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Electricity Distribution Mapping in Oyo State, Nigeria: A Case Study of Kosobo

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Abstract: The research attempts to proffer a model solution to some of the problems, militating against the efficient management and maintenance of electricity distribution in Nigeria, using Durba – Kosobo Area as a case study. Thus, the project serves as a prototype for demonstrating the relevance of employing electricity distribution information system. The study site is the Dubar – Kosobo Area bounded by Owode Road to the North, the Apostolic Church Street to the East, Mobolaje Road by the West and by the Hon Raheem Wasiu Street to the South, all in Oyo East Local Government of Oyo State in Nigeria. It lies within Latitude 07° 49' 03" N, and 07° 50' 02" N, Longitude 03° 57' 03" E and 03° 56' 02" E. The relevance of the study is in fault detection, increased revenue generation, quick time to effect repairs, timely schedule maintenance of network facilities and a lot of other advantages. The electricity distribution information system is needed for planning and management. The database design consisted of design phase and construction/implementation phase was made using ArcGIS 10.2 suit of software. The followings were considered under the design phase namely, view of realty, conceptual design and logical design. Attribute data was collected through oral interview from both DISCOs and GENCOs official and the residents in the area about the street name, building use, transformer, and other relevant information. Head-up or on-screen digitizing was adopted on the acquired imagery to trace out the outline of the features within the study area. In the process different layers such as buildings and road-network were electronically traced out using the ArcGIS 10.2 software. This study recommended an increased sensitization and awareness campaign for all stakeholders who are potential users of GIS. The electricity distribution information system is needed for planning and management. It is recommended that the electricity provider, DISCOs and GENCOs Plc should adopt GIS as a tool for efficient management of her facilities to enhance their supply of electricity to users.

Keywords: Electricity, Mapping, GIS, DISCOS, GENCOS, Kosovo

1. Introduction

Lightening is essential to human living and comfort. The sun provides light in the day time, while at night the moon does not as much as the sun, particularly inside the buildings. Man uses light to see objects. Before the invention of electricity, animal wax, plant oils and coal were used as sources of lightening up the rooms. However, Michael Faraday invented a source of light energy known as electricity. This energy not only serves as a source of light but also powers moving machines and other electrical appliances [13].

Electricity is defined as the supply of electric current for heating, lighting, etc.

Research has shown that, once generated, electricity is transmitted, and converted into heat, light, motion, and other forms of energy through natural processes, as well as by devices built by people. Electrical activity takes place constantly everywhere in the universe, and today, the amount of electrical energy generated by a country determines her developmental status in this technology-driven economy. Electrical energy is an extremely versatile form of energy needed by every citizen and sector of the economy. Electricity is a basic amenity whose provision and distribution is critical to the wellbeing of the nation. Its regular supply to the manufacturing section keeps our industries in production. Homes that enjoy its regular supply could refrigerate some of their fresh foods. Likewise in the same manner the institutions and hospitals could preserve specimens, drugs and vaccines.

Nigeria, like many developing countries is not only faced with the challenge of generating but effectively distributing electricity to her numerous populaces. The DISCOS and GENCOS are power companies charged with the responsibility of generating, distributing electric energy in Nigeria. It achieves this through building of dams and gas thermal stations.

Electricity distribution is possible since this energy can be transmitted almost instantaneously over long distances. Therefore, when generated, effective distribution of this energy not only requires installment of certain facilities like transformers, transmission cables, poles and meters but proper mapping of such facilities for optimum service and maintenance.

In, Nigeria, most of the existing maps are void of utilities. Probably because of their scales, it has become difficult to represent the dimensions of these utilities objects or features like electricity distribution lines, electricity high tension lines, power lines, water pipelines, overhead telephone lines, gas (or petroleum products) pipelines, streets' lights, etc, whose dimensions are below the plotable point on such scales like 1:25,000; 1:50,000 1:100,000 and other smaller scales [2].

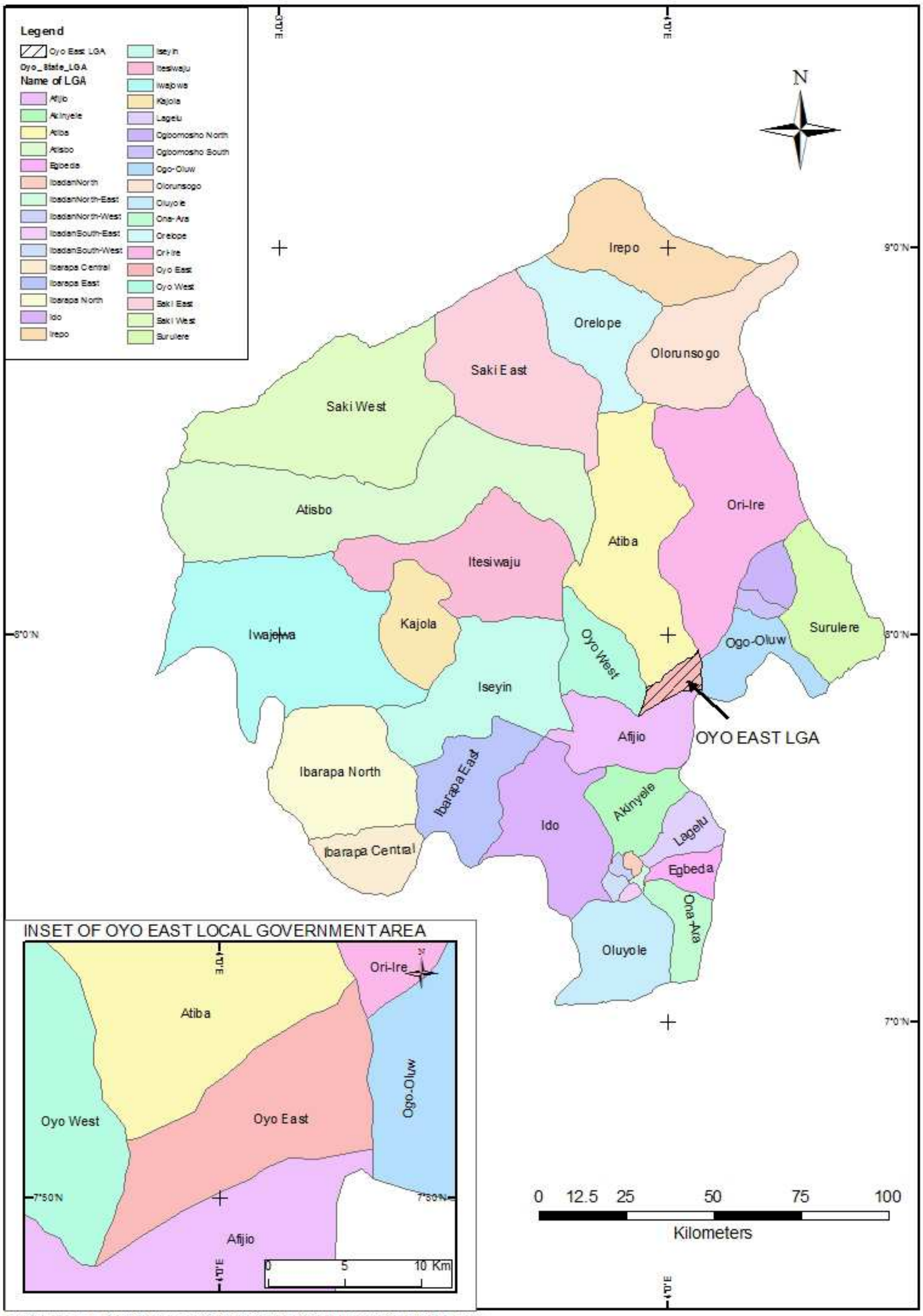

FIGURE 1.1: MAP OF OYO STATE SHOWING OYO EAST LGA

Figure 1. *Map of Oyo state showing Oyo East LGA.*

The scope of the research is as follows: -

i. Provision of GPS controls over the area on the basis of “working from whole to part” principle that will be used for the georeferencing of the satellite.
ii. Digitization of the existing Oyo satellite imagery, particularly, the study area.
iii. GPS data acquisition of the existing electricity infrastructures, subsequently creation of database, and finally production of maps at various scales.

2. Study Area

The study site is the Dubar – Kosobo Area bounded by Owode Road to the North, the Apostolic Church Street to the East, Mobolaje Road by the West and by the Hon Raheem Wasiu Street to the South, all in Oyo East Local Government of Oyo State in Nigeria. It lies within Latitude 07° 49' 03" N, and 07° 50' 02" N, Longitude 03° 57' 03" E and 03° 56' 02" E.

The area covered is about 200 hectares or 2 square kilometers.

3. Material and Methodology

Methodology is a body of methods, rules, and procedure that was adopted for the successful execution of the project [12].

3.1. Database Design

The database design consisted of design phase and construction/implementation phase was made using ArcGIS 10.2 suit of software.

3.2. Design Phase

The followings were considered under the design phase namely, view of realty, conceptual design and logical design.

(i). View of Reality

The view of reality for this study area was articulated based on geographic features which include: roads, transmission lines, electric poles, service lines, distribution lines, transformers, and buildings. How the GIS expert perceived this reality was very important in the data model design [5]. The reality served as input into design phase.

(ii). Conceptual Design

The primary entities that were conceptualized for this study were transformer (node or point), electric pole (node or point), roads (linear) and buildings (polygon) as entities. The location of each object is given in either Geographic coordinates (Latitude and Longitude) or Planimetric coordinates (Easting, Northing) but the latter was adopted for this work [6].

(iii). Logical Design (Data Structure)

It involved representation of the designed data model, in the conceptual schema, to reflect the recording of the data in the computer system in a logical model regarded as data structure or logical design of data. The data were structured to illustrate logical order of organizing the data in the database.

Table 1. *Node entity and its attributes.*

FIELD NAME	DESCRIPTION
Node_Id	Node Identifier
N_Location	Node Location
N_Transformer	Transformer Source
N_Easting	Easting Coordinate
N_Northing	Northing Coordinate

Relational data structure was adopted for the study in which data are stored in personal geodatabase containing tables. A table contains records (rows) and columns (fields). Each field has a name, and attributes (data type and field properties).

3.3. Data Acquisition

3.3.1. Reconnaissance

This involved office planning and field reconnaissance.

(i). Office Planning

The gathering of necessary information that helped in the execution of the project was done. Google Earth online web imagery was accessed to have an overview or aerial view of the study area. Also the group had meeting with the supervisor on how to go about the project.

(ii). Field Reconnaissance

The study area was visited on the first instance to know the area and its existing electrical facilities. Road junctions that have clear sky visibility were selected as ground control points (GCP). Five (5) of such points were monumented with bottle corks. and nails. These points were to be used for georeferencing and were deemed to have formed good configuration over the area.

3.3.2. Equipment Used / System Selection and Software

(i). Hardware

(A) Data Acquisition Hardware

The following hardware were made use of in the course of the work.

i. A set of Leica Differential GPS 1200 receivers.
ii. One hand-held Garmin GPS and three handheld E-Trex GPS receivers.
iii. One hired taxi cab.
iv. One hammer, bottle corks and nails.

(B) Data Management Hardware

One Laptop and a flash drive were used at this stage of the work.

(C) Data Presentation Hardware

The following were used as the data presentation hardware.

i. The Laptop’s screen was used for online presentation;
ii. One A3 printer;
iii. One flash drive and
iv. One A0 plotter.

(ii). Application Software

The following softwares were used during the project execution.

i. Google Earth;
ii. ArcGIS 10.2 suit of softwares;
iii. Microsoft Excel and Word;
iv. Leica Geosystem Office;
v. Rising Antivirus.

3.3.3. Test of Instrument

(i). Differential GPS Receiver

The instrument was setup over XSN007 control beacon and the necessary connections were made with the cables. The receivers after they had been powered on were configured with the time zone (+1hour) and the local coordinate of the control beacon [8]. The battery levels were also checked to ascertain whether they were still full sequel to their recharge. The receivers were left on for about fifteen (15) minutes to acquired data. After the acquisition of the data, the acquired data were processed. After processing the result obtained displayed the approximate coordinate of the point occupied and the correct local time of observation [9].

(ii). Hand Held GPS Receiver

A test was carried out on each of the hand held GPS receiver by using it to observe at the control beacon, XSN007 within the school premises [11]. The coordinate obtained was compared with the coordinate of the control beacon [7]. The difference between the observed reading and coordinate of the control was within tolerance.

3.3.4. Control Check

The receiver, after it had been powered up displayed coordinate nearly the same with the coordinate of the control beacon, XSN007.

Table 2. *Coordinate of the control point.*

S TATION	LATITUDE	LONGITUDE	REMARK
XSN007	7° 50' 32.924" N	3° 56' 57.925" E	Computed
XSN007	7° 50' 32.776" N	3° 56' 57.811"E	Observed

3.3.5. Geometric Data Acquisition

(i). Acquisition of Satellite Imagery

An IKONOS imagery of Oyo was obtained from USGS website.

(ii). Control Establishment for Georeferencing

The master receiver was setup on XSN007 while the rover was taken to each of the GCP on a static mode where observation was made in static mode for a minimum of thirty (30) minutes at every point to be coordinated.

(iii). Electrical Facilities with Hand Held Gps

Hand-held GPS receivers were used to acquire the position of each electrical facility like electric poles and transformers within the site. The hand-held GPS receiver was placed at sa fe distance to the object and reading was recorded.

3.3.6. Attribute Data Acquisition

Attribute data was collected through oral interview from both DISCOs and GENCOs official and the residents in the area about the street name, building use, transformer, and other relevant information.

3.4. Data Processing

3.4.1. GPS Data Downloading and Processing

The GPS data was first downloaded and then processed with the Leica Geosystem Office software. Subsequently, the coordinates of these points were used to georeference the obtained imagery [15].

3.4.2. Georeferencing

The following steps were followed in the georeferencing process:

A new empty map was opened.

From the data frame properties its coordinate system was set to WGS84 UTM Zone 31N.

The satellite imagery was added to the map.

Subsequently, the Georeferencing palette was activated and the snapping in the Editor was equally activated.

1) Then the Auto-adjust on dropdown option of the georeferencing palette was turned off by clicking on it.
2) While the 1st Order Polynomial (Affine) remained turned on.
3) The Add Control tool was used to add those ground control points above mentioned by clicking on the identified point on the imagery and right-clicking to select the option for keying-in the corresponding coordinates.
4) After the controls were added, the Auto-Adjust was then turned on to perform the georeferencing operation.
5) Finally, the rectification was performed by clicking on Rectify.

3.4.3. Digitization

Head-up or on-screen digitizing was adopted on the acquired imagery to trace out the outline of the features within the study area. In the process different layers such as buildings and road-network were electronically traced out using the ArcGIS 10.2 software [14].

3.4.4. Data Input and Editing

The coordinates observed with the hand-held GPS receivers were entered into Microsoft Excel file and edited prior to plotting. It was at this stage that the fields were created and populated.

3.5. Physical Design (Data Declaration)

This was the representation of the data structures in the format of the implementation software. The objects and their attribute tables were translated into ArcGIS 10.2 structure. The way the data was stored which involved the encoding of data as transformed in the logical design with the implementation software [2]. Data types were classified to identify possible values for and operations that can be done on the data, as well as the way the data in that field was stored in the database.

Below are the attribute tables for Buildings, Electric pole, and transformers tables.

Table 3. *Building table attributes.*

Field Name	Data Type	Field Properties				
		Allow NULL values	Default Value	Length	Geometry Type	Grid 1
SHAPE	Geometry	Yes	Nil	Nil	Polygon	1000
B_Id	Short Integer	Yes	Nil	Nil	Nil	Nil
B_Size	Text	Yes	Nil	50	Nil	Nil
B_Use	Text	Yes	Nil	30	Nil	Nil
B_Energy_CT	Text	Yes	Nil	25	Nil	Nil
SHAPE_Length	Double	Yes	Nil	Nil	Nil	Nil
SHAPE_Area	Double	Yes	Nil	Nil	Nil	Nil
B_Type	Text	Yes	Nil	25	Nil	Nil
B_Owner	Text	Yes	Nil	50	Nil	Nil
B_Address	Text	Yes	Nil	50	Nil	Nil
B_Service_Line	Text	Yes	Nil	15	Nil	Nil

3.6. Database Construction / Implementation

Here tables were created and records of the geospatial features were keyed in accordingly.

3.7. Database Management System

The relational database management system (RDBMS) provided by the ArcGIS had Microsoft Access at the back-end.

3.7.1. Data Security

The only observed threat to the database was virus infection. To this regard the installed antivirus, Rising Antivirus was updated on regular basis and it ensured every flash drive inserted to the laptop was scanned for virus.

3.7.2. Data Integrity

There was enforcement that the right type of data was entered into the appropriate field.

3.7.3. Database Maintenance

The database was backed up to flash drive and copied to group members who were assigned tasks to perform.

4. Analysis of Results and Information Presentation

This deals with the storage, editing, updating and manipulation of data gathered and result of which is presented in forms of tables and maps. GIS analysis is integrated and manipulated in such a way that it could provide answers to generic questions of:

Location What is at …………………?

Condition Where is ……………………?

Trend What has changed …………..?

Routing Which is the best way ………?

Pattern What is the pattern ………….?

Modelling What if ………………………?

The geospatial data acquired are also structured for intelligent use. This research is to develop electricity distribution information system to manage and perform operations faster and more efficiently.

4.1. Spatial Analysis

Spatial analysis itself deals with spatial patterns defining the locational relationship among points, lines, polygons and spatial processes that defines the nature of these in term of their operation, distance and direction or the connectivity of points. This allows for the creation of new information about the features, which has already been linked up in the database by their spatial and attribute data [4].

In order to make a GIS answer the generic questions above mentioned and its capability for spatial analytical function distinguishes it from any other information system.

4.2. Query and Presentation of Analysis

Queries and specific questions in the form of “what is where”, “where is what”, etc which provide answers to the needed information through processing or manipulating geospatial data. Spatial searches are very essential when searching for attribute within the neighbourhood, which must be defined systematically [10].

(i). Single Criteria Analysis

The single criteria analysis refers to the situation whereby a single conclusion is used to query a database as shown below.

QUERY 1: To display buildings used for commercial purpose.

SYNTAX: [B_Use] = 'COMMERCIAL'

There are a total of forty-seven (47) buildings being used for commercial purpose within the study area. These buildings would consume more electricity than those used for residence. The result would help the electricity provider to know where to give electricity mostly during the working hours.

QUERY 2: To display wooden electric poles

SYNTAX: [EP_Type] = 'WOOD'

ANALYSIS OF RESULT:

The outcome of the query showed that there are 494 of 783 that are wooden electric poles. It means that they are temporal and should be monitored for replacement.

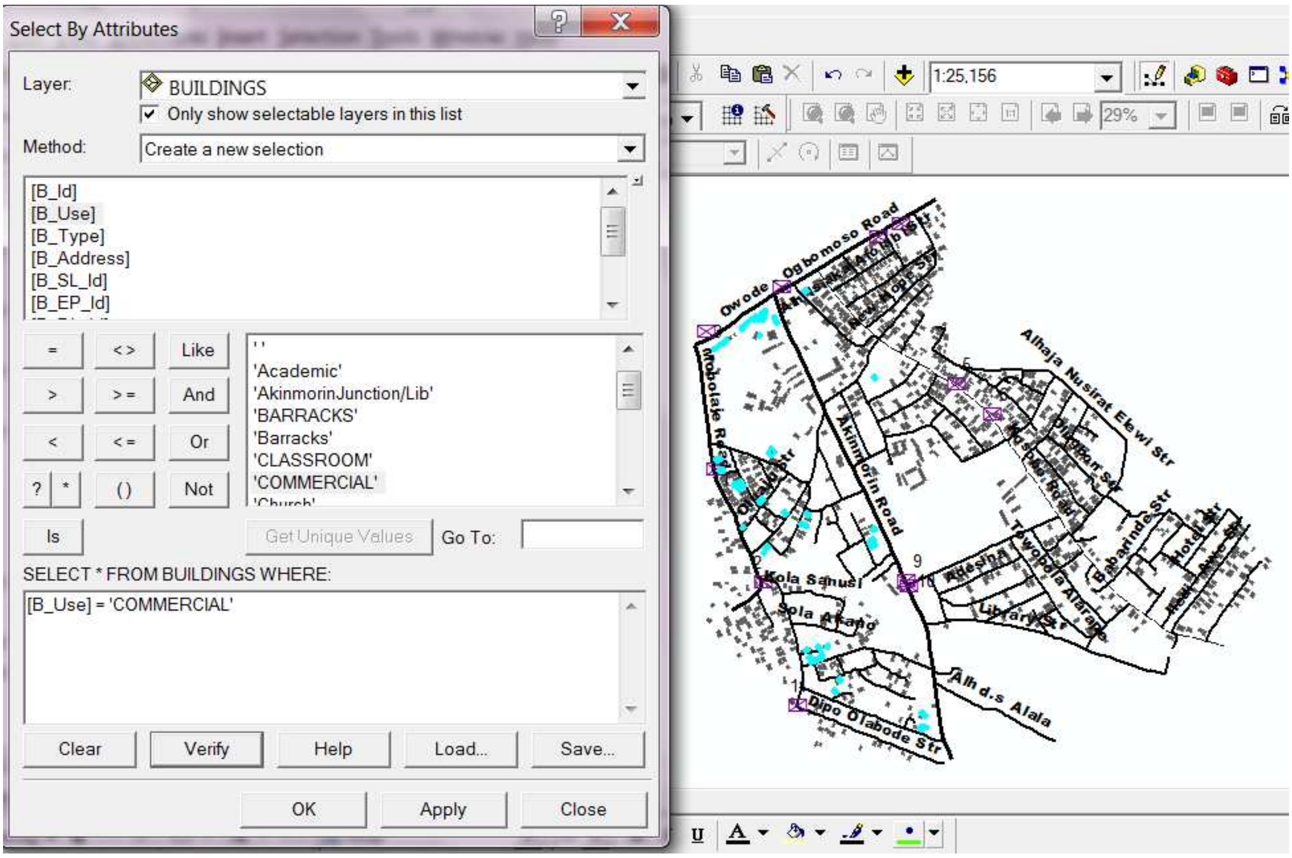

Figure 2. *Result of the query for commercial buildings within the study area.*

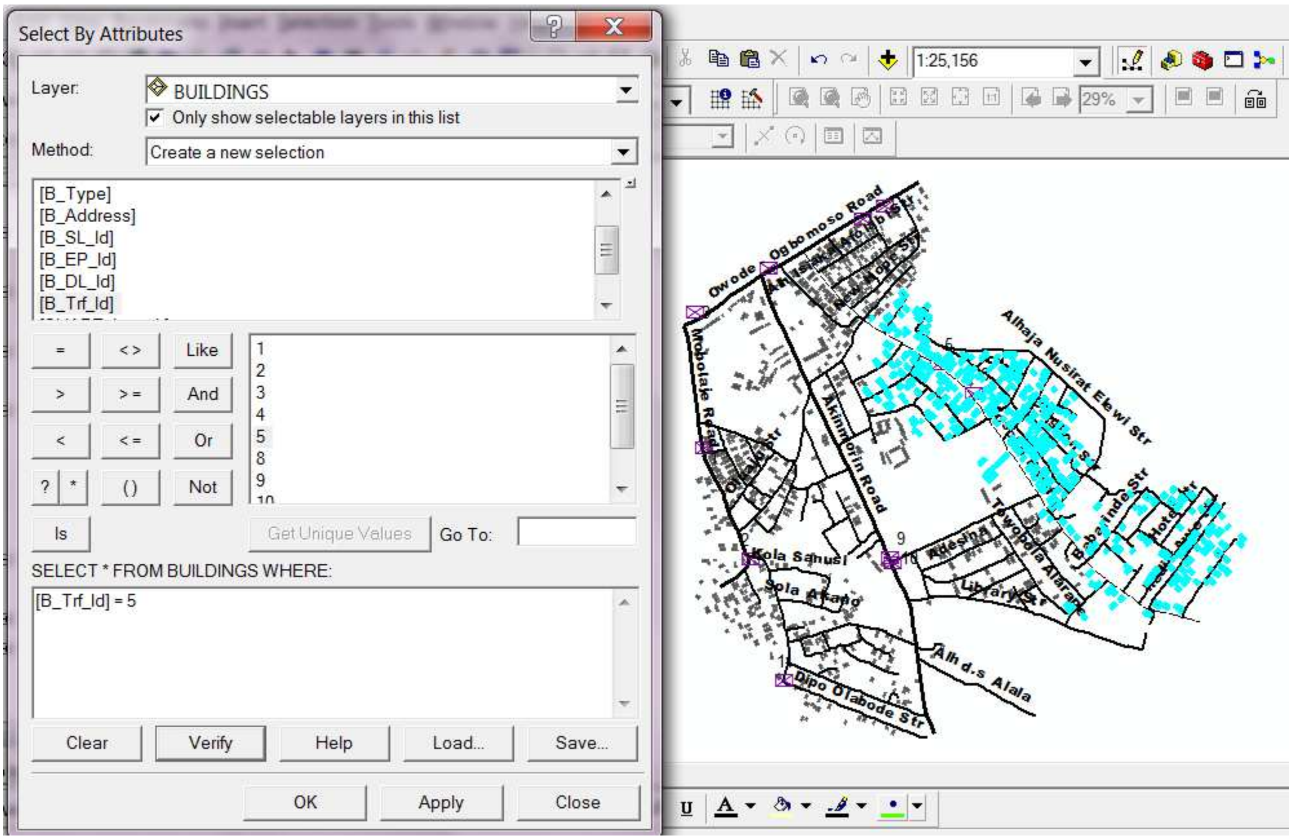

Figure 3. *Result of the query for those buildings connected to Kosobo transformer.*

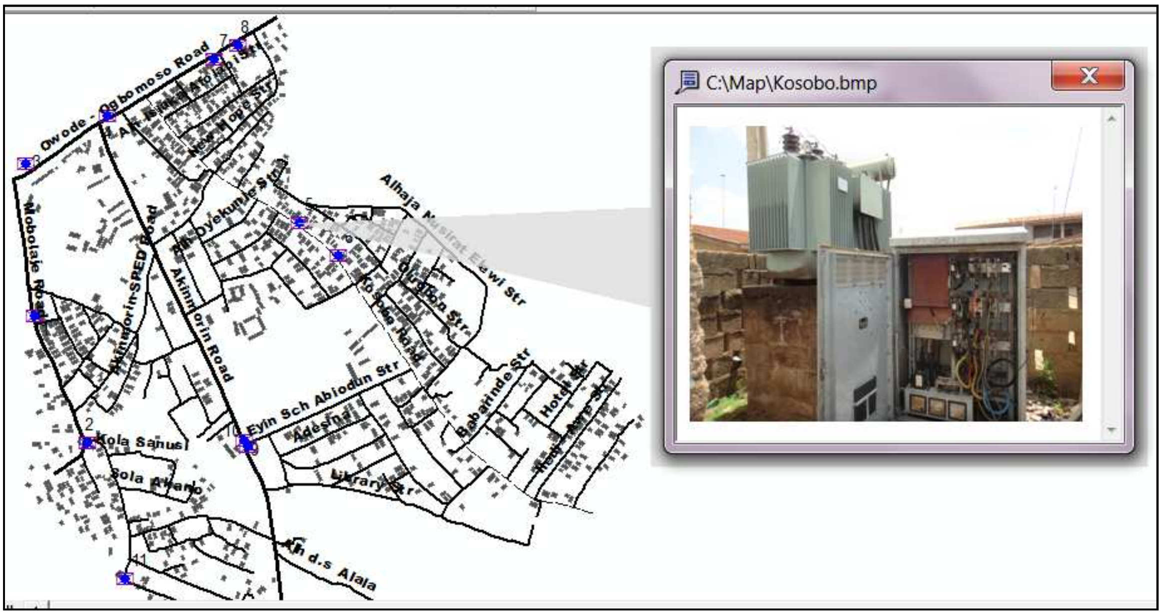

Figure 4. *HTML Popup image of Kosobo transformer.*

ANALYSIS OF RESULT: The essence of this query is to know those buildings that are connected to the Kosobo transformer. The outcome was used to map the transformer's catchment area.

(ii). Multi Criteria Analysis

This is the situation whereby more than one conditions are used to perform a spatial search as shown below.

QUERY 3: The purpose of this query is to know those wooden electric poles along Akinmorin Road.

SYNTAX: [EP_Type] = 'WOOD' AND [SL_Location] = 'Akinmorin Road'

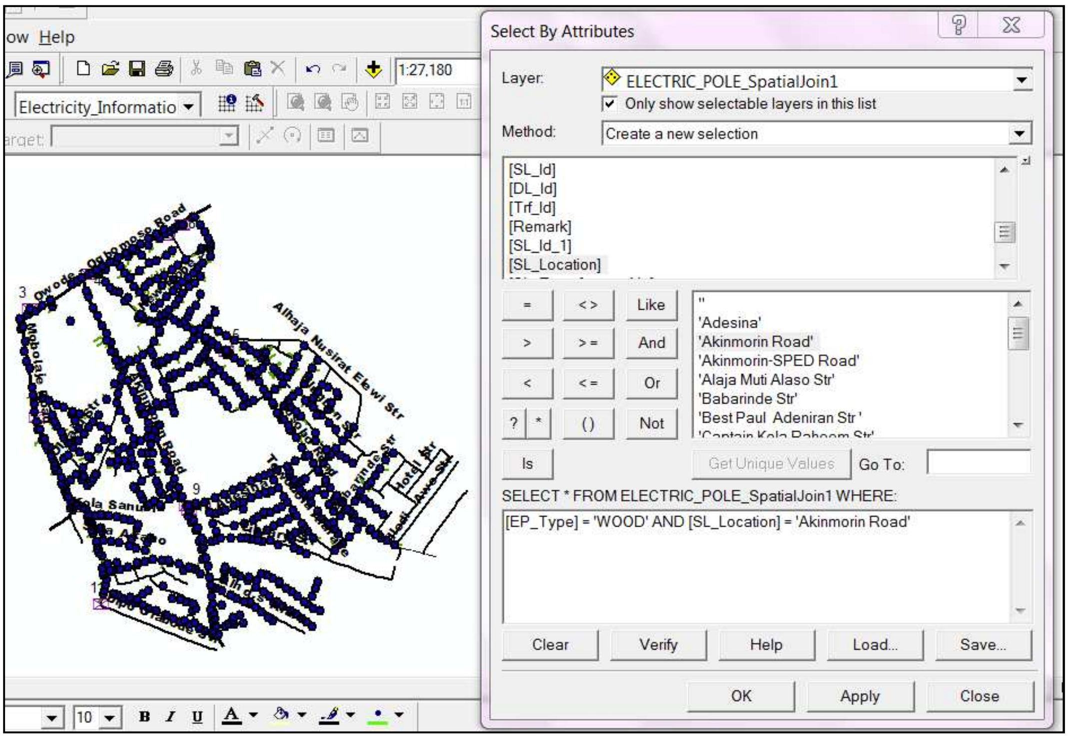

Figure 5. *Query for wooden electric poles with service lines along Akinmorin Road.*

ANALYSIS OF RESULT: The outcome of the query showed that there are three (3) wooden electric poles with service lines along Akinmorin Road. It means that they are temporal and should be monitored for replacement.

QUERY 4: The purpose of this query is to know those concrete electric poles that are carrying both transmission and distribution lines along Akinmorin Road.

SYNTAX: ([EP_Elec_Li] = '33KV&11KV' AND

[EP_Loc] = 'AKINMORIN ROAD') AND [EP_Type] = 'CONCRETE'

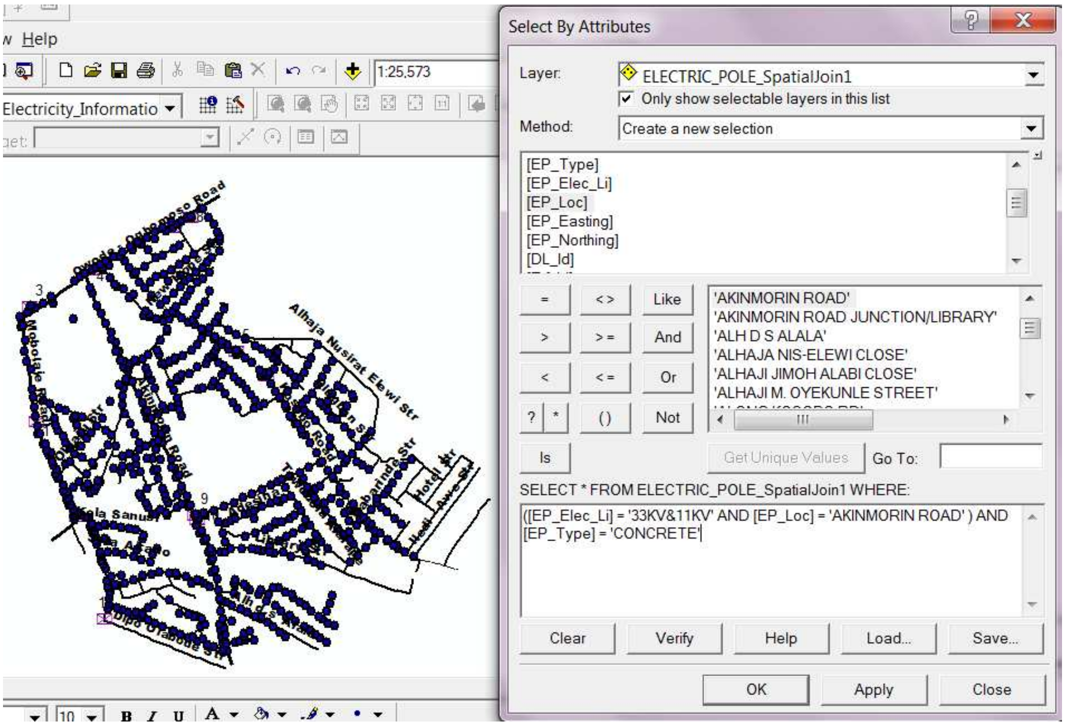

Figure 6. *Query for concrete electric poles carrying both transmission and distribution lines along Akinmorin Road.*

Analysis of Result:

The outcome of the query showed that there are eleven (11) concrete electric poles with both transmission and distribution lines. It means that they are very important and should be protected.

(iii). Buffering Analysis

Buffer is an analysis that is distance dependent relative from the object of interest [3]. The operation was performed by creating a 10m buffer zone along the transmission lines.

Buffer operation: The operation was performed through Select by Location to ascertain the extent of encroachment on the minimum 10m reserve of the 33KV Transmission line.

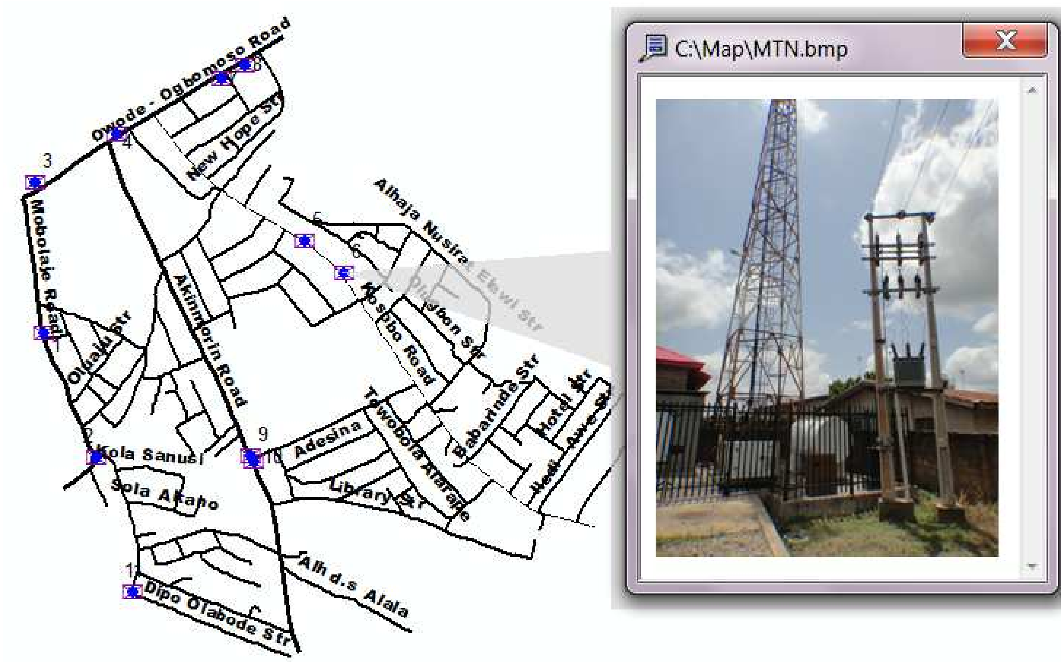

Figure 7. *HTML Popup image of the MTN transformer in the study area.*

ANALYSIS OF RESULT:

This type of analysis would be helpful to a maintenance crew that is working at Mabolaje2 and has to go to Kosobo for another job as shown in figure 6 which locates four points for the determination of closest transformer to the Guest House opposite St Francis Catholic College.

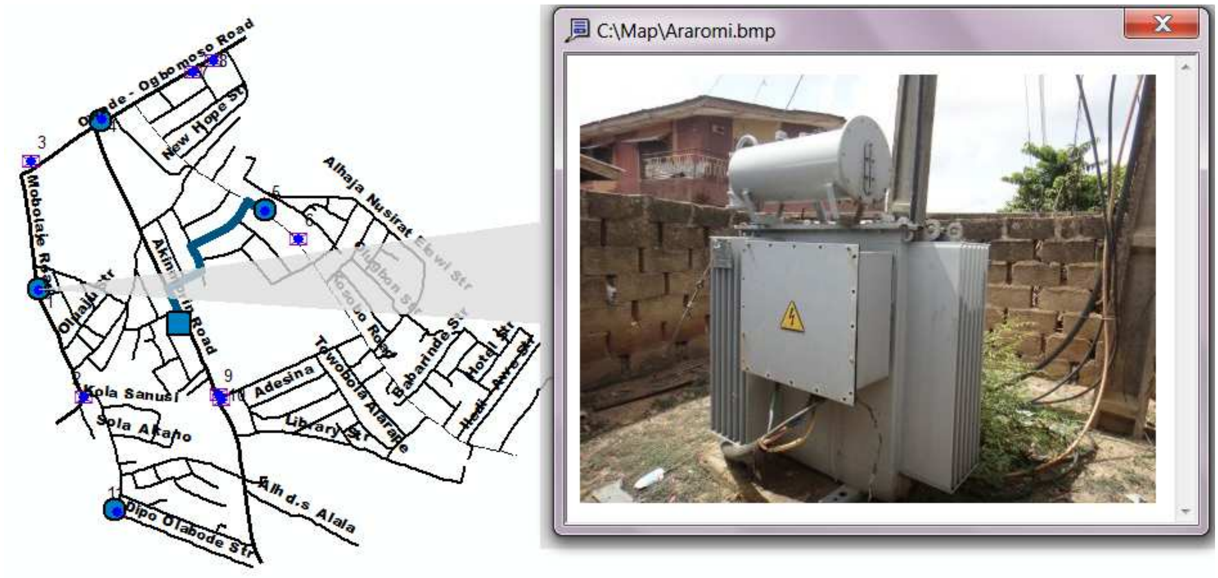

***Figure 8.** HTML Popup image of Araromi transformer.*

The difference between the closest transformer of 839.8m and its alternative being 1230.2m is 400.4m. This type of analysis would be helpful to the Guest House who might want to change to another transformer when the one serving it has broken down beyond repair.

QUERY 6: The purpose of this query is to know those buildings within the service area of range 0 – 1500m.

5. Conclusion

The project attempted to proffer a model solution to some of the problems, militating against the efficient management and maintenance of electricity distribution in Nigeria, using Durba – Kosobo Area as a case study. Thus, the project serves as a prototype for demonstrating the relevance of employing electricity distribution information system.

It would be helpful in fault detection, increased revenue generation, quick response time to effect repairs, timely schedule maintenance of network facilities and a lot of other advantages.

6. Recommendation

The electricity distribution information system is needed for planning and management. It is recommended that the electricity provider, DISCOs and GENCOs Plc should adopt GIS as a tool for efficient management of her facilities to enhance their supply of electricity to users.

There should be increased sensitization and awareness campaign for all stakeholders who are potential users of GIS.

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