial data, which makes it more beneficial over the traditional database. Moreover GIS has the functionality of having information as layers, which helps in a systematic and refined manner of managing voluminous data. The spatially referenced data provides useful reference for setting up of new facilities, necessary information on land use pattern for planning optimum expansion of network and other network operations and maintenance. The database can also handle non-spatial queries as done with any other normal DBMS.

The use of GIS in power system can greatly enhance the efficiency in energy sector. Proximity to the furthest customer and high cost to invest capital, are the reasons that make the distribution system as an important part of electrical utility, which endeavor to improve the reliability of general power system. Analyses such as selection of suitable areas, optimum path finding, the profile analyses, the engineering design of wires and towers, and the cost estimation can all be done using GIS (Dare-Alao, 2013).

OlaniyiandUsman(2006)worked on Electricity Distribution Engineering and Geographic Information System in Kubwa II feeder Abuja. The study focused on the location and mapping of all PHCN facilities towards effective distribution and the study adopted GIS Mapping involving a participatory approach. The findings showed that 14.2%of the facilities are high tension concrete poles and 0.4% are high tension wooden poles , while 7.9% of the facilities accounted for dual high tension concrete poles and 0.2% accounted for dual high tension wooden poles. The study revealed that 41.2% accounted for low tension concrete poles and 32.5% are low tension wooden poles. The study further revealed that 1.4% accounted for private transformers while 1.3% accounted for public transformers in the area. The study was able to map out the length of cables where by high tension cables had a length of 7156.225m and low tension cable 4412.525 m. The study demonstrated the capability of GIS as a planning, technique deployed for facility map.

Oras,Ahmed, and Bahaa (2015) conducted a study on GIS utilization for redistributing the electricity network power on rural areas of Samara city Iraq. This study presents REG

(Redistributed of Electrical network based-on GIS) was applied to solve the problem of electrical network distribution. The findings revealed that REG used the factors of save cost, Efficiency, and accessibility. Which made a benefits of the mentioned factors as: save cost (19.2%), accessibility (95%), save power (14%).

Hariniand Santhosh(2006) in their work “Electricity distribution information systems”, they portrayed that electrical distribution system has a spatial dimension to it. With GIS, it can be visualized as it is laid on the ground. Just by looking at the map and clicking at a particular feature (say a transformer), all the information is displayed. This provides a more flexible understanding of the network and hence a faster approach to solution.

Omilabu, Igbokwe, Ejikeme, Igbokwe, and Njoku (2015) carried out a study on the development of utility information system for management of electricity distribution of Iyaji residential layout, Oyo, Oyo State, Nigeria. This study focused on proper working of electricity distribution infrastructure that can only be assessed and monitored using Geographic Information System. The result of the analyses revealed that 23.9% and 76.0% of the buildings were connected to transformer 1 and 2. 34.6% of the buildings were using prepaid meter while 65.4% of the buildings were using analog meter. Buffering operation was also utilized to determine buildings that contravened the setback rule of 6m. Only one of such buildings existed within the study area. Best route analysis was also performed from a building to transformer 2 in case of any fault or fire outbreak that affects electrical facility or buildings. The findings revealed that IBEDC would be able to know the spatial relationship that exist among the facilities and for it to perform to the expectation of customers there is the need for the analogue data to be converted to digital format which will aid information acquisition quickly and faster in order to yield quality services and ensure prompt and accurate decision making.

Ihiabe, Ajileye, Samson,Samuel and Onuh (2015)appraisesd the use geospatial technique for effective management of electricity distribution in Olanade community of Ife central local government. The study assessed the spatial relationship between power holding company of Nigeria (PHCN) assets and their customer's connectivity in the study area. The result shows that, the study area had only one transformer rated 500KVA with 4 upriser connected to numerous distribution lines serving 250 buildings with an average consumption rate of 0.38%KW and total consumption of 94.9%KW with an excess of 4.6%KW, indicating that the transformer is overloaded. It is evident from the finding that asset management, load shedding technique, can easily be managed with the use of geospatial technique.

Alamu (2013) analyzed public power distribution and transformer management using GIS in Ikeja- Lagos, Nigeria The study is aimed at examining electricity distribution transformers belonging to PHCN and consumers location within the study area. The study was able to ascertain the actual number of electricity distribution transformers within the study area and indicated that there was a cluster of electricity distribution transformers at the Commercial Avenue of Ikeja. This study was able to detect the number of transformers within the study area which were 69 in all and also determined the following information; ownership, capacity, utilization and location of transformer. Transformer Ownership within the study area is both public and private, while public transformers were24.6%the privately owned transformers has 75.4%. The study was able to show the coverage and optimization of public transformers, which also indicated that the transformers were not over utilized. Also, the coverage of these transformers indicated the number of buildings that would be affected if a transformer is faulty as well as the nearest transformer which could provide backup. The research has been able to prove the usefulness of GIS as a tool that can assist the electricity power authority personnel in taking vital decisions.

Chatta, (2015) examined spatial distribution and utilization of electricity transformer in Sabon-Gari local Government. The study examines the distribution of electric transformers using GIS technique. The results indicated that 40% of transformers found in both Samaru and Dogarawa area were Public owned, while 20% are found in Pz area. It also revealed that 30% of the transformers found in Samaru area are owned by private organizations, 14% in Dogarawa and about 56% in PZ where there are more banks and companies. The study revealed that in terms of the capacity level of the transformer, 40.0% accounted for 50KVA which is the lowest capacity level of a transformer while 70.0% accounted for 500KVA which is the highest capacity level of transformers in the study area. Finding on the conditions of public transformers revealed that majority (80.0%) of the transformers need repair while the rest (20.0%) needs to be change. About 100% of the private transformers in the study are in good condition. The result revealed the response of respondents on power supply duration show that most of the respondents (67.31%) reported that they have power supply for 12 hours, while only a few (2.22%) reported that they have power supply for 24 hours every day.

2.3.2 Characteristics of Electricity Distribution Transformers

The magnetic circuit is an important active part of transformers, which transfers electrical energy from one circuit to another. It is in the form of a laminated iron core structure which provides a low reluctance path to the magnetic flux produced by an excited winding. Most of the flux is contained in the core, which reduces stray losses in structural parts. Due to research and development efforts by steel and transformer manufacturers, materials with improved characteristics have been developed and employed with better core building technologies. In the early days of transformer manufacturing, inferior grades of laminated steel (according to today's standards) were used with associated high losses and magnetizing volt-amperes. Later, it was found that an addition of silicon (4 - 5%) improved the performance characteristics of the material significantly, due to a marked reduction in its eddy loss on account of an increase in resistivity and permeability. Its hysteresis loss also reduced due to a decrease in the area of the *B-H* loop. Since then the silicon steels have been in use as the core material in most transformers Kulkarni and Khaparde (2013).

The addition of silicon also helps to reduce aging effects. Although silicon makes the material brittle, the deterioration in the property is not to an extent that can pose problems during the core building process. Subsequently, a manufacturing technology with the cold rolling process was introduced, wherein material grains are oriented in the direction of rolling. This technology has remained the backbone of developments for many decades, and newer materials introduced in recent times are no exceptions. Different material grades were introduced in the following sequence: non-oriented, hot-rolled grain-oriented (HRGO), cold-rolled grain-oriented (CRGO), and high permeability cold-rolled grain-oriented (Hi-B), mechanically scribed, and laser scribed. Laminations with lower thickness are manufactured and used to take advantage of their lower eddy loss. Currently, laminations with thickness in the range of 0.23 mm to 0.35 mm are used for power transformers. The thickness of laminations used in small transformers can be as high as 0.50 mm. The lower the thickness of laminations, the higher the core building time is, since the number of laminations for a given core area increases. An inorganic coating (generally glass film and phosphate layer) having thickness of 0.002 to 0.003 mm is provided on both the surfaces of laminations, which is sufficient to withstand induced voltages having magnitude of a few volts.

Since the core is in the vicinity of high voltage windings, it is grounded; otherwise it can acquire a high potential due to capacitively transferred voltages from the windings. If the core is sectionalized by ducts (of about 5 mm) for the cooling purpose, individual sections have to be grounded. Since the capacitance between any two touching laminations is very large due to their large surface area and a very small insulating gap between them, the capacitive reactance between them is negligible. Therefore, all the laminations within each section remain almost at the same potential. Hence, each of the sections is grounded at only one point. Some users prefer to ground the core outside tank through a separate bushing for the monitoring purpose.

All internal structural parts of transformers (e.g., frames) are grounded. While designing the grounding system, due care must be taken to avoid multiple grounding connections forming loops in which troublesome circulating currents may be induced. The tank is grounded externally by a suitable arrangement. The frames, used for clamping the yokes and supporting windings, are generally grounded by connecting them to the tank at one point by means of a copper or aluminum strip. If the frame-to-tank connection is done at two places, a closed loop thus formed may link an appreciable amount of stray leakage flux. A large circulating current induced in the loop can eventually burn the connecting strips.

2.3.3 Capacity and state of electricity distribution transformers

According to an online electrical engineering study site (Electrical4u), transformer‖ is seen as a static machine used for transforming power from one circuit to another without changing frequency. The importance of transformer in electricity power generation cannot be overemphasized, more especially in a country like Nigeria where power transmission has been characterized by current fluctuations. For instance, power generation in low voltage level is very much cost effective. Hence electrical power is generated in low voltage level. Theoretically, this low voltage level power can be transmitted to the receiving end. But if the voltage level of a power is increased, the electric current of the power is reduced which causes reduction in ohmic or I2R losses in the system, reduction in cross sectional area of the conductor i.e. reduction in capital cost of the system and it also improves the voltage regulation of the system. Because of these, low level power must be stepped up for efficient electrical power transmission (http://www.electrical4u.com/electrical-power-transmission-system-and-network/). This is done by step up transformer at the sending side of the power system network. As this high voltage power may not be distributed to the consumers directly, this must be stepped down to the desired level at the receiving end with the help of step down transformer. Based on the distribution level (transmission power of up to 10MVA) there are two main categories of distribution transformers Short, (2004).

2.3.4 Proximity of Transformers to Customer

A Distribution Transformer has the final voltage transformation in electric power distribution system stepping down medium voltages to low voltages. Distribution Transformer can either be of single-phase type or three-phase type.Three phase Distribution Transformer shall have a vector group Dyn11. Transformers used in Distribution Substation shall conform to the specifications of IEC 60076 All Parts Nigerian Electricity Supply and Installation Standards Regulation (2014).

The protection devices for distribution transformers shall be able to allow for the normal range of operating current due to energization, transient current, lightning and heavy temporary loading. Protection devices shall also be adequate to protect the transformer during extended period of heavy overload thereby protecting the system from a failed transformer.

- Transformer Primary Protective Devices

Fuses for the protection of distribution transformers shall be installed in accordance with manufacturer's specifications.

- Transformer Secondary Protective Devices As specified in Clause **6.2.2.1**

a. *Connection Cables*

The following regulations shall apply for the safe operation of transformer cables.

- *Medium Voltage Cables*

Medium Voltage Cables are cables that are capable of being operated at nominal voltage range of 1,000V to 33,000V. The insulation withstand voltage of high tension cables shall not be less than twice the nominal voltage rating of the cable as specified in IEC 60502-2.

- *Low Voltage Cables*

Low Voltage Cables are cables that are capable of being operated at nominal voltage of less than 1,000V. All Low Voltage cables shall be in compliance with Clauses XXX. The low voltage cables for 400/230 V level are to consist, according to requirement of single, two and four-core low voltage power cables.The standard phase colour shall be Red (L1 or R), Yellow (L2 or Y), Blue (L3 or B)(RYB), unless otherwise specified in IEC 60173.The insulation withstand voltage of low tension cables shall not be less than twicethe nominal voltage rating of the cable as specified in IEC 60502-1 NERC 2014.

- *LV Distribution (Feeder Pillar) Panels*
- *Structural and Mechanical Specifications*

Distribution Feeder Pillars can be designed / manufactured as a four way, six way or eight way power distribution application. Rear mounted phase bus bar, double door construction, weather proof coating, rubber seal gasket must have neutral and neutral earth bus bars.

Feeder Pillars shall be installed on a plinth of not less than 600 mm from the ground furnished with tamper proof lock and appropriate cable clamp.

- *Electrical Insulations*

The electrical insulation of Low Voltage Feeder Pillar shall be capable of withstanding a voltage not less than two times its nominal voltage.

- *Metering*

Low Voltage Distribution Feeder Pillars shall be metered for the purpose of measuring the parameters of the distribution network at each substation in accordance with the Nigerian Metering Code.

The following instruments shall be installed for the measuring of LV feeder pillar parameters;

- . Ammeter:

At least one ammeter shall be installed on a feeder pillar incomer bus bar.

- Voltmeter:

Voltmeter shall be installed on a feeder pillar to show line-to-line and line-to neutral voltages.

- Energy Meter:

Energy Meter for low voltage distribution feeder pillar panels shall be installed in accordance with the requirements of the Nigerian Metering Code.

- *Compact Distribution Substation (Transformer)*

Compact Distribution Substation shall be of indoor, outdoor or underground substation type with compartment for medium voltage switchgear, transformer and low voltage distribution board complete with necessary connection accessories in accordance with the requirements of IEC 62271-202 (NERC, 2014)

- *Pole Mounted Distribution Substation*

The requirements for distribution transformer specified in clause 6.2.1 shall apply. Pole mounted transformers for overhead Distribution Substation shall be installed at a minimum height of 3.0 m from the base of the pole. The materials to be used shall be of light weight, outdoor compatible, with integrated high and low voltage bushings and complete with corrosion, protection on all steel parts for improved public safety.The nominal operating voltage for pole mounted transformer substation shall lie between the medium voltage range and low voltage (NERC, 2014).

CHAPTER THREE
STUDY AREA AND METHODOLOGY

3.1 The Study Area

3.1.1 Location

The study area is absolutely located between Latitudes 11° 6′N - 11° 10′N of the Equator and Longitudes 7° 36′E - 7° 42′E of the Greenwich meridian and 652.6 meters above sea level. It is situated in Kaduna state of Nigeria. The area is bounded by Kudan LGA to the Northeast and Soba to the east, Igabi LGA to the southeast and Giwa LGA to the northwest. (See Fig. 3.1)

3.1.2 Climate

Zaria lies within a region which has the tropical continental climate (*Aw*), with distinct wet and dry seasons, the wet season occurring in the high-sun period. The rainfall is seasonal in character and about 90% of it falls between April and October, with the heaviest recorded in July and August. The mean annual rainfall is 800mm (Ojo, 1982). The low and seasonal rainfall of the area make its mark on the vegetation, which assumes various shades of green in the wet season and turns brown, pale or yellow in the dry season (Hore, 1970). According to Schwedferger (2007), the local people distinguish four seasons as follows:

a) *Bazara*(hot and dry): Mid-February to mid-May, the hot dry season;

b) *Damina*(wet): Mid-May to the end of September, the rainy season;

c) *Kaka* (dry): October to mid-December, the harvest season; and

d) *Rani* (cold and dry): Mid-December to mid-February, the cold dry season of the harmattan.

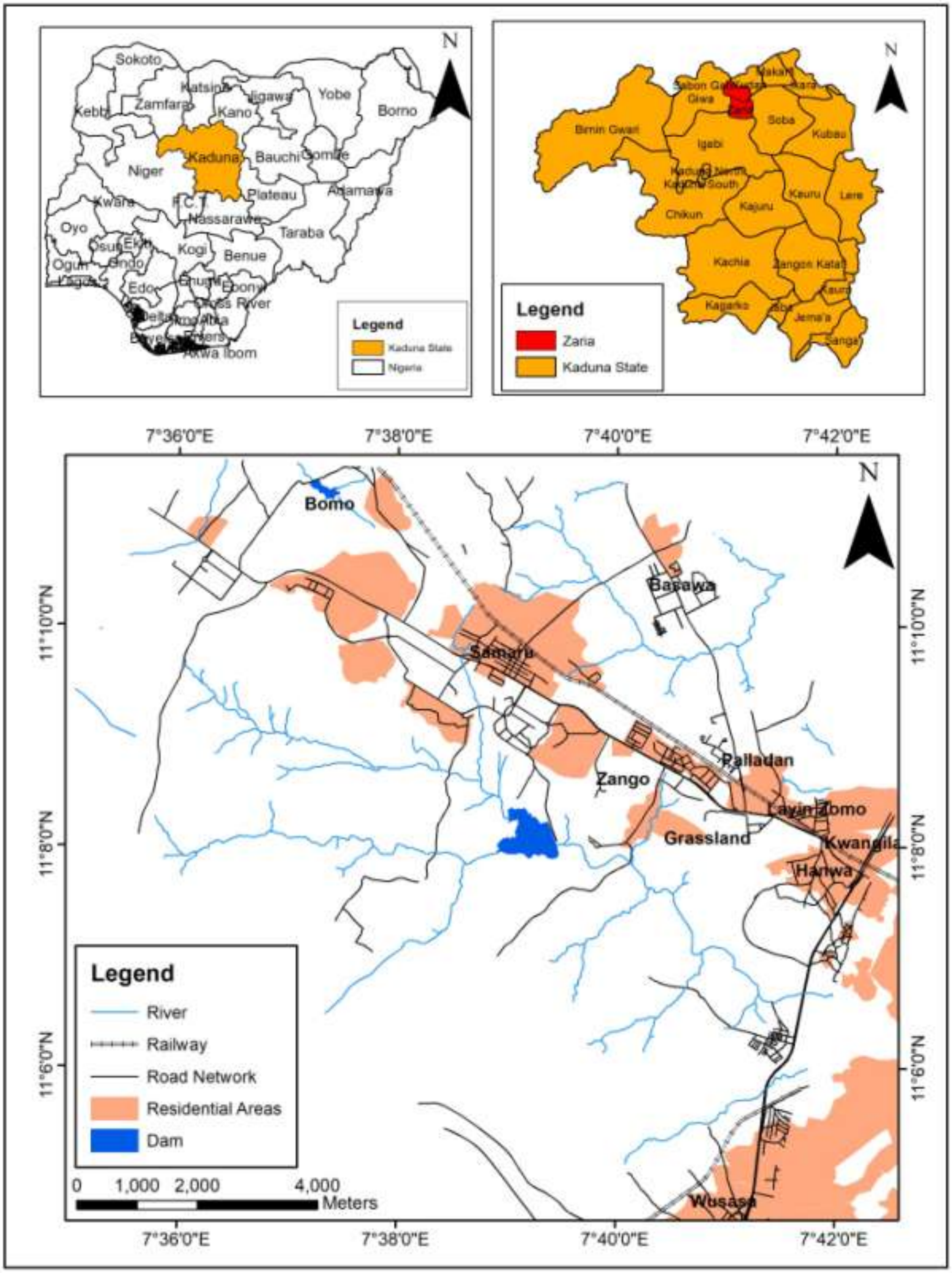

Fig.3.1: Samaru Business unit

Source: Adapted from Google Earth Pro, 2014

The onset of the rainy season is highly variable and unpredictable in the area, although long-term average appears to be first week of May (Owonubi and Olorunju, 1985). Variability in the mean cessation date of the rainy season has been reported to be October 8th, with an upper limit of October 23rd (Akintola, 1986). The dry season is practically rainless. It is characterized by hazy to dusty conditions, as well as low temperature, which is sometimes as low as 10^0C at night. Zaria and environs experiences a brief period of hot, but dry weather in March and April, during which average temperatures get higher than the approximately 27^0C monthly mean. As a result of this weather condition the study area has high demand for electricity supply for their day to day activities.

3.1.3 Population and people

Zaria has experienced rise or increase in population over the years. The population rose from less than 400,000 people in 1991 to 695,109 in 2006 (Federal Republic of Nigeria, 2007). Zaria has witnessed the high influx of people due to the expansion of educational and commercial establishments (Makera, 1989). With the increase in population, the demand for power supply has also increased thereby, mounting great pressure on the facility.

The inhabitants include Hausa, Fulani, Gbagi, Nupe, Yoruba, Ebira, Igbo, Kaje, Kagoro, Tiv, Idoma, Igala, Ikulu, Jaba, Ninzom, Kanuri, Zuru and a host of others. The density of the population ranges from 50-300 persons per square kilometer. Since the inception of Zaria in 1536 it has kept on growing and has since given rise to satellite towns such as Tudun-Wada, Samaru, Palladan, Muchia and Chikaji (Nigeria Galleria, 2016).

Zaria is also known as a nodal town that connects the northwest part of Nigeria which makes it a major commercial center. Most of these commercial activities depend on stable electric power to carry out businesses, handwork, and small industrial activities. The inconsistency of the electric power supply has caused people and industries many setbacks in their day to day activities in Zaria (Nigeria Galleria, 2016).

3.1.4 Economic activities

Economic activities found in Zaria include farming (rainfall and irrigation) such as maize, millet, guinea corn, vegetables among others. Other activities include administrative work, banking services, teaching, industries, and animal rearing (such as cattle, sheep, goat and horses).Among the major industries located in Zaria include the British American Tobacco, Zazzau pharmaceutical industry, Zazzau gunnery mills and other several small scale industries such as bricks and furniture making (Abbas, 1997).

The main types of land are found in the Zaria area: *gona* or upland fields which support, during the wet season only. Crops of relatively low value per acre such as millet, guineacorn, groundnut, and cotton. *Fadama* or low land fields which support, throughout the year, more labor-intensive, higher value per acre crops such as sugar-cone (Yusuf, 2010).With all these economic activities in Zaria, it is expected that the higher the volume of economic activities, the higher would be the demand for electricity supply.

3.2 Methodology

This section presents the reconnaissance survey, types of data, data processing design of database, and data analyses

3.2.1 Reconnaissance survey

A Reconnaissance survey was conducted by the researcher in order to be acquainted in the process, potential transects to be followed during the survey were selected in the study area. The reconnaissance survey provided the researcher withan in-depth knowledge of the electricity supply and distribution transformers in the study area. Also the survey helped to determine the type of analysis to be employed as well as the various issues to be address in the research.

3.2.2 Types and sources of data

S/No	Type	Source	Uses
1	Imagery	Goggle Image	Image of the study area
2	Location/Coordinate	Global Positioning System (GPS) Garmin78xc	Coordinates of Transformers
3	Non spatial/Attribute Data	KAEDCO/Self	Transformer Information
4	Population Data	National Population commission (NPC)	Sampling

Source: Author's Compilation

3.2.3 Data processing

The acquired satellite image of the study area was imported into the ArcGIS 10.1. The image wasgeoreferenced to register the image to a common coordinate system to establish the relationship between coordinates on a planar map and real world coordinates.The recorded coordinates of the various electricity distribution transformers was copied in notepad and saved as a .txt (plain text) file format. The file of coordinates (plain text) was imported and/or plotted into the digitized image (map of the study area) in the Arc Map 10.1 environment. A file geodatabase was involved with dataset projected using coordinate system WGS 1984 UTM zone 31N. The file geodatabase contain features named as building, roads, and transformers. The area of interest was delineated from the satellite image and subsequently used to subset other thematic layers. The coordinate point of the transformers acquired with the hand-held GPS, and was linked together and captured into the geodatabase using add xy coordinate in Arc Map environment. Electricity Distribution transformer map and data was created which shows the spatial location of the transformer as well as the spatial relationship between all KAEDCO asset and customer's connectivity to the transformer.

3.2.4 Sampling size and sampling technique

3.2.4.1 Sampling size

For the business units of the study area, nine areaswere randomly selected from the study area. The business units of the study area were selected on the basis of standing as the major educational, commercial and industrial areas in the business unit, and having the highest power consumption in the study area. This is based on the educational and commercial activities taking place as observed during the reconnaissance survey carried out. Therefore, a Sample of 9 areas was used for the study.

In determining the population of the study, Krejice and Morgan (1970) method of determining sample size was used. According to this method of sampling size determination for an area with a population of 50,000, it suffices to use a sample size 381 respondents. It was on this account that the sample population of the study, which stood as 381, was ascertained.

The proportion of respondents that was used per area in the study was determined using the formula for determine respondents given as:

$$s = X^2NP\ (1\text{-}P) \div d^2\ (N—1) + X^2\ P(1—P)$$

Where,

s = required sample size.

X^2= the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841).

N = the population size.

P = the population proportion (assumed to be 0.50 since this would provide the maximum sample size).

d^2= the degree of accuracy expressed as a proportion (.05).

3.2.4.2 Sampling technique

The fact that the study area was connected to the electricity distribution network all the nine areas of Samaru business unit were selected for this study to ensure adequate representation of the study area. This include: Basawa, Bomo, Hanwa, Kwangila, Layin-zomo, Palladan, Samaru, Wusasa and Zango. However the 9 area randomly sampled for this study to ensure a good geographical spread across the study area. Purposive sampling according to Bernard (2002) "is the deliberate choice of an informant due to the quality the informant process." The three hundred and eight one copies of a questionnaire were purposively administered proportional to the population of each area. For the purpose of administering the questionnaire, respondents were issued questionnaire. The purpose of this is to generate information from households who are residing in the area, who utilities electricity supplies for their livelihood and comfort. However, this research recorded a response rate of 100% (381 copies of the questionnaire were retrieved) which is adequate as it fell above recommended by Kelley, Clark, Brown, Viviene and Sitizia (2003).

3.2.5 Data analysis

Objective I: Identify and map the electricity distribution transformers in the study area.

To achieve the first objective, the image was georeferenced, and digitized to delineate the map. The recorded geographic coordinates of the various electricity distribution transformers were copied in notepad and saved as a .txt (plain text) file format. The coordinates were overlaid on the digitized map of the study area in the Arc Map 10.1 environment. A point map was generated showing the spatial distribution of electricity distribution transformers in the area.

Objectiveii: Create a Geodatabase of existing electricity distribution transformers in the area

The second objective was achieved through the use of the Arc Catalog Tool in the ArcGIS 1o.1environment.A file geodatabase was created using goggle map image and feature class named as roads, federal_roads, local_roads, rail_line, runway, stream and transformer coordinate were used and non spatial data of electricity distribution transformers were linked together and captured into the file geodatabase using add xy coordinate in the ArcMap environment of ArcGIS 10.1 Software.

Objectiveiii: characterize the electricity distribution transformers in the study area.

This objective was achieved using the non-spatial/attribute data of the electricity distribution transformers which was already integrated into the file geodatabase. Attribute of the electricity distribution transformer map showing transformers capacity was produce in ArcGIS 10.1 environment using the non-spatial data of electricity distribution transformer through the use of the symbology tool on the layer properties dialogue box of the ArcGIS 10.1 environment

Objective iv: determine the proximity of electricity distribution transformers to customers in the study area.

In order to determine the fourth objective, proximity analysis (buffer) of 600 meters was constructed around the electricity distribution transformers to determine the relationship or calculate the distance of an electricity distribution transformer from a customer.This is adopted from the KAEDCO‘s technical set standard that a transformer is supposed to serve a customer farthest at 600m distance from it position to avoid power losses.

Objective v: To determine the amount of power supply in the area

In order to achieve the fifth objective, descriptive statistics was used through frequency distribution and presentation of result in percentage

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents and discusses the results obtained from the analysis of data obtained from the field and the staff of KAEDCO. The results are presented using tables, maps and charts. A total of 84 electricity distribution transformers were captured.

4.2 Mapping of Electricity Distribution Transformers

The study covered Samaru distribution unit. Results obtained from the field survey showed that the distribution unit consists of 9 areas with different types of electricity distribution transformers. In the 9 areas of Samaru Distribution Unit, a total of 84 distribution transformers were identified and mapped. This is shown in Table 4.1

Table: 4.1: Distribution of Transformers

S/No	Area	Number of Transformers	Percentage (%)
1	Samaru	28	33.3
2	Wusasa	7	8.3
3	Hanwa	19	22.6
4	Palladan	8	9.5
5	Basawa	4	4.8
6	Bomo	3	3.6
7	Layin-zomo	3	3.6
8	Zango	9	10.7

9	Kwangila	3	3.6
	Total	84	100

Source: Author's field survey (2018)

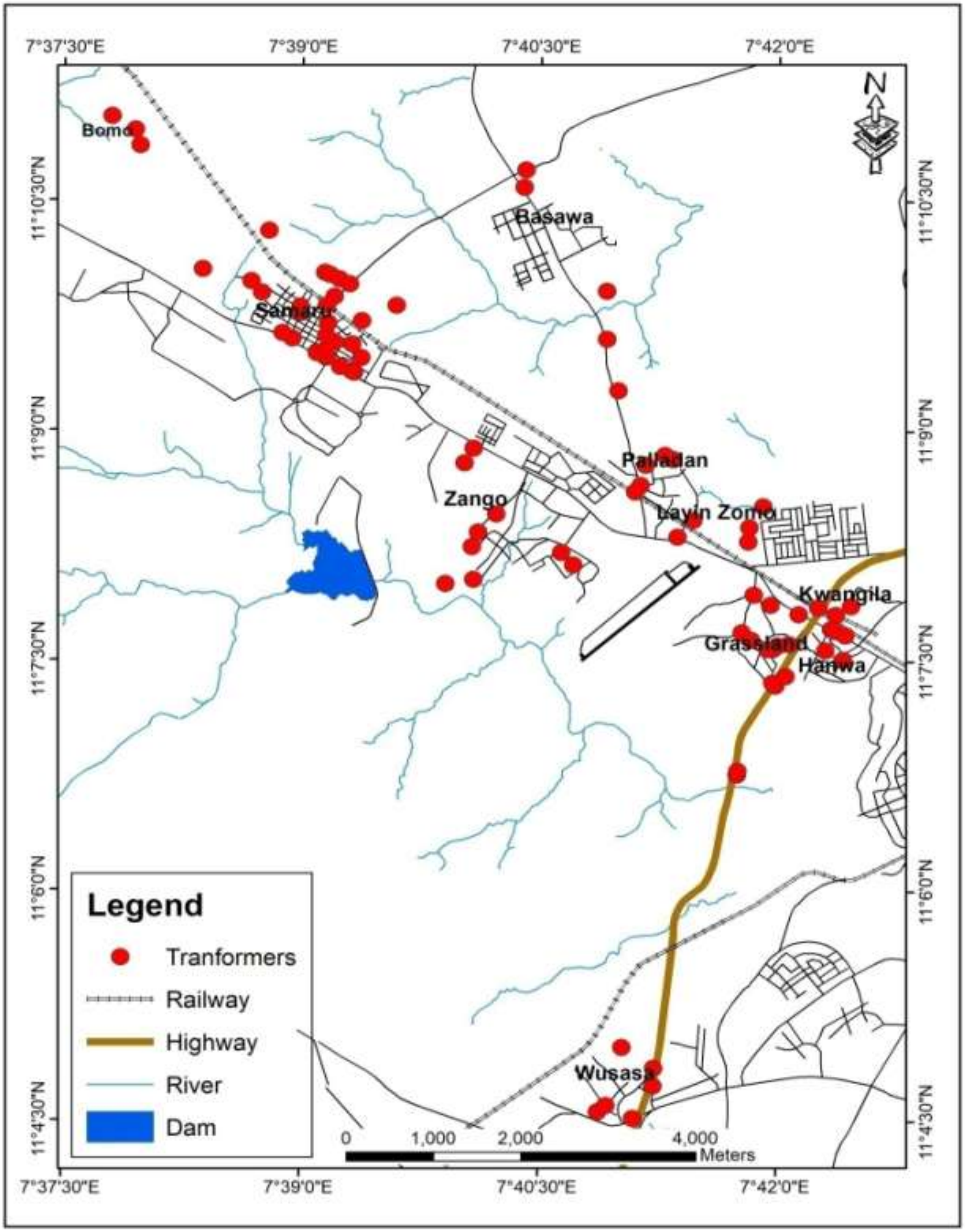

Fig 4.1: Distribution of Electricity Transformers in Samaru Business unit.
Source: Author's field survey (2018)

The findings from the study area revealed that Samaru and Hanwa distribution units had the highest concentration of electricity distribution transformers. Table 4.1 shows that Samaru distribution unit had the highest percentage of electricity distribution transformers in the area (33.3%), while Bomo, Kwangila and Layin-zomo, areas had the least (3.6%). The results further revealed that the areas with the least number of electricity distribution transformers are the areas which are experiencing rapid growth and development, but the areas with high number of electricity distribution transformers are areas with high population and presence of educational and commercial activities. This result corresponds with the findings of Chatta (2015) which revealed that areas with higher concentration of educational and commercial activities have high proportion of electricity distribution. The result on electricity distribution transformers further indicates that educational and commercial activities lead to high concentration electricity distribution transformers.

4.3 Types of Electricity Distribution Transformers

According to KAEDCO the types of electricity distribution transformers can either be public or dedicated (private). The research finding shows that majority of the transformers in Samaru Business unit are public transformers. Table 4.2 shows types of electricity distribution transformers.

The results in Table 4.2 shows that Samaru had the highest proportion of public electricity distribution transformers (28.8%) in the area, followed by Hanwa (17.8%), while Bomo, Basawa and layin-zomo had the least of public electricity distribution transformers. The result further shows that Samaru had the highest proportion of dedicated electricity distribution transformers which accounted for 38.5%, while Bomo and Layin-zomo had the least of dedicated electricity distribution transformers. The result

Table 4.2 Typesof Electricity Distribution Transformers

S/No	Distribution Unit	Public Transformers		Dedicated Transformers		Total	
		Freq	**(%)**	**Freq**	**(%)**	**Freq**	**(%)**
1	Basawa	2	4.4	2	5.1	4	4.8
2	Bomo	2	4.4	1	2.6	3	3.6
3	Hanwa	8	17.8	11	28.2	19	22.6
4	Kwangila	3	6.6	-	-	3	3.6
5	Layin-zomo	2	4.4	1	2.6	3	3.6
6	Palladan	5	11.1	3	7.7	8	9.5
7	Samaru	13	28.8	15	38.5	28	33.3
8	Wusasa	4	8.8	3	7.7	7	8.3
9	Zango	6	13.3	3	7.7	9	10.7
	Total	**45(53.5)**	**100**	**39(46.4)**	**100**	**84**	**100**

Source: Author’s Analysis (2018)

revealed that the areas where commercial and educational activities are taking place like Samaru had the highest concentration of public and dedicated transformers, because of these commercial and educational activities in the area has warranted for high demand for electricity supply,

The study further reveals that 53.6% of the electricity distribution transformers in the area were general public electricity distribution transformer while 46.4% were dedicated. It was realized that the dedicated transformers in the area were installed by organizations such as banks and even residential houses in order to boost their electricity supply from the distribution network and avoid problems like load shedding and tripping of transformers.

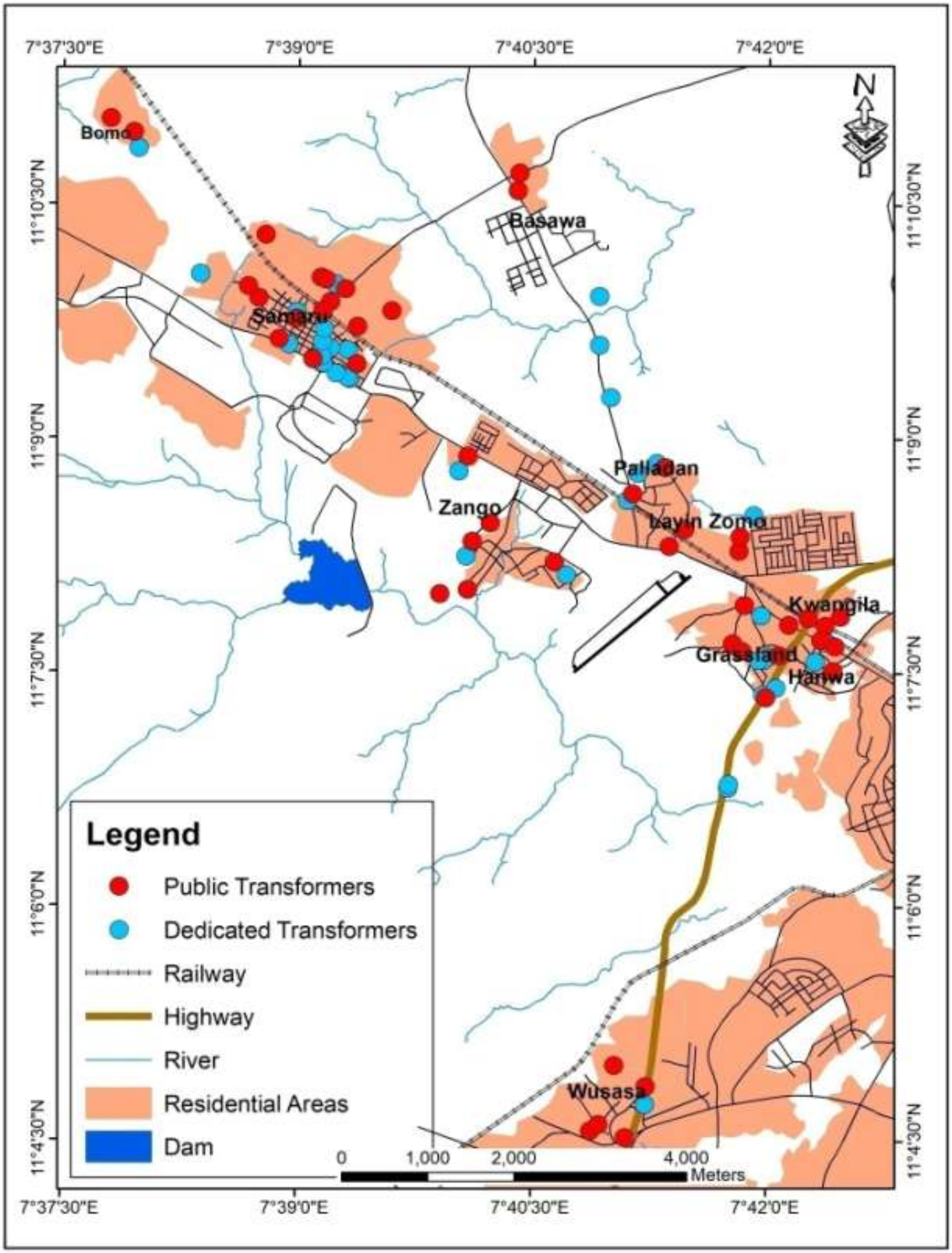

Figure: 4.2 Types of Electricity Distribution Transformers
Source: Author's field survey (2018)

4.4 Characteristic of Electricity Distribution Transformer in the Study Area

4.4.1Capacity of Electricity Distribution Transformer

The characteristics of electricity distribution transformers were examined through the process of spatial query analysis carried out on the database created. The electricity distribution transformers were characterized into four categories based on their capacity. They are 500KVA, 300KVA, 100KVA and 50KVA. Table 4.3 present this

Table 4.3: Capacity of Electricity Distribution Transformers

Distribution unit(s)	500KVA		300KVA		100KVA		50KVA		Total	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Basawa	-	-	1	4.8	4	14.3	-	-	5	4.8
Bomo	-	-	1	4.8	1	3.6	1	5.9	3	3.6
Hanwa	3	16.6	5	23.8	6	21.4	5	29.4	19	22.6
Kwangila	2	11.1	1	4.8	-	-	-	-	3	3.6
Layin-zomo	-	-	2	9.5	1	3.6	-	-	3	3.6
Palladan	3	16.6	2	9.5	3	10.7	-	-	8	9.5
Samaru	6	33.3	7	33.3	6	21.	9	52.	28	33.

						4		9		3
Wusasa	3	16.6	1	4.8	1	3.6	1	5.9	6	8.3
Zango	1	5.5	1	4.8	6	21.4	1	5.9	9	10.7
Total	18 (21.4%)	100	21(26.2%)	100	28(32.1)	100	17(20.2)	100	84	100

Source: Author's Analysis (2018)

Table 4.3 shows the capacity of electricity distribution transformer in the study area. The result shows that Samaru had the highest percentage of 500 KVA(33.3%) while Zango had the least 5.5%. In addition, Hanwa distribution unit had the highest percentage of 300 KVA electricity distribution transformers (23.8%). Hanwa, Samaru and Zango units accounted for the highest percentage of 100 KVA transformers while Bomo, Layin-zomo has the least percentage of 100 KVA transformers which accounted for 3.6%.

The 50KVA electricity distribution transformers have the least capacity in the study area, and Samaru unit accounted for the highest percentage of it (52.9%) while Basawa and palladan units do not have such type of electricity distribution transformers. The analysis carried out on the capacity of electricity distribution transformers reveals that the 100KVA accounted for the highest percentage of electricity distribution transformers in the study area (32.1%) while 50KVA electricity distribution transformers accounted for the least percentage of electricity distribution transformers which accounted for 20.2% of electricity distribution transformers in the study area. From the result, it shows that the 100KVA transformers are the most widely used transformers in the study area. This is so because it is used for both the general public and private purposes. The result contradicts with that of Chatta (2015)in Sabongari local government area Zaria, Kaduna state, Nigeria where it was found that 500KVA wasthe highest capacity of transformer in the study area, with a proportion of 70% which is mostly found in the residential areas because the transformers carry more houses than the other transformers. While on the other hand the result disagreed with the findings of Chatta (2015) that 100KVA is the lowest capacity of transformer in the study area.

Figure 4.3 shows the capacity of electricity distribution transformers in the area. The 500KVA electricity distribution transformers are represented in blue colour, the 300KVA electricity distribution transformers are represented in red colour, the 100KVA electricity distribution transformers are represented in green colour, while the 50KVA electricity distribution transformers

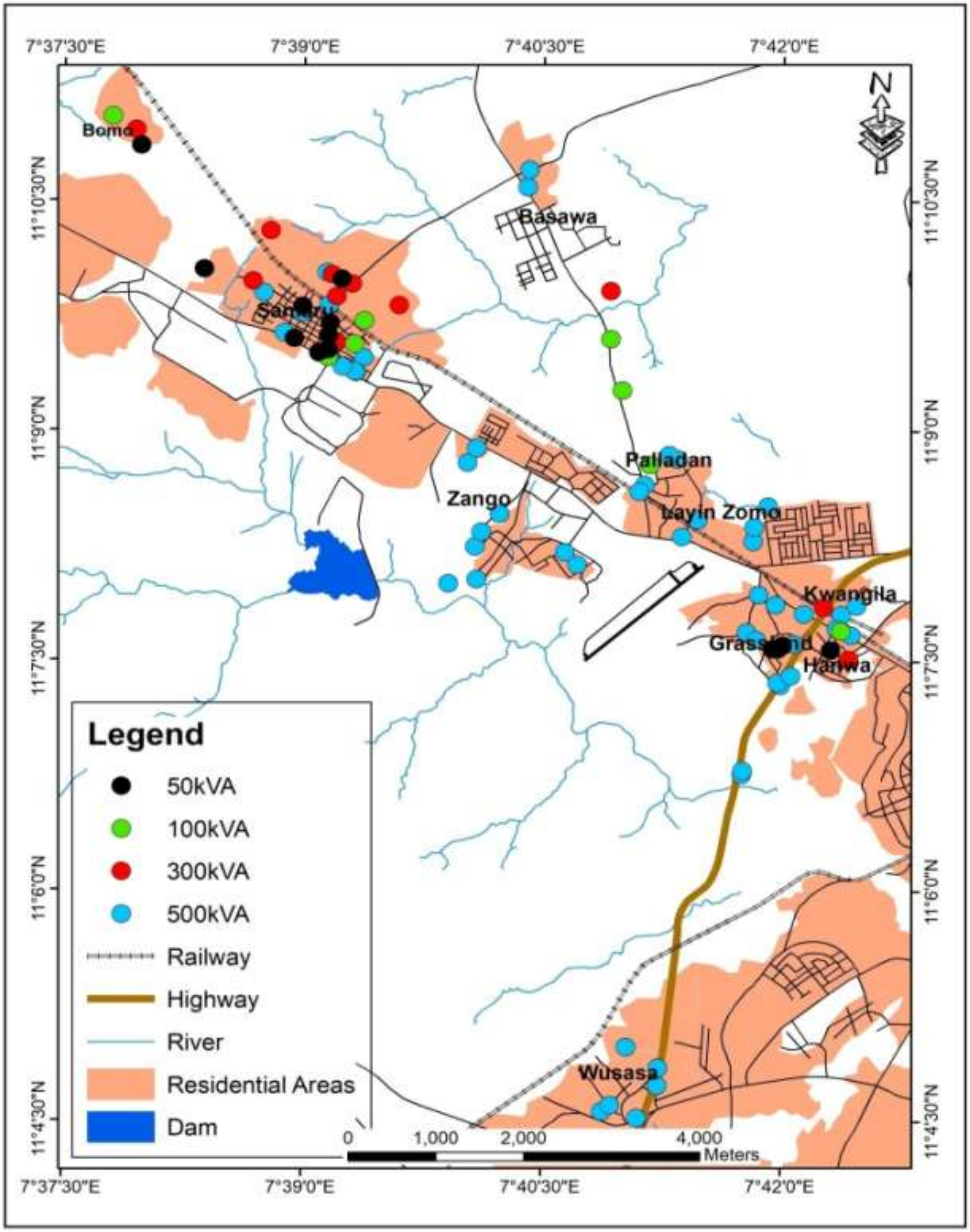

Figure 4.3: Capacity of Electricity Distribution Transformers in the study area
Source: Author's Field Survey (2018)

are represented in black colour. From the map it shows that electricity distribution transformers are sparsely distributed in the area, only few are in cluster form.

4.4.2 Present status of electricity distribution transformer in the study area

In order to determine the present state of electricity distribution transformers spatial query was carried out on the database to identify the electricity distribution transformers that were not connected or were connected to the electricity distribution network. The result shows that almost all the electricity distribution transformers in the study area were connected to the electricity distribution network.

It can be seen from Table 4.4 that Samaru has 34.2% of connected electricity distribution transformers which had the highest, followed by Hanwa with 20%. As shown from the study that in all the units studied, Samaru and Hanwa were the main areas of educational and commercial activities, followed by Zango with 11.4%, Palladan and Wusasa had 8.9%, Basawa accounted for 5.1%, Bomo, Kwangila, and Layin-zomo had the least number of connected electricity distribution transformers. On the other hand, Hanwa had 60% of electricity distribution transformers that were not connected to the electricity distribution network, followed by Palladan and Layin-zomo with 20% each. The study also revealed that majority of the electricitydistribution transformers that were not connected to the electricity distribution network are dedicated electricity distribution transformers. The result conform with that of Chatta (2015) which showed that about 80% of public transformers need repairs, while the rest 20% need to be

Table 4.4: Statusof Electricity Distribution Transformers

S/NO	Distribution unit(s)	Connected		Not connected		Total	
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
1	Basawa	4	5.1	-	-	4	4.8
2	Bomo	3	3.8	-	-	3	3.6
3	Hanwa	16	20.1	3	60	19	22.6
4	Kwangila	3	3.8	-	-	3	3.6
5	Layin-zomo	3	3.8	1	20	3	3.6
6	Palladan	7	8.9	1	20	8	9.5
7	Samaru	27	34.2	-	-	28	33.3
8	Wusasa	7	8.9	-	-	7	8.3
9	Zango	9	11.4	-	-	9	10.7
	Total	79(94.0)	100	5(6.0)	100	84	100

Source: Authors Field Survey (2018)

changed and about 100% of the private transformers were in good condition. Equally, the result agreed to some extent with the finding of Ihiabe, Ajileye, Samson, and Onuh (2015) in Ife central local government that all the distribution substation were connected to the distribution network.

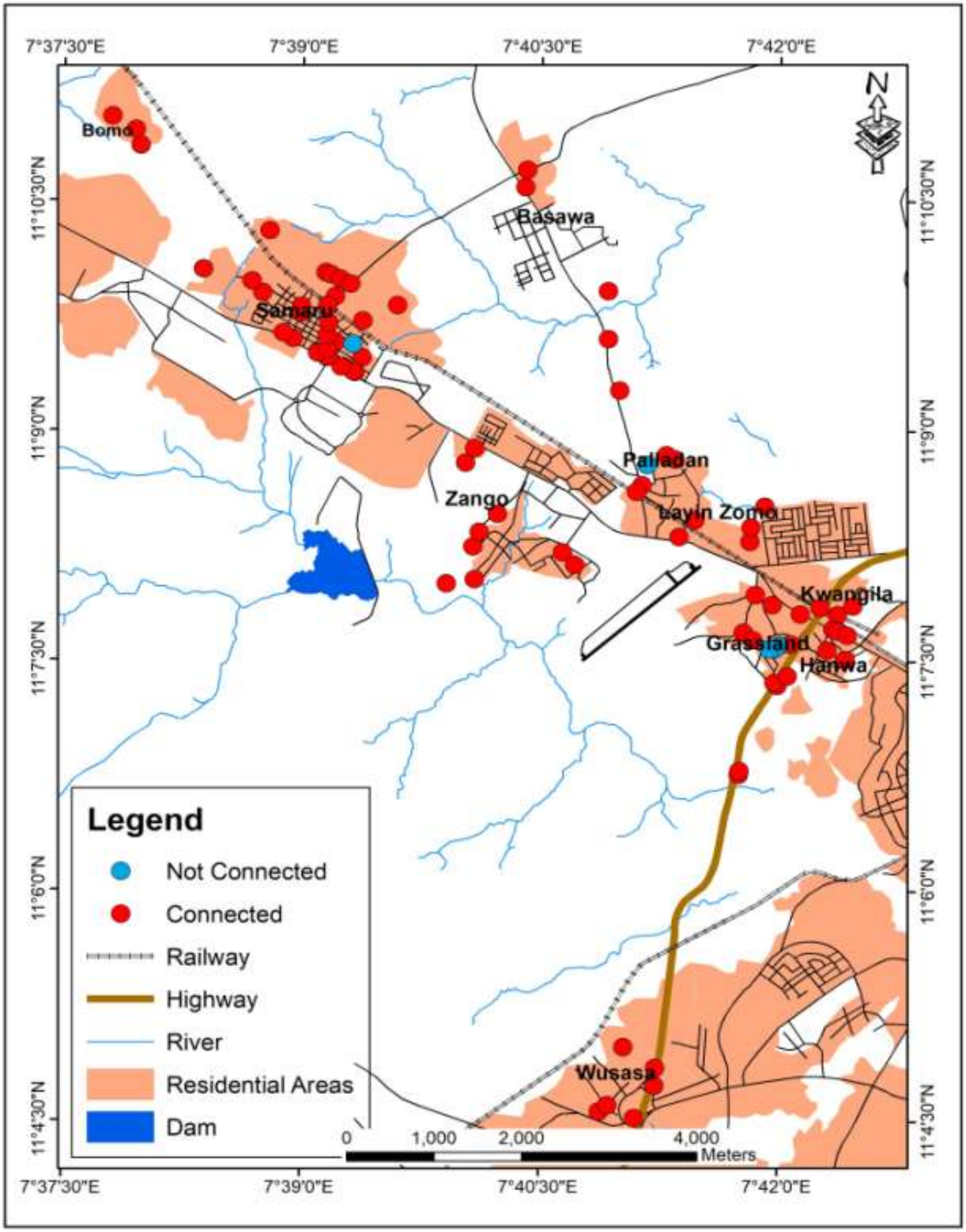

Figure 4.4:Present Status of Electricity Distribution Transformers in the Study Area
Source: Author's Field Survey (2018)

4.5 Proximity of Electricity Distribution Transformer to Consumer

Proximity analysis reveals that the houses that fall within the buffer zone of 600 meters radius were properly served by the electricity distribution transformers,while houses that fall outside the zone would not be properly served. Houses that are close to the electricity distribution transformer will be properly served by the electricity distribution transformer, while houses that are farther from the electricity distribution transformer will experience poor power supply, because an electricity distribution transformer is expected to serve an approximate geographical area of 600metersraduis to avoid power loses due to power conduction over longer distances and also to ensure that the protection mechanism (fuses) perform optimum (Short, 2004). The buffer was overlaid on the raster image of the study area showing that about 300 houses were connected to electricity distribution transformers.

Figure 4.5shows that 55% - 60% of households connected to the electricity distribution transformers were properly served with higher voltage of power, while about 40% - 45% were averagely served, because they are outside the radius. Equally the result agreed to some extent with the findings of Ihiabe, Ajileye, Samson, and Onuh (2015) in Ife central local government area where a transformer rated 500KVA with 4 upriser connected to numerous distribution lines serving 250 buildings with an average consumption rate of 0.38% KW and total consumption of 94.9%KW with an excess of 4.6%KW, indicating that the transformer is overloaded.

The result in Figure 4.5 authenticated the findings of Ospokalor and Dare-Alao (2013) that consumers within a 300meter radius to a distribution substation transformer, experience higher voltage of power compared to the households outside the radius. Wanjohi (2016) dictates that medium voltage does not exist around demand centers; it would require extension of medium voltage line.

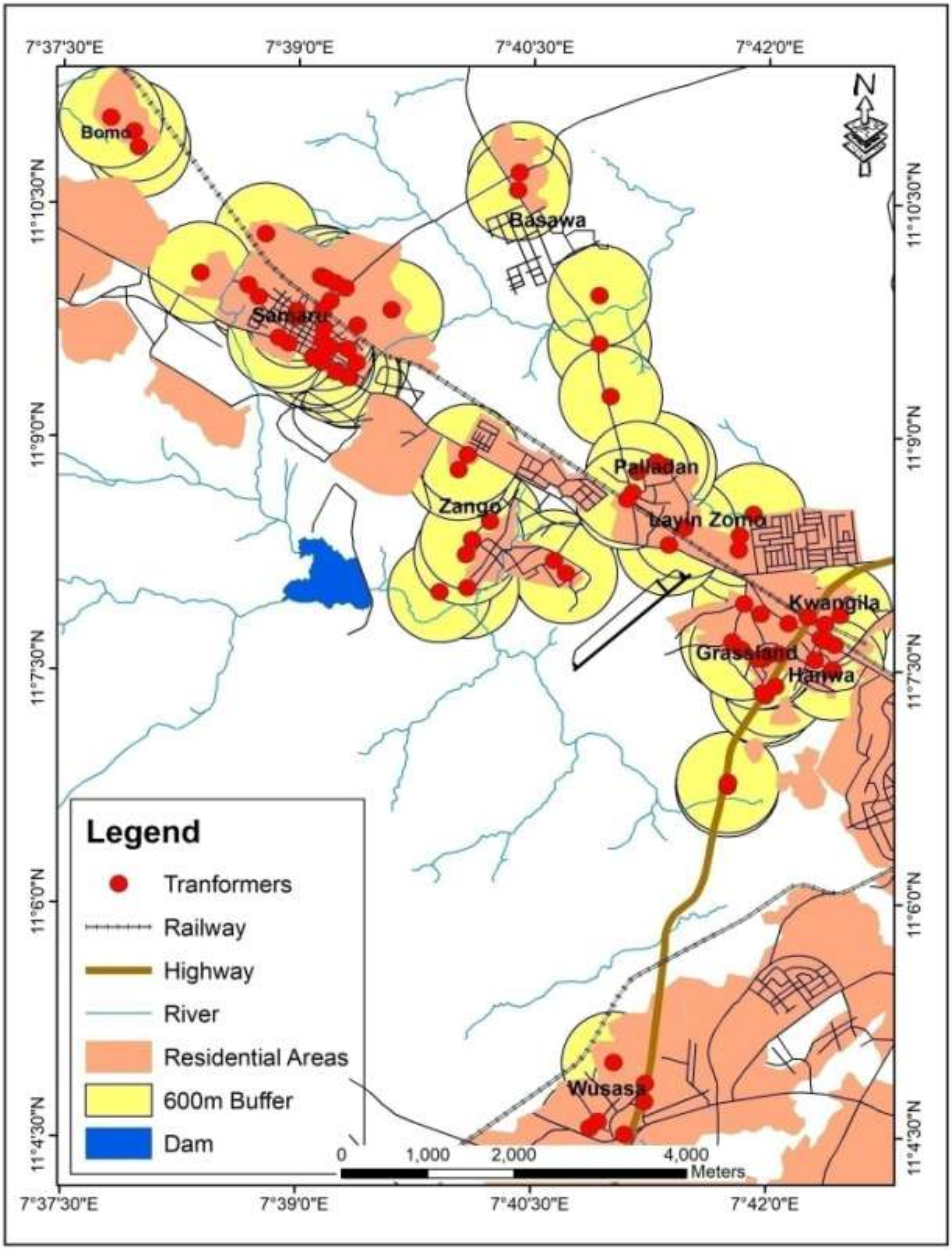

Figure 4.5: Proximityof Electricity Distribution Transformers to Residents
Source: Author's Field Survey (2018)

4.6 Socio-Demographic Characteristic of Respondents

The socio-demographic characteristic of respondents plays an important role in assessing electricity distribution transformers. The respondent's characteristics cover sex, age, marital status, household size, occupation, and level of education of the respondents in the study area.

4.7.1 Gender of the respondents

The sex distribution of respondents in the study area is presented in Table 4.9

Table4.5: Gender of the Respondents

Sex	Basawa	Bomo	Hanwa	Kwangila	Layin-zomo	Palladan	Samaru	Wusasa	Zango	Total	
										Freq	%
Male	20	30	35	28	19	15	42	20	24	233	61.15
Female	5	7	26	16	8	14	35	18	19	148	38.84
Total	25	37	61	44	27	29	77	38	43	381	100

Source: Author's Field Survey (2018)

From Table 4.5 the male constitute the dominant population 61.80%. A major reason for this result was that most of household heads, artisans and others business related to the use of electricity were dominated by males. This is in line with the studies carried out in Sabon-Gari local government area by Chatta (2015) which reveals that males are mainly the household heads and participate in productive activities than the females. Although females actively participate in the primary activities, the males' population weremore to predominantly involved, thus the high percentage of male respondents is recorded.

4.7 Distribution of respondents by age

The age distribution of the respondents in the study area is presented in Table 4.1

Table 4.6: Age Distribution of Respondents

Age	Basawa	Bomo	Hanwa	Kwangila	Layin-zomo	Palladan	Samaru	Wusasa	Zango	Total	
										Freq	%
Less than 20	1	3	-	4	2	2	2	3	1	18	5.50
21-30	8	7	13	12	11	10	14	9	13	97	25.40
31-40	11	10	16	10	11	13	20	14	14	119	31.50
41-50	8	5	10	7	10	12	9	13	7	81	21.00
51-60	1	2	7	6	4	10	9	8	5	52	13.50
Above 61	-	-	2	-	3	2	4	1	2	14	3.30
Total	29	27	48	39	41	49	58	48	42	381	100

Source: Author's Field Survey (2018)

Table 4.6 reveals that 31.00% falls between the adult age group of 31-40 years, it implies that majority of the respondents are old enough to provide wealthy information and responses to the research questionnaire with regards to their perceptions of the study under review. The results indicate that most of the respondents are of ages ranging from 31 years. With such an aged resident, information on power supply is bound to be correct. The result is in agreement with the findings of Chatta (2015) which posited that the high usage of electricity supply to earn an income or source of livelihood in the area, are implicated for the relatively productive age that uses the electricity supply.

4.8 **Occupation of Respondents**

The distribution of occupation in the study area is presented inTable 4.7

Table 4.7:Occupation of Respondents

Occupation	Basawa	Bomo	Hanwa	Kwangila	Layin-zomo	Palladan	Samaru	Wusasa	zango	Total	
										Freq	%
Civil service	9	10	19	9	11	10	32	13	17	130	34.12
Petty trading	8	5	10	8	6	7	14	11	7	76	19.94
Farming	17	16	14	13	8	14	20	6	10	118	30.97
Artisan	3	1	5	9	4	6	15	8	6	57	14.96
Total	37	32	45	39	29	37	81	38	40	381	100

Source: Author's Field Survey (2018)

Table 4.7 reveals that 34.07% of the respondents were civil servants. This result is in agreement with other related studies on electricity distribution in some parts of the study area. The result shows that almost 100% of the respondents are into one specific occupation or the other where electricity supply is very essential for their daily activities. Electricity is required by traders for their business operations, artisans like welders use it to operate their machines. The civil servants required electricity in their offices for their electrical appliances to work. This reveals that there is high utilization of electricity in the area since virtually every occupational group requires electricity.

4.9 Types of Electrical Appliances in Houses

The type of electrical appliance in the study area is presented in Table 4.8

The response on types of electrical appliances by the respondents are presented in Table 4.8: the area with highest number of electrical appliances in the area is Zango with 25.20% and all the area were found to be significant with pressing iron having the highest number 5.55% followed by blender 30%, television 25.68%, refrigerator 26.28%, electrical stove 33.33% respectively followed by radio, washing machine, water heater, electrical oven and grinding machine in that order. This result is supported by the findings of Olaniyi and Usman (2006) that electricity distribution transformers are greatly affected by electrical appliance in an area with appliances with higher electricity consumption.Hanwa was the next area with high response on types of electrical appliances in the study area with 23.88%.

The result of the respondents in the study area was equally significantly high with pressing iron having 21.11%, followed by television and blender with 27.59% and 25% respectively.

Table 4.8: Type of Electrical Appliance in the Study Area

	Washing Machine		Pressing Iron		Television		Blender		Refrigerator		Radio		Water Heater		Electric Stove		Electric Oven		Grinding Machine		Total	
Area	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%
Basawa	-	-	1	1.11	2	3.44	-	-	1	2.44	5	6.94	-	-	-	-	-	-	-	-	9	2.36
Bomo	-	-	2	2.22	1	1.25	-	-	-	-	3	4.17	-	-	-	-	-	-	-	-	6	1.57
Hanwa	5	50	19	21.11	16	27.59	15	25	10	24.39	15	20.83	2	40	4	13.33	5	50	-	-	86	23.88
Kwangila	-	-	1	1.11	4	6.89	1	1.66	3	7.32	6	8.33	-	-	-	-	-	-	1	20	16	4.19
Layin-zomo	-	-	2	2.22	3	5.17	2	3.33	3	7.32	15	20.83	-	-	2	6.67	-	-	-	-	22	7.08
Palladan	-	-	5	5.55	2	3.44	5	8.33	2	4.88	6	8.33	-	-	1	3.33	1	10	-	-	22	5.77
Wusasa	-	-	10	11.11	5	8.62	8	13.33	5	12.19	5	6.94	-	-	1	3.33	-	-	-	-	34	8.92
Samara	1	10	18	20.00	10	17.24	11	18.33	6	14.63	12	16.67	-	-	12	40	2	20	3	60	75	19.68
Zango	4	40	32	5.55	15	25.68	18	30	11	26.83	5	6.94	3	60	10	33.33	1	10	1	20	91	25.20
Total	10	100	90	100	58	100	60	100	41	100	62	100	5	100	30	100	10	100	5	**100**	**361**	**100**

Source: Author's Field Survey (2018)

The response of respondents in Samaru and Wusasa areas were high with 19.68% and 8.92% respectively. The types of electrical appliances for each of these areas were significantly highwith pressing iron having the highest respondents with 20.00% for Samaru while Wusasa on the other hand is having the highest types of electrical appliance with 11.11% for pressing iron. The fact that most of the respondents have access to electricity supply the use for their residential activities and economical activities for their livelihood made electricity supply consumption high in the area. This result on types of electrical appliances is in agreement with the findings of Wanjohi (2016),Ihiabe, Ajileye, Samson and Onuh (2015) which posited that types of electrical appliance can lead to higher consumption of electricity supply in the area. The result on types of electrical appliances further indicates that usage of electrical appliances with higher consumption above the carrying capacity of an electricity distribution transformers leads to tripping or load shielding.

4.10 Duration of Power Supply

Duration of power supply of the respondents in the study area is presented in Table 4.9

Table 4.9 reveals the duration of power supply in the area less than 6 hours accounted for 59.84% with Hanwa having the highest proportion of 15.75%, followed by Palladan and Samaru(14.09%), Kwangila(12.13%), and Wusasa(11.36%).

About26.24% of the respondents had 7-12hours power supply. Wusasa had the highest proportion (25.93%) followed by Hanwa and Zango with 20.37% and 15.74% respectively.

Table 4.9: shows the duration of power supply

S/No	Area	Less Than 6 Hours		7-12 Hours		13-18hours		19-24hours		Total	
		Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
1	Basawa	17	7.73	8	7.40	5	9.43	-	-	30	7.87
2	Bomo	20	9.09	7	6.48	7	13.20	-	-	34	8.92
3	Hanwa	35	15.91	22	20.37	5	9.43	-	-	62	16.27
4	Kwangila	28	12.73	10	9.26	3	5.66	-	-	41	10.76
5	Layin-zomo	18	8.18	-	-	8	15.09	-	-	26	6.82
6	Palladan	31	14.09	-	-	10	18.86	-	-	41	10.76
7	Wusasa	25	11.36	28	25.93	-	-	-	-	53	11.28
8	Samaru	31	14.09	16	14.81	5	9.43	-	-	52	16.27
9	Zango	15	6.82	17	15.74	10	18.86	-	-	42	11.02
	Total	220	100(59.84)	108	100(26.24)	53	100(13.91)	-	-	381	100

Source: Author’s Field Survey (2018)

The results also show 13.91% of the respondents had 13-18 hours power supply of which Palladan and Zango had 18.86% followed by Layin-zomo(15.09%), Bomo(13.20%), Samaru and Basawa(9.43%) while Kwangila had the least (5.66%). The result on the duration of power supply aliens with the findings of Ladigbolu (2010) that some areas experiences less than 12 hours of power supply while some areas receives less than 6 hours.

.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Findings

This study analyzed the distribution of electricity distribution transformers in Samaru Business unit. The findings revealed that there were 84 electricity distribution transformers in the study areas, and 33.3% of them were found in Samaru area. This high concentration of the transformers in Samaru area was due to the presence of educational, commercial activities and growing manufacturing industrial. The findings also shows that 28.8% of dedicated electricity distribution transformers were found in Samaru, while 4.4% of the public electricity distribution transformers were found in Basawa, Bomo and Layin-zomo. Hanwa had the highest concentration of private (dedicated) electricity distribution transformers while Layin-zomo and Palladan had the least (2.6%).

The capacity level of the electricity distribution transformers shows that areas where educational and commercial activities are taking place, like Samaru had the highest concentration of the transformerswith high capacity (33.3%) and most of these transformers were public electricity distribution transformers .The 100kva electricity distribution transformers were the most widely used transformers in the study area accounting for 32.1%. This type of electricity distribution transformers is used for both public and private purposes.

About 34.2% of the electricity distribution transformers that were connected to the electricity distribution network were found in Samaru while 60% of the electricity distribution transformers that were not connected to electricity distribution network were found in Hanwa area and they are dedicated electricity distribution transformers.

The proximity analysis shows that houses that fall within the buffer radius of 600meter would be adequately served by the electricity distribution transformer within the buffered area while the ones that fall outside the zone would be inadequately served.

5.2 Conclusion

This study has provided comprehensive information on the existing electricity distribution transformers in Samaru business unit, Kaduna State. It has shown how geospatial techniques can be employed in the management of electricity distribution transformers and information of other related facilities for effective and efficient power supply. The analogue system means acceptance of in flexibility resulting from data storage in fixed forms and format. The rapid increase in population of the study area has brought the expansion of settlement in the area, which has raised the demand for electricity in the area, thus leading to the extension of the electricity distribution network. Therefore, there is the need for up-date information of the electricity distribution facilities and that of development and growing concern over environmental issues to aid efficient and effective power supply in the area.

5.3 Recommendations

The study made the following recommendations

In light of the findings of this study, the following are important recommendations that are meant to improve the management strategies of electricity supply.

1. The KAEDCO should provide more electricity distribution transformers in the study area like Zango, Palladan, Layin-zomoetc that experience rapid growth and development, so as to meetup with the growing demand electricity supply.

2. Areas with electricitydistribution transformers with lower capacity should be upgraded with higher capacity electricity distribution transformers so as to improve electricity supply in the area.
3. The proximity of an electricity distribution transformer to a customer should be adhere, so as to avoid power loses and ensure that protection mechanism (fuses) performs optimum.
4. There should be involvement of spatial intelligence planning which could be achieved by employing the services of GIS. The current state of not having a proper distribution mapping system is not good for essential planning and management. In many instances what is available are land base and electricity network distribution sketches and not maps lined up with any known coordinate system. Thus having a robust GIS section in the electricity industry.

5.4 Suggestions for Further Studies

1. There is the need for more studies on electricity distribution transformers especially issues related to site selection, suitability and optimization.

2. Transformer maintenance was not considered by the study simply because of time limitation; this can be an area for future research.

3. Transformer auditing as a vital issue in the electricity sector can also be a vital area of research.

4. Transformers on 33kva distribution network were not captured by this study, it can also be an area of research.

5. Customers consumption of electricity power has not been considered by this research, which can be an area for research

REFERENCES

Abbas.I.M (The Political Economy of Rural Development in Nigeria: A Study of Rural Zaria. Unpublished Ph.d Dissertation Ahmadu Bello University Zaria.

Adejuwon. S. A,Adejuwon. J. O, and Balogun, E.E (1989).The Annual and Seasonal Patterns of Rainfall Fluctuations in Sub-saharan West Africa. *International Journal of Climatology, vol. 10*, Pp 839-843.

Adekunle, A.A. (1995), Utility Mapping Using GIS Technique: A case study of University of Lagos, Unpublished B.sc project Submitted to the Department of Geography and Planning, University of Lagos.

Adeoye, A. (1998), Geographic/Land Information Systems: Principles and Application, Information Management Consultants, Ebute-Metta, Lagos, Nigeria, pp. 77-79, 172175.

Adetoro, S.A. (2002), Developing Geographic Information System for Utility Management: A case study of Electricity Distribution Lines and Transformer Stations in ObefemiAwolowo University: Ile-Ife, Proceeding of the Technical Session of the 37th Annual General Conference and Meeting of Nigerian Institution of Surveyors, Owerri, Imo State, Nigeria, pp. 57-62.

Akus, G. (2011). An Analysis of the Spatio-Temporal Variation of Public Electricity supply and Demand in the Zaria Area, an Unpublished M.sc. Thesis Submitted to the Department of Geography, Ahmadu Bello University, Zaria, Nigeria.

Alawiye, A (2011) Power Sector and Industrial Development in Nigeria case: Power Holding Company of Nigeria An unpublished Bachelor‘s Degree. Degree Programme in International Business Lahti University of applied sciences Autumn

Ayobowale, I. (2011) A Legal Appraisal of the Electric Power Sector Reforms in Nigeria An unpublished LL.B Long Essay submitted to the Faculty of Law, University of Ilorin

Ayodele, A. S. (2004). Improving and sustaining power (electricity) supply for socio economic development in Nigeria.

Baker, M (2012) Updated GIS Database Design: Geodatabase Model City of Suffolk, Virginia

Bawa, M.(2005) The effect of irregular supply of electric power to small scale enterprises in the central business district of SabonGari Zaria, An unpublished B.sc project submitted to the Department of Geography Ahamdu Bello University Zaria.

Berst, T. & Michael, C (2008): *New Opportunities from the Transformation of the Electric Power Sector*, The Electricity Economy fifth edition. Available at http://www.globalenvironmentfund.com/data/uploads/The%20Electricity%20Economy.pdf Accessed 22/10/2014 11:30am

Burrough, P.A. and McDonnell, R. (1998).Principles of geographical information systems, Oxford: Oxford University Press.

Caven B. (1998) Optimization of the Reliability of Electricity Power supply in Nigeria. A working paper presented in NEPA Headquarters. Vol. 1 pp 39-41

Chatta, G.O, (2015) Spatial Distribution and Utilization of Electricity Transformer in Sabon Gari Local Government Area Zaria, Kaduna State, NigeriaAn unpublished M.sc dissertation submitted to the school of postgraduate studies, Ahmadu Bello university, Zaria, Nigeria

Chudi, N. (2011) 'Road Map to the Reform of the Electric Power Sector' http://www.nercng. Accessed on 27 March 2016

Donald G, Fink T and Wayne H B (2013):"Standard Handbook for Electrical Engineers," McGrew Hill International Edition, Pp 98-104.

Electric Power Sector Reform Implementation Committee, (EPIC) (2004).National electric power policy.Retrieved on 21st July, 2007. Accessed on 7/7/2014

Electric Power Sector Reform Act No. 77 of 2005.

Electrical Technology, (2012) Transformer Construction, working, types, application and limitations Http://electricaltechnology.org. Accessed 3/4/2017 1:30pm

Emengini, E.J. (2004), Application of Geographic Information System (GIS) to Utility Information Management: A Cases study of Onisha-North L.G.A., Anmabra State, Nigeria, An Unpublished M.sc Thesis Submitted to the Department of Survey and Geoinformatics, NmandiAzikiwe University, Akwa, Anambra State Nigeria. http://www.allbusiness.com/utilities/680477-1.html. Accessed on 5/6/2013 1:19pm

Emoh, F.I., Oni, A.O., &Egolum, C.C.(2013). Prioritizing Residential Land Value Determinants in Onitsha, Nigeria.*International Journal of Academic Research in Business and Social Sciences*; 3(3), pp. 201- 213.

Energy Information Administration (2009) Annual Energy Review 2007, National Energy Education Development projectIntermediate Energy Infobook, 2007.EIA

Federal Republic of Nigeria,(2007). Federal Republic of Nigeria, Official Gazette Vol 94, No 24.Lagos: Government Printer.

Global Environment Fund (2008): *The Electricity Economy New Opportunities from the Transformation of the Electric Power Sector.* http://www.globalenvironmentfund.com/

Hassan. H. T. and Akhtar. M. F. (2012) Mapping of power Distribution Network Using Geospatial Information System(GIS)*International journal of Emerging Technology and Advanced Engineering* Vol.2 issue 6, ISSN (2250-2459) www.ijetae. Com Access 3/7/2014 1:50pm

Harlow, J. (2004) Electric Power Engineering CRC Press Boca Raton, Florida

Harini and Santhosh, R. (2006). Electricity distribution information systems. Map India proceeding 2006. Viewed 28th September 2015 http://www.gisdevelopment.net/proceedings/mapindia/2006/student%20oral/mi06sla_46 html

Hore (1970): Climate and Weather in Mortimore, M.J (ED) Zaria and its Region. Department of Geography, Ahmadu Bello Univessity, Zaria.

Ighalo. G. I. and Williams, A. A. (2012) Simulating Power Distribution Network In Nigeria – The Ikpoba-Hill District Network *International Journal Of Scientific & Technology Research Volume 1, Issue 9, October 2012*.

Ihiabe, Y. A, Ajileye O.O, Alaga A.T, Samson. A. S. and Onuh, S. O. (2015) Application of GIS in Electrical DistributionNetwork System *European International Journal of Science and Technology Vol. 4 pg 8 October, 2015*

Inugonam, T.(2009) "Electricity Demand Challenges in Nigeria"PHCN News.Jan-Aug,2009 ed.

Jochem. E. (2004). World Energy assessment: Energy and the challenges of sustainability. Energy end-use efficiency, pgs 174-217.

Joskow P.L (1997) restructuring, competition and regulatory reform in the electricity sector, journal of economic perspectives vol 11 issues 3 pg 119-138

Kowal and Kassum (1970): "Soil", in Mortimore, M.J (ED) Zaria and its Region. Department of Geography, Ahmadu Bello Univessity, Zaria.

Kowal and Kassum (1972) An Agro-climate Logical Atlas of Northern States of Nigeria, Ahmadu Bello Univessity, PressZaria.

Kufoniyi, O. (1998), Database Design and Creation, In C.U Ezeigbo (ed), *Principles and Applications of Geographic Information Systems,* Lagos Panef Press, pp.1-15.

Ladigbolu, T. (2010) Effect of Power Failure on Small-scale Business in Sabon-gari, Zaria An unpublished B.sc project submitted to the Department of Geography A.B.U Zaria.

Longley, P. Goodchild, M. , Maguire, M. and Rhind, D. 2001. Geographic Information Systems and Science.Wiley. New York.

Mortimore, M.J. (1970) Zaria and its Environs, Occasional paper No 4 Department of Geography, A.B.U., Zaria, published foe the 14th annual conference of Nigeria Geographical Association, Zaria. Pp, 15.

Muhammed. B. (2005) Checking the Odds, NEPA Review Magazine, Vol.4 pg 10

Muriuki. M.W (2016) Gis-Based Power Transformer's planning and LocationCase Study: Kirinyaga West Sub-County, An unpublished M.sc project submitted to the Department of Geospatial and Space Technology of the University of Nairobi

Nom.J. (2012) Effect of Erratic Power Supply on Small-scale Business in Samaru, Zaria An unpublished B.sc project submitted to the Department of Geography A.B.U Zaria.

Odulare, G.O, and Okonkwo, C. (2009) Does Energy Consumption Contribute to Economic Performance? *Empirical Evidence from Nigeria Journal of Economic and Business vol xii No 2 pg43-47*http://www.academicjournals.org/jef

Okolobah,V. & Ismail, Z. (2013) "On The Issues, Challenges and Prospects of Electrical Power Sector in Nigeria. *International Journal of Economy, Management and Social Sciences.*

Olaniyi, S. and Usman, R. (2006) Electricity Distribution Engineering and Geographic Information System(DeGIS) Shape the Change XXIII FIG Congress Munich Germany

Oluwatoyin, K., Oluwasegun, M. and Alabi (2015) Issues and Challenges of Ownership and Privatization of Power Stations in Nigeria*Journal of Scientific Research &Reports8(3): 1-8, 2015; Article no.JSRR.1829ISSN: 2320-0227*SCIENCEDOMAIN *international* www.sciencedomain.org

Omilabu, J.O, Igbokwe, J.I, Ejikeme, J.O, Igbokwe, E.CandNjoku, R..E(2015) Development of Utility Information System for Management of Electricity Distribution of Iyaji Residential Layout, Oyo, Oyo State, Nigeria International Journal of Scientific & Engineering Research, Volume 6, Issue 9http://www.ijser.orgAccessed on 5/7/2014 10:59am

Oras, Ahmed, and Bahaa (2015) GIS Utilization for redistributing the Electricity Network power on rural areas journal of information engineering and applications vol 5, No 5

Osakpolar, E.S, and Dare-Alao, D. (2014) Geospatial Modeling of Electricity Distribution in Ife Central Local Government Area, Osun state, *Nigeria Science journal of Environmental Engineering Research Science Journal publications*http://www./ijeer org Accessed on 5/7/2014 10:59am

Oyedepo, S.O. (2012) Energy and Sustainable Development in Nigeria: The way forward. *Energy, sustainability and Society Springer Open journal* http://energsustain soc.com/ content/2/1/5 Accessed on 3/5/2014 Vol. 1(2), pp. 044-058,

Pikering. D, Park, J.M, and Bannister, D.H (1993), Utility Mapping and Record keeping for infrastructure, Urban Management and infrastructure, Urban Management Programme, Washington, D.C. Vol. 10, pp.ix-ii.

Rosenberg, N. (1989). "Energy Efficient Technologies : Past, Present and Future Perspectives." Presented at "How Far Can the World Get on Energy Efficiency Alone?" at Oak Ridge National Laboratory.

Rosenberg, C. (2011): *The role of electricity in industrial development*,http://www.allbusiness.com/utilities/680477-1.html Accessed 1:45pm 21/9/2013

Russ.W. (1951) The Geology of parts of Niger, Zaria and Sokoto.

Sambo. A.S.(2008) Matching Electricity Supply with Demand in Nigeria *International Association for Energy Economics Fourth* pg 32-36

Scwertdtfeger, F.W. (2007). *Hausa Urban Art and its Social Background: External House Decorations in a Northern Nigerian City*. Transaction Publishers, New Brunswick, U.S.A. and London, pp.15-19.

Short, T.A. 2004) *Electric Power Distribution handbook* CRC Press Boca Raton, Florida

Sun,Y., C.J Van Western and E.J. Sides (2001), Spatial Data Analysis in A.D.B. Rolf (ed), Principles of Geographic Information Systems, pp. 134-156.

Syed, N, Farkhunda. B, Muhammad Azam, and ShaziaNaz (2012)GIS for power distribution network: A case study of Karachi, Pakistan *GEOGRAFIA Online TM Malaysia Journal of Society and Space 8 issue 1* (60 - 68) 2012, ISSN 2180-2491

Thorp, M.P. (1970) "Landforms" cited in Zaria and its region, *Mortimore M.J. (ed) Occasional paper No. 4* Department of Geography, A.B.U., Zaria. Pp 13-18.

Tomlison. P. R, (1963) Soils of North Nigeria. Agric. Research, Samaru. Zaria.

Tripta. T (2005)GIS Based Power Distribution System: A Case study for the Bhopal City Dept. of Electrical Engineering, MANIT, Bhopal Access 16/2/2013 at 2:35pm

Uju, I.V. and Iyanda, S.T. (2012).Comparative Analysis of the Determinants of Residential and Urban Land Values.*Chinese Business Review*, *11(2)*, pp. 187-192

Uluocha, N. O. (1998), Mapping for Utility Management in Nigeria in O.Y. Balogun and Uluocha. N.O. (eds), Cartography and Challenges of the 21st Century in Nigeria,pp. 183-192.

Wanjihi, M.M (2016) Gis-Based Power Transformer's planning and Location: A Case Study: Kirinyaga, Kenya West Sub-County An unpublished M.sc project submitted to the Department of Geosatial and space Technology of the University of Nairobi.

Winder.J.J, (2002) Power Transformers Principles and Application, Marcel Dekker. New York

Wright, S.B and McCurry, P. (1970) Geology, in *Mortimore M.J (ed) Zaria and its Region*, *Ocassional paper* department of Geography, A.B.U., Zaria No 4 Pp5-12.

Yusuf.W (2010) Socio-economic importance of Lower River Kubani in Zaria, Unpublished B.sc project Department of Geography, A.B.U Zaria.

Http://www.gisdevelopment.net/application/urban/overview/power/index.htmAccessed 1:30pm 2/10/2012. March 2011

Appendix 1: Database Report of Samaru Business unit Electricity Transformers

S/No	Tr_Id	Shape	Easting	Northing	Tr_Location	Type of Ownership	Capacity	Status	Feeder_Name
1	T1	Point	352131	1234559	Saidu Primary School	Public	500	Connected	Samaru
2	T2	Point	352009	1234698	Samaru Extention	Public	300	Connected	
3	T3	Point	352215	1235306	Anguwan Gwaiba	Public	300	Connected	Samaru
4	T4	Point	352856	1234800	Yandoruwa	Public	500	Connected	Samaru
5	T5	Point	352912	1234775	Nagurmi Street	Public	300	Connected	Samaru
6	T6	Point	353024	1234721	Nagurmi Street	Dedicated	50	Connected	Samaru
7	T7	Point	353139	1234660	Basawa Road	Public	300	Connected	Samaru
8	T8	Point	352964	1234512	Basawa Road	Public	300	Connected	Samaru
9	T9	Point	352877	1234407	Old Kano Road	Public	500	Connected	Samaru
10	T10	Point	353279	1234216	Yola Road	Public	100	Connected	Samaru
11	T11	Point	353675	1234400	Hayin-Danyaro	Public	300	Connected	Samaru
12	T12	Point	353268	1233775	Danraka	Public	500	Connected	Samaru
13	T13	Point	353165	1233939	Shu'iabu Afagbwa Street	Dedicated	100	Not Connected	Samaru
14	T14	Point	352965	1233964	Yaro Street	Dedicated	300	Connected	Samaru
15	T15	Point	352865	1233780	UBA Bank	Dedicated	100	Connected	Samaru
16	T16	Point	356372	1224626	Wusasa	Public	500	Connected	Samaru
17	T17	Point	355972	1224706	Wusasa	Public	500	Connected	Wusasa
18	T18	Point	356065	1224781	Sadauki Street	Public	500	Connected	Wusasa
19	T19	Point	356249	1225479	Anguwan Dankali	Public	500	Connected	Wusasa
20	T20	Point	356607	1225016	Danmagaji KAEDCO Office	Dedicated	500	Connected	NNPC
21	T21	Point	354815	1231894	Zango	Public	500	Connected	Samaru
22	T22	Point	356615	1225228	Danmagaji	Public	500	Connected	Wusasa
23	T23	Point	357572	1228751	Express Road	Dedicated	500	Connected	Zaria
24	T24	Point	357580	1228797	Express Road	Dedicated	500	Connected	Zaria
25	T25	Point	358017	1229823	Hanwa Express Road	Public	500	Connected	Zaria
26	T26	Point	357982	1229857	Jim Harrison Hotel	Dedicated	500	Connected	Zaria
27	T27	Point	358134	1229937	University Press	Dedicated	500	Connected	Zaria
28	T28	Point	358170	1230322	Hanwa Low-cost I	Public	500	Connected	Samaru
29	T29	Point	358282	1230681	Hanwa Low-cost II	Public	500	Connected	Zaria
30	T30	Point	357961	1230795	Zaria Hotel	Dedicated	500	Connected	Samaru
31	T31	Point	357630	1230461	BUK/Nasara Street	Public	500	Connected	Samaru
32	T32	Point	357767	1230914	Eze Igbo Avenue Grace Land	Public	500	Connected	Samaru
33	T33	Point	357705	1231552	Layin-zomo	Public	500	Connected	Samaru
34	T34	Point	357719	1231725	Layin-zomo	Public	500	Connected	Samaru
35	T35	Point	357879	1231978	FAAN Layin-zomo	Dedicated	500	Connected	Samaru
36	T36	Point	356893	1231612	Palladan/Sokoto Road	Public	500	Connected	Samaru
37	T37	Point	357075	1231815	Palladan	Public	500	Connected	Samaru
38	T38	Point	356847	1232543	Anguwan Fulani	Public	500	Connected	Samaru

					Palladan				
39	T39	Point	356753	1232595	Anguwan Fulani Palladan	Dedicated	500	Connected	Samaru
40	T40	Point	356473	1232236	Old Kano Road	Public	500	Connected	Samaru
41	T41	Point	355561	1231427	Hayin Mallan Zango	Public	500	Connected	Samaru
42	T42	Point	355697	1231279	Hayin Mallan Zango	Dedicated	500	Connected	Samaru
43	T43	Point	354553	1231106	Jama'a Village I	Public	500	Connected	Samaru
44	T44	Point	354231	1231057	Jama'a Village II	Public	500	Connected	Samaru
45	T45	Point	354535	1231500	Zango I	Dedicated	500	Connected	Samaru
46	T46	Point	354606	1231675	Zango II	Public	500	Connected	Samaru
47	T47	Point	354454	1232506	Federal Ministry of Works and Housing II	Dedicated	500	Connected	Samaru
48	T48	Point	354558	1232683	Federal Ministry of Works and Housing I	Public	500	Connected	Samaru
49	T49	Point	353186	1233598	Union Bank Samaru	Dedicated	500	Connected	Samaru
50	T50	Point	353162	1233612	First Bank Samaru	Dedicated	500	Connected	Samaru
51	T51	Point	353028	1233665	Umaru Mutalab Academy (former Stanbic Bank Samaru)	Dedicated	500	Connected	Samaru
52	T52	Point	352875	1233785	Diamond Bank Samaru	Dedicated	500	Connected	Samaru
53	T53	Point	352759	1233842	Mr Biggs Samaru	Dedicated	50	Connected	Samaru
54	T54	Point	352759	1233832	Tinau/Sokoto Road	Public	500	Connected	Samaru
55	T55	Point	352862	1233870	Yawo Street	Dedicated	50	Connected	Samaru
56	T56	Point	352870	1234043	Tinau Street	Dedicated	50	Connected	Samaru
57	T57	Point	352889	1234192	Habibi Street	Dedicated	50	Connected	Samaru
58	T58	Point	352480	1234008	Independence cinema	Dedicated	50	Connected	Samaru
59	T59	Point	352366	1234075	Sokoto Road/Iya Road	Public	500	Connected	Samaru
60	T60	Point	35	1234312	Iya Road/Alin Basawa Road	Public	500	Connected	Samaru
61	T61	Point	350739	1236335	Bomo III	Dedicated	50	Connected	Samaru
62	T62	Point	358507	1230760	Kwangila/Express Road	Public	300	Connected	Samaru
63	T63	Point	358709	1230673	Kwangila/Rail	Public	500	Connected	Samaru
64	T64	Point	358588	1230245	Hanwa Extension	Dedicated	50	Connected	Samaru
65	T65	Point	352576	1234394	Alin Basawa Road	Dedicated	50	Connected	Samaru
66	T66	Point	351454	1234843	Dac Quarters	Dedicated	50	Connected	Samaru
67	T67	Point	350685	1236523	Bomo I	Public	300	Connected	Samaru Feeder II
68	T68	Point	350417	1236684	Bomo II	Public	100	Connected	Samaru Feeder II
69	T69	Point	358886	1230777	Kwangila	Public	500	Connected	Samaru
70	T70	Point	358656	1230502	Hanwa Water Board Booster Station	Public	500	Connected	NNPC
71	T71	Point	358706	1230475	Al Nasiha Resturant	Dedicated	100	Connected	Samaru
72	T72	Point	358818	1230424	Sokoto Road Opposite Hanwa Extension	Public	500	Connected	Samaru
73	T73	Point	358793	1230132	Anguwan Nashuka Hanwa Extension	Public	300	Connected	Zaria
74	T74	Point	358829	1239872	Hanwa Extension I	Dedicated	50	Not	Zaria

								Connected	
75	T75	Point	358775	1239831	Hanwa Extension II	Dedicated	50	Not Connected	Zaria
76	T76	Point	358718	1239832	Hanwa Extension III	Dedicated	50	Not Connected	Zaria
77	T77	Point	358527	1239940	Hanwa Extension IV	Public	500	Connected	Zaria
78	T78	Point	356089	1233993	Arewa Confenctioners Ltd Old Kano Road	Dedicated	100	Connected	Samaru
79	T79	Point	356218	1233372	Arewa Agriculture Enterprise Old Kano Road	Dedicated	100		Connected
80	T80	Point	356086	1234567	Anna Kitch Medical Center	Dedicated	300		Connected
81	T81	Point	356530	1232477	St Joseph Seminary old Kano Road	Dedicated	100		Not Connected
82	T82	Point	356410	1232156	NITT	Dedicated	500		Connected
83	T83	Point	355164	1236027	Basawa I	Public	500		Connected
84	T84	Point	355141	1235820	Basawa II	Public	500		Connected

MORGAN'S TABLE FOR SAMPLE SIZE

Population Size	Confidence = 95% Margin of Error				Confidence = 99% Margin of Error			
	5.0%	3.5%	2.5%	1.0%	5.0%	3.5%	2.5%	1.0%
10	10	10	10	10	10	10	10	10
20	19	20	20	20	19	20	20	20
30	28	29	29	30	29	29	30	30
50	44	47	48	50	47	48	49	50
75	63	69	72	74	67	71	73	75
100	80	89	94	99	87	93	96	99
150	108	126	137	148	122	135	142	149
200	132	160	177	196	154	174	186	198
250	152	190	215	244	182	211	229	246
300	169	217	251	291	207	246	270	295
400	196	265	318	384	250	309	348	391
500	217	306	377	475	285	365	421	485
600	234	340	432	565	315	416	490	579
700	248	370	481	653	341	462	554	672
800	260	396	526	739	363	503	615	763
1000	278	440	606	906	399	575	727	943
1200	291	474	674	1067	427	636	827	1119
1500	306	515	759	1297	460	712	959	1376
2000	322	563	869	1655	498	808	1141	1785
2500	333	597	952	1984	524	879	1288	2173
3500	346	641	1068	2565	558	977	1510	2890
5000	357	678	1176	3288	586	1066	1734	3842
7500	365	710	1275	4211	610	1147	1960	5165
10000	370	727	1332	4899	622	1193	2098	6239
25000	378	760	1448	6939	646	1288	2399	9972
50000	381	772	1491	8056	655	1318	2520	12455
75000	382	776	1506	8514	658	1330	2563	13583
100000	383	778	1513	8762	659	1336	2585	14227
250000	384	782	1527	9248	662	1347	2626	15555
500000	384	783	1532	9423	663	1350	2640	16055
1000000	384	783	1534	9512	663	1352	2647	16317
2500000	384	784	1536	9567	663	1353	2651	16478
10000000	384	784	1536	9594	663	1354	2653	16560
100000000	384	784	1537	9603	663	1354	2654	16584
300000000	384	784	1537	9603	663	1354	2654	16586

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL MANAGEMENT SCIENCE

AHMADU BELLO UNIVERSITY, ZARIA

Dear Respondent,

I am a student of the above department. This questionnaire is design to collect information for an Msc Research on the "GEOSPATIAL ANALYSIS OF ELECTRICITY DISTRIBUTION TRANSFORMERS IN SAMARU BUSINESS UNIT, KADUNA STATE." This exercise is purely academic and so any information supplied would be used strictly for that purpose and thus treated as confidential.

SECTION: A SOCIO-DEMOGRAHIC CHARACTERISTICS

1. Area of residence (Neiborghood) ________________________

2. Sex (a) Male [ ] (b) Female [ ]

3. Age: (a) Less than 20 years [ ] (b) 21-30 years [ ] (c) 31-40 years [ ] (d) 41-50 years [ ] (e) 50 and 60years [ ] (f) Above 60 years

4. Marital status: (a) Single [ ] (b) Married [ ] (c) Divorced [ ] (d) Separated [ ]

5. Educational attainment (a) Primary [ ] (b) Secondary [ ] (c) Tertiary [ ] (d) None [ ]

6. Occupation (a) Civil service [ ] (b) Trading [ ] (c) Farming [ ] (d) Artisan (e) Others specify ____________

7. How many years have you resided in this area? (a) 5-10 [ ] (b) 11-20 [ ] (c) 21 and above [ ]

SECTION: B

8. How many electrical appliances do you have in your house? (a) 1-5 [ ] (b) 6-9 [ ]

9. Which of these electrical appliances do you have in your house?

(a) Washing machine [ ]
(b) Pressing iron [ ]
(c) Television [ ]
(d) Blender [ ]
(e) Refrigerator [ ]
(f) radio [ ]
(g) Water heater [ ]
(h) Electric stove [ ]
(i) Electric oven [ ]
(j) Grinding machine [ ]

10. Do you have adequate power supply to make use of your appliances (a) Yes [ ] (b) No [ ]

11. How many hours do you have power supply daily? (a) less than-6 hours [ ] (b) 7-12 hours [ ] (c) 13-18 hours [ ] (d) 19-24hours [ ]

12. What type of transformer serves your resident? a. Dedicated transformer [ ] b. Public transformer [ ]

13. Do you experience low voltage? Yes [ ] No [ ]

14. If yes in 13 how often? ______________________________

15. Why do you experience low voltage ________________________

16. What is the proximity (distance) of your house to the transformer [ ] a. Close [ ] b. Far [ ] c. Very far [ ]

17. Is the transformer in your area connected to the distribution network? (a) Yes [ ] (b) No [ ]

18. Do you think the transformer in your area serve your community effectively? (a) Yes [ ] (b) No [ ]