PROCEEDINGS OF

MAIDEN CONFERENCE

OF THE NIGERIAN INSTITUTE OF BUILDING (NIOB) NIGER STATE CHAPTER

Venue:
LT 1, School of Environmental Technology, Federal University of Technology, Minna, Niger State, Nigeria

THEME:

QUACKERY & BUILDING COLLAPSE: ROLES OF PROFESSIONALS IN CURBING THE MENACE

Editor in Chief:
Bldr. Dr. Ogunbode Ezekiel Babatunde

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FOREWORD BY THE CHAIRMAN, NIOB NIGER STATE CHAPTER

Current environmental challenges that are confronting the world and Nigeria in particle, like climatic change, building collapse, quackery in the practice of building profession, desertification, flooding among others, have inflicted grave risk to human habitation, health and social-economic life.

It became essential to take weighty action to deal with the problems. This can only be achieved through pragmatic intellectual ideas and knowledge in tackling these challenges to achieve building collapse free environment.

The maiden conference of the Nigerian Institute of Building (NIOB) Niger State Chapter therefore, provides a niche for the compilation and cross breed of professional ideas, researches and knowledge for addressing these great challenges.

I therefore recommend proceedings of maiden conference of the Nigerian Institute of Building Niger State Chapter for every one seeking knowledge or willing to share it.

Bldr Dr Shehu Ibrahim Abubakar
Chairman
NIOB Niger State Chapter

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PROCEEDINGS OF MAIDEN CONFERENCE OF THE NIGERIAN INSTITUTE OF BUILDING (NIOB) NIGER STATE CHAPTER

A publication of NIOB Niger State Chapter

An Optimal Geospatial Model for Efficient Power Distribution Management in Enugu Nigeria

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Abstract

Inefficient power management constitute one of the most expensive costs in an organization, especially when multiple networks of Transformer (DSS) are involved. There has been obvious lack of detailed maps of electricity facilities in terms of spatial and attribute information, as well as the lack of proper identification of energy consumers in the network of distribution in terms of proximity to DSS. This has made management of power infrastructure difficult in most Nigerian cities. Therefore, this paper presents an optimal geospatial model with a view to enhancing energy distribution, accessibility and management. The study area covers the Hilltop feeder of Enugu Electricity Distribution Company (EEDC), Enugu state. Coordinates of selected power assets location, user points and building footprints were acquired using hand-held Globa positioning system (GPS) receiver as well as other attribute information on power infrastructure and users as obtained from EEDC GIS cloud. The data were manipulated in QGIS environment and rule-based relational database was created. Several connectivity models were generated which were integrated to realised the desired power management model. The model was validated by performing fault tracing to identify location of faults and detecting poles and user connectivity for evaluation of impact level and enhances planning for maintenance. The results revealed that there are 204 buildings, 106 electric poles, 117 direct customer connectivity, 32 indirect connectivity and 91 unconnected individuals at the Ngwo service area. Furthermore, the model has the ability to minimised the challenges faced by power operators in detecting fault and control power usage. Therefore, exploring the potential of this model in mitigating power management challenges in Nigeria would be remarkable.

Keyword: Geospatial Model for Power Management, Distribution Sub-station. Route Network Analysis, Electricity Assets Connectivity, Electricity Distribution Assets.

1. Introduction

The distribution of electrical energy to its end users in Nigerian Communities has faced diverse spatial problems leading to low voltage, overload on equipment, difficulties in fault tracing, and delay in fault clearing. Current methods of management of electrical energy have shortcomings that have made it difficult to search and update previous records as well as real-time information on the distribution of power assets (Aliyu *et al.,* 2013). Therefore, one of the major factors that have differentiated the modern ways of living from the ancient ways is the effective ways of managing energy (Arinze, 2014). In recent times electric energy has become the most available form of energy used in industries, domestic homes, recreation, transportation, and health care services. Geospatial data modeling plays an important role in the geospatial domain of Electricity Distribution, not least in the context of current regional, national, and international spatial data infrastructure (SDI) initiatives, where more and more conceptual models are being developed using formal modeling languages that support the technological advancement of utility management and supply (Mejia *et al.,* 2018). Better use of spatial data is one of the key areas of focus for many electrical, gas, and water utilities (Gayathri & Kumar*,* 2016).

Electricity is a vital aspect of the utility sector that is very necessary to the smooth development of any city; it is an important part of any person (Kaseke & Hosking, 2013). The stages in electricity delivery process for public use is divided into three: Generation, Transmission, and Distribution. After Electricity is generated (either by Hydro, Coal, Gas, Nuclear, Biogas, Wind or Solar) and moved along high-voltage transmission lines (330KV powerline), It comes off first at the transmission substation where it is reduced by stepped down Transformers to 132KV for onward re-transmission and then at Sub-Transmission Substations (also referred to as Transmission Substation) where it is further stepped down to 33KV for Distribution. The Electricity Distribution System involves the interaction of various electrical equipment at various point in the chain of electricity distribution from the Transmission system to the final consumers. These equipment and the point of their location and function are regarded as Electricity Distribution Assets. Electricity Distribution assets are categorized by their point of function. They include; Injection Substation and related assets, Feeder Lines and related assets, Distribution Substation (DSS) and related assets, Distributor Lines and related assets and Service Wire/point.

According to Oseni & Durowoju (2020), Electricity distribution and Energy consumption are areas of GIS application in Nigeria that have received less attention. Nevertheless, the need for fast retrieval and easy accessibility of information from electricity distribution companies for the purpose of planning, managing and monitoring of power facilities cannot be over emphasized (Mejia *et al.,* 2018). However, the problem facing electricity consumption as it concerns effective distribution and management can be viewed from the obvious lack of detailed maps of power facilities in terms of spatial and attribute information, as well as the lack of proper identification of energy consumers in the network of distribution in terms of proximity to DSS. This has made management and efficient power distribution to be difficult, with great loss of power through illegal connections, consistent power disruption due to overloading of power assets (Mwada *et al.,* 2020, Emovon *et al.,* 2011) Therefore, this paper seeks to develop an optimal geospatial model for efficient power distribution management in Enugu.

2. Material and Methods

The study area covers the Hilltop feeder of Enugu Electricity Distribution Company (EEDC), Enugu state. The power distribution in the study area is divided into four districts, which includes Abakpa, Awkunanaw, Ogui and Nsukka. Among the four districts, an agglomeration of some parts in Awkunanaw, Ogui and Abakpa which forms Enugu town (Figure 1).

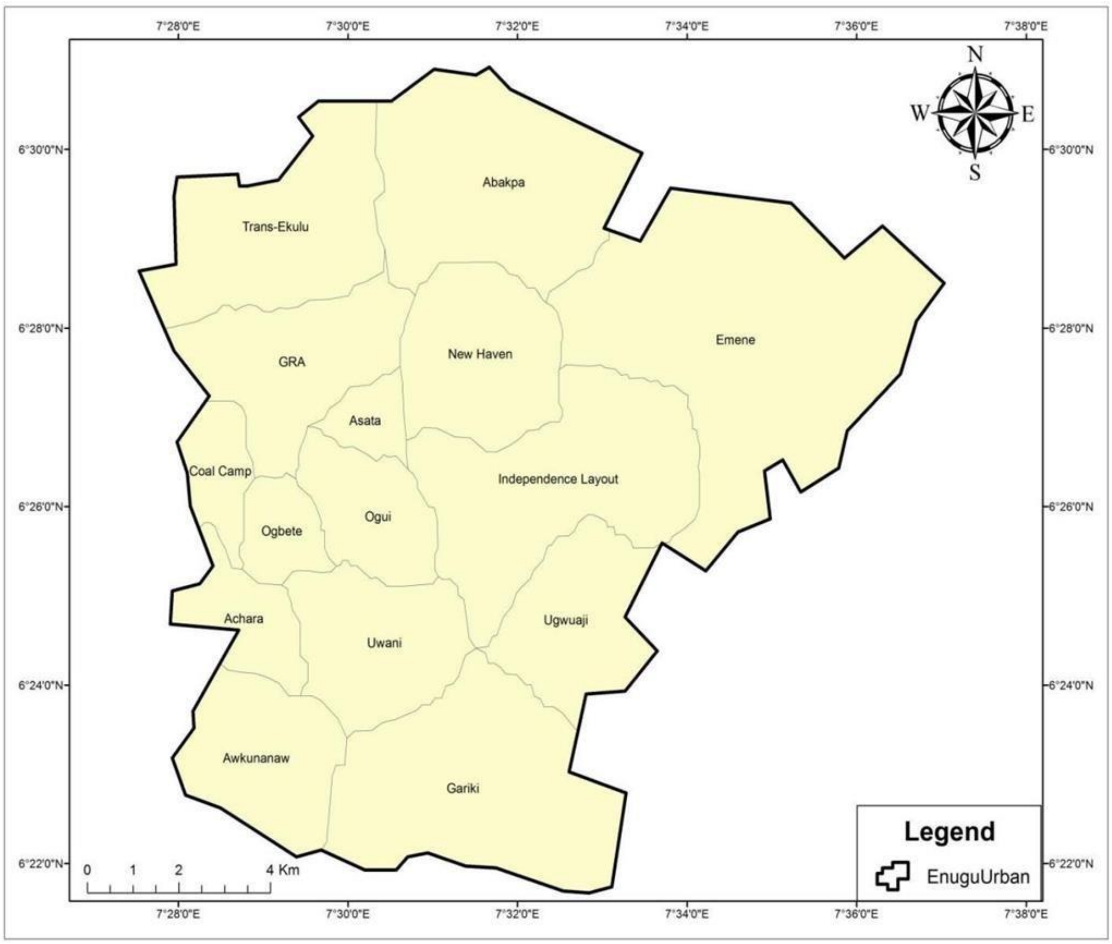

Figure 1. The study area

Within the town, there is further division of areas based on feeder lines, based on the rate of management challenges such as energy loss rate, poor revenue turnout and difficult terrain as disclosed by the unit.

Data used for this study was acquired through both primary and secondary means. Primary data were acquired for the purpose of validation. The key primary data is the locational and attribute information on the service centre and 50 selected poles in the service area. Global positioning receiver was used for the location data collection. Generally, the major data required are the spatial and attribute information on poles, transformers, feeder boundaries and enumerated energy consumers which were accessed from the GIS unit of Enugu Electricity Distribution Company. Other secondary data source includes Google Earth image, digital elevation model (DEM) from USGS website and base map of the study area.

The power asset distribution within the study area such as poles, transformers, and feeder boundaries were mapped using QGIS. Also, the road network and the building footprints were extracted from the Google earth image and base map of the area. Attribute information about energy users were used to conduct customer enumeration and categorization of different energy users. All the data were then collated and converted to the same mapping formats using QGIS 2.18.16 software. One of the advantages of using QGIS platform for such process is the ability to easily convert different data formats in to a single format thus, the pole layer in visual point format, the injection layer and consumer layer in KML were all converted to shape file and referenced to the same coordinate system (Minna Datum, UTM zone 32).
To develop the optimal model for seamless power distribution management, shortest path algorithm (route network analysis) was performed using the service Centre as the origin and the power asset such as transformer as destination. This requires performing node alignment to ensures that the overall road network has no break at any point, hence, the entire network is made an entity. The procedure is achieved using Network analysis spatial tool in QGIS environment. A spatial and attribute database on the power assets in the study area was developed on Google cloud relying on entity relational database. Using 'rule-based' categorization query, the power assets (transformers and poles) were categorized into types, user and voltage capacity. For the purpose of unique spatial polygon identification for every consumer point within the study area, unique codes were assigned to each building in the service area using National Identification Code (NAC) engine, which is an online platform that can automatically generate and assign globally accepted unique code, either in batches or one at a time with the aid of the coordinate at the centroid of each building. Then analysis was performed based on connection status categorization using a factor of direct connection to pole. This yielded three different unique categories of users who are either directly taking supply from pole, indirectly taking from fellow individuals or not connected at all. On this basis, the titles of 'Direct connectors' 'Indirect connectors' and 'Not connected' was assigned to individual points, depending on the category each power user is associated with. In addition, the layer for the payment status of the users was created. Finally, the spatial chains from where energy emanated down to the final end user of the energy were analysed and the basic categorizations considered are the Transformer to Pole Connectivity, Pole to Customer Connectivity, and Customer to Consumer connectivity. The integration of all the categorizations and connectivity analyses yielded the optimal power distribution model. The model was validated by querying identified power distribution challenges in the service area.

3. Results

The digital elevation model (DEM) of the study was generated to depict the terrain configuration as shown in Figure 2

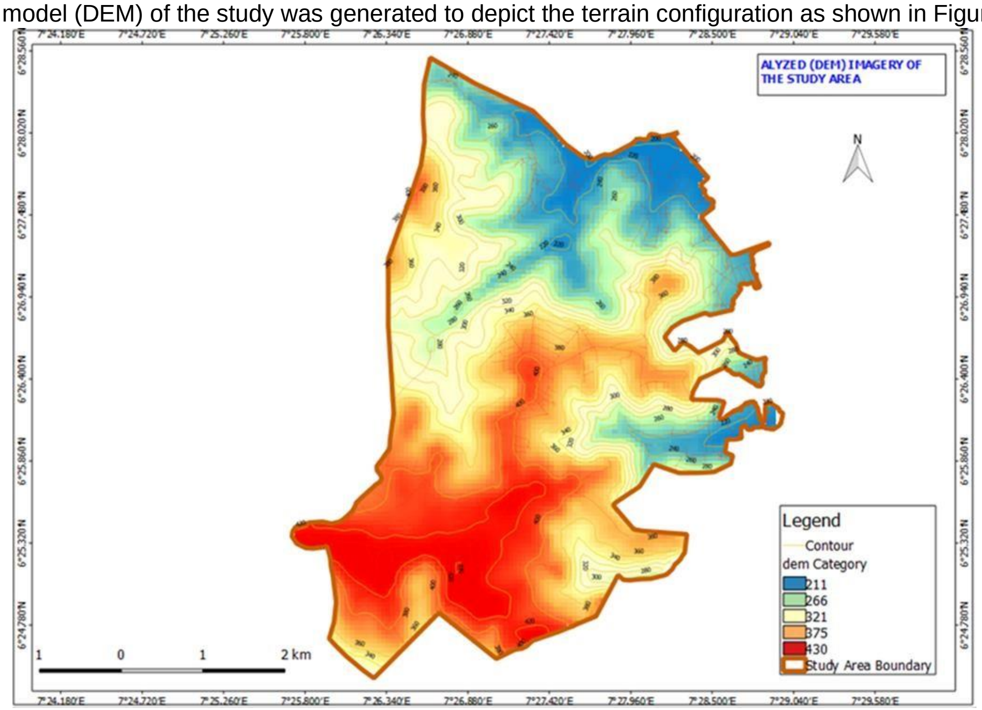

Figure 2 Digital Elevation model of the Study Area

The DEM revealed that the area has a relatively difficult terrain topography with the height pattern ranging from about 430m above mean sea level in the southern part to about 211m above mean sea level in the northern part of the study area, this gave a south-north terrain slope of over 200m. This topographic pattern greatly influenced the settlement pattern of the area as reflected in the data collation map presented in Figure 3.

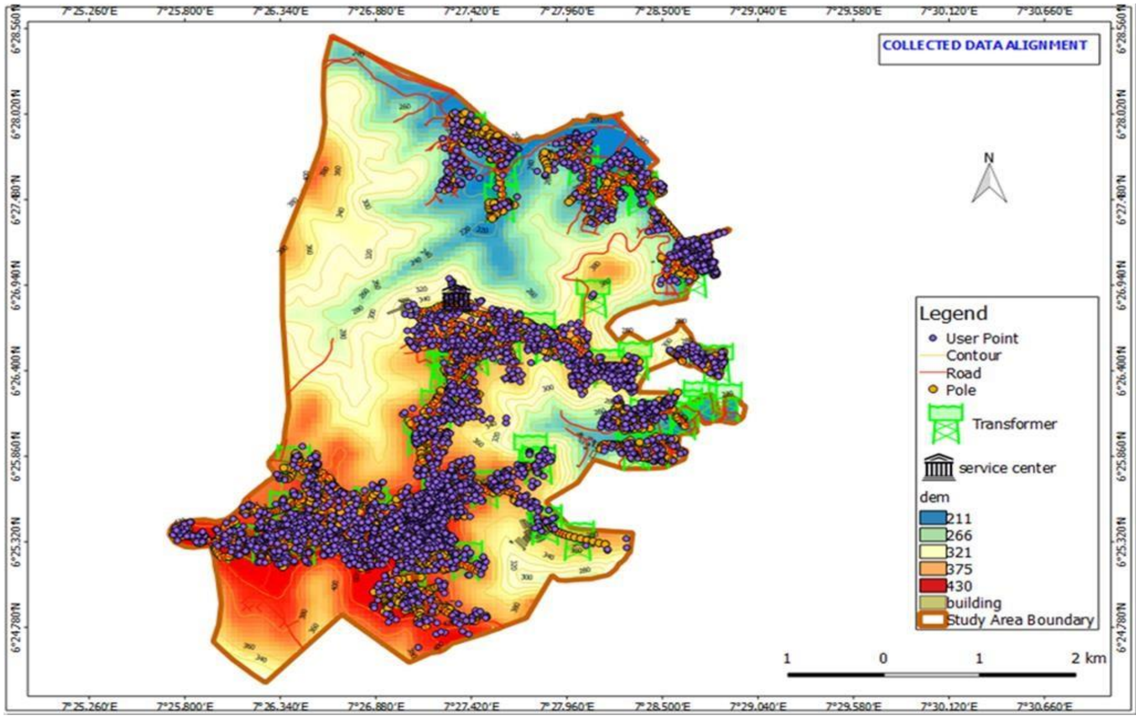

Figure 3 Data collation and referencing

The distribution of the power asset and building footprint as shown in Figure 3 revealed a dense user points and power assets in the elevated southern part while a sparsely nucleated user points and power assets are seen in the central and northern section of the study area with its relatively low elevation.

In order to examine the spatial topology of the power assets distribution in the study area, the model should be able to reveal the route path characteristics for the various access route from service centre to the desired nodes (transformers or poles). This is most remarkable for enhancing quick response mechanism in electricity service delivery; therefore, Figure 4 depicts the route network analysis for the study area.

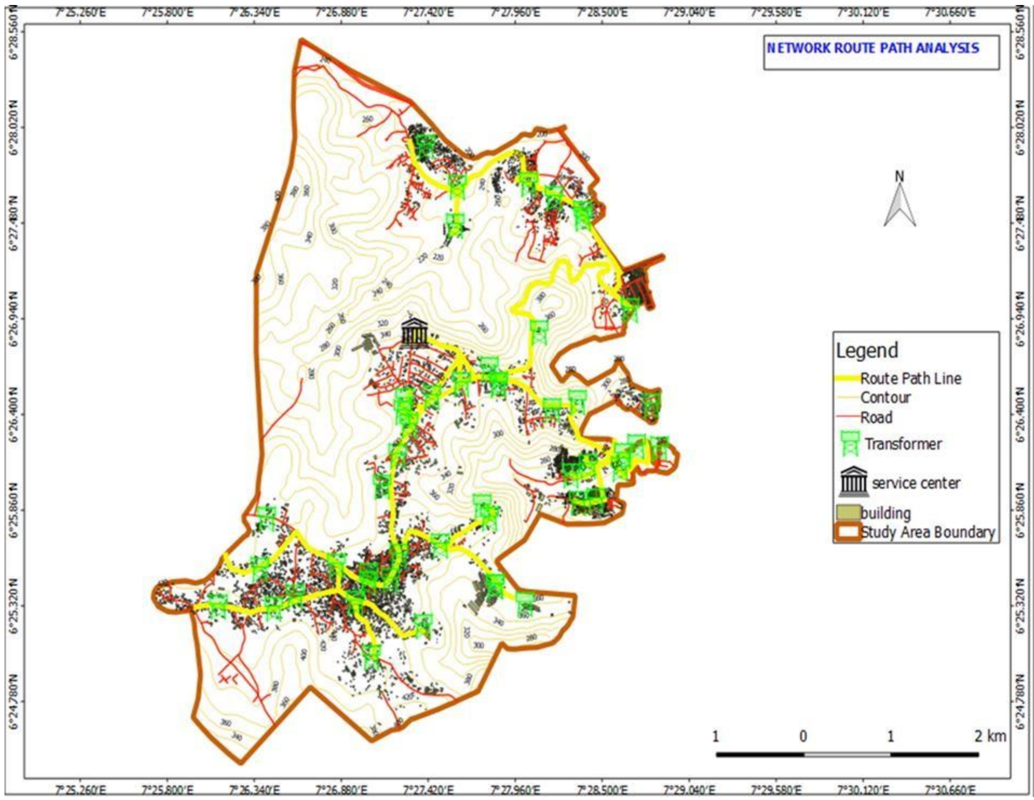

Figure 4 Route Network analysist

The transformers were categorised according to the kind of customers they serve (public, private or rural bulk), their activation status (energised or non-energised). The categorisation map is shown in Figure 5

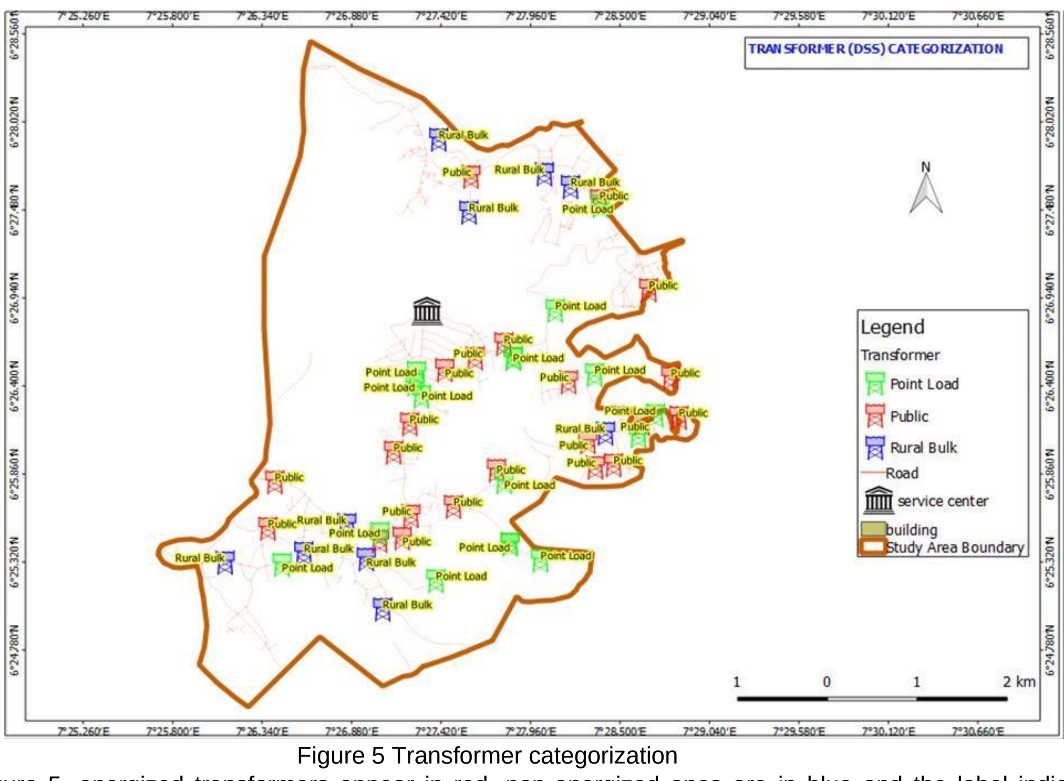

Figure 5 Transformer categorization

As shown in Figure 5, energized transformers appear in red, non-energized ones are in blue and the label indicates the transformers belonging to private individuals with one account (point load), public individuals with different accounts (public)

and community with one account (Rural bulk) This categorization on feeder coverage level aids the functionality of the model in knowing transformers that are no longer in use due to fault or vandalization.
Similarly, the electric poles were categorized in relation to the transformer they service into four (4) upriser layers as depicted in Figure 6.

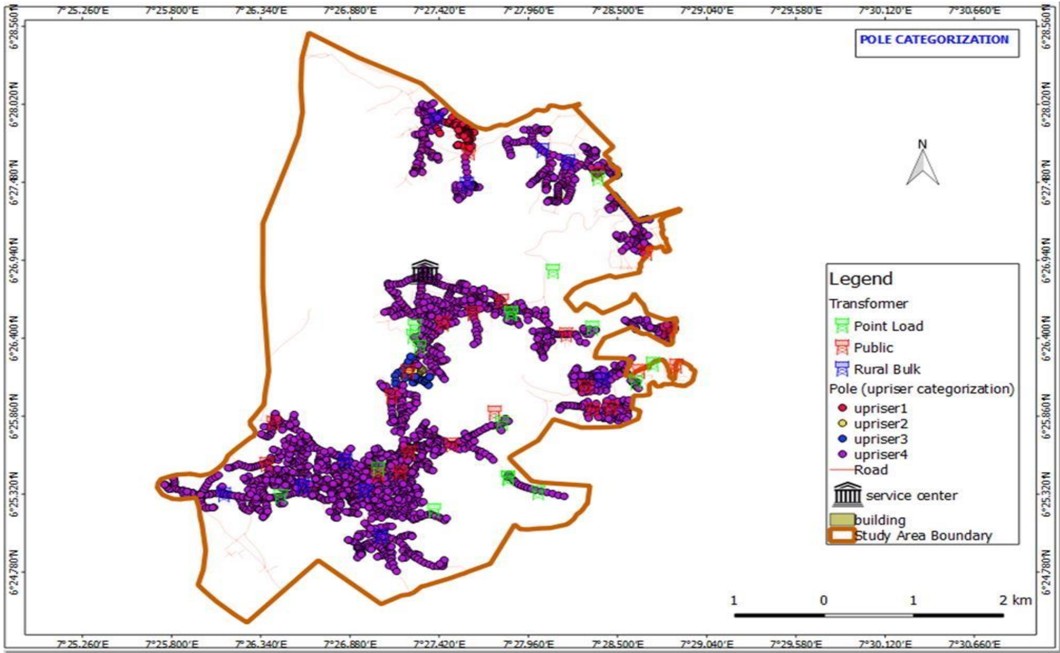

Figure 6 Pole categorization

User categorisation was also done based on connectivity status and customer classification as shown in Figure 7.

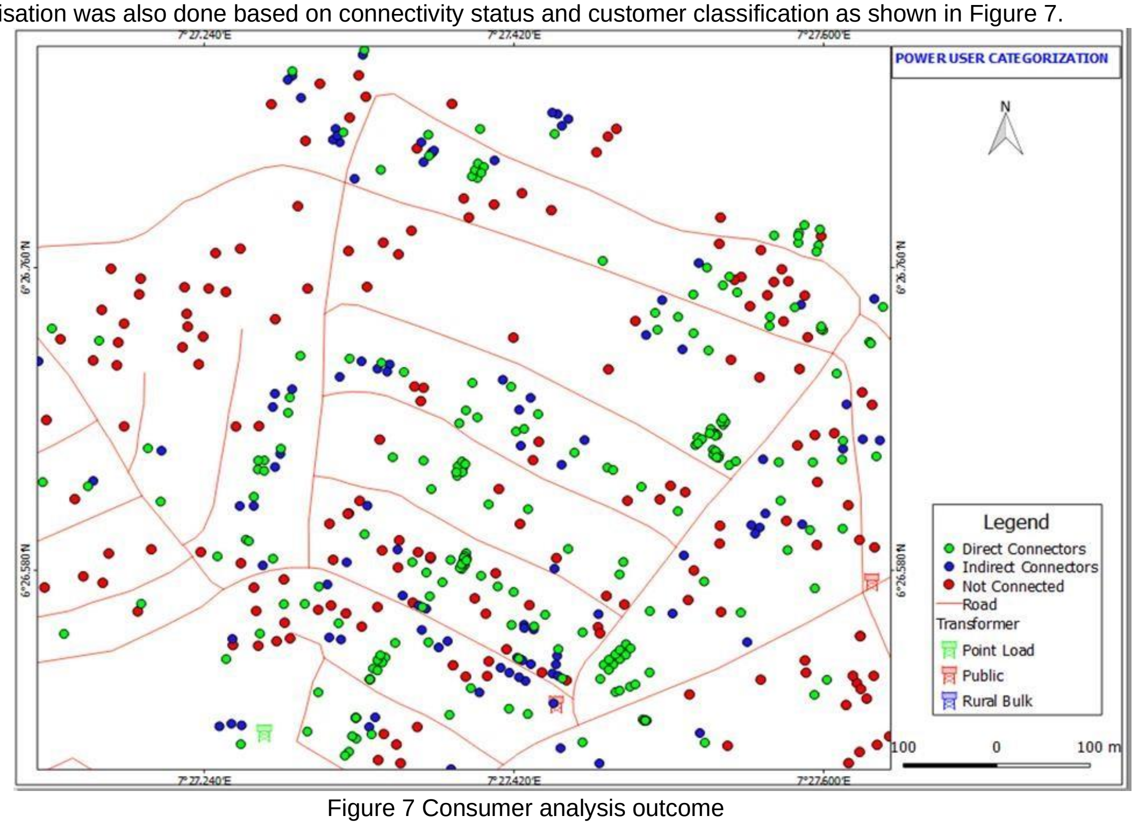

Figure 7 Consumer analysis outcome

In terms of connectivity, as can be seen from Figure 7, we have direct connectors (green dots), indirect connectors (blue dots) and not connected individuals (red dots) who double as potential customers in terms of customer classification. The essence of the categorization to the model is for easy identification of individual users on the field. The full users' identification model was created by overlaying the map of buildings unique codes and that of the user points categorization based on connectivity status as shown in Figure 8.

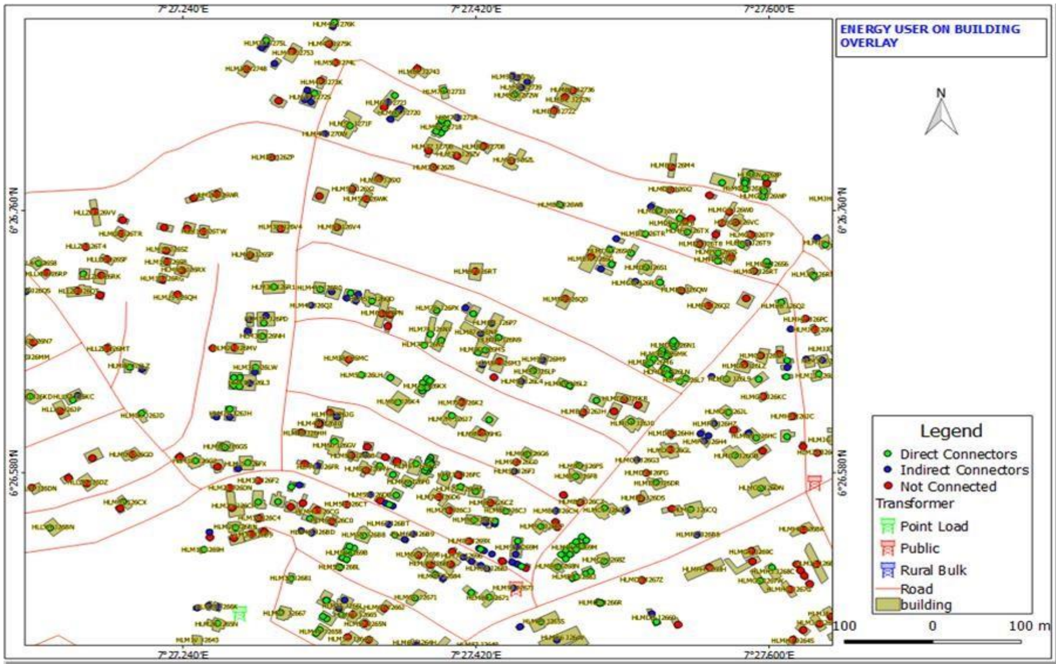

Figure 8 Energy User on Building Overlay

The impact of this on the proposed model is that each user can be located in the field using the building structure and code in connection to the closest pole.

The final geospatial model for power distribution was realised through the various connectivity models, which include; transformer to pole connectivity (Figure 9).

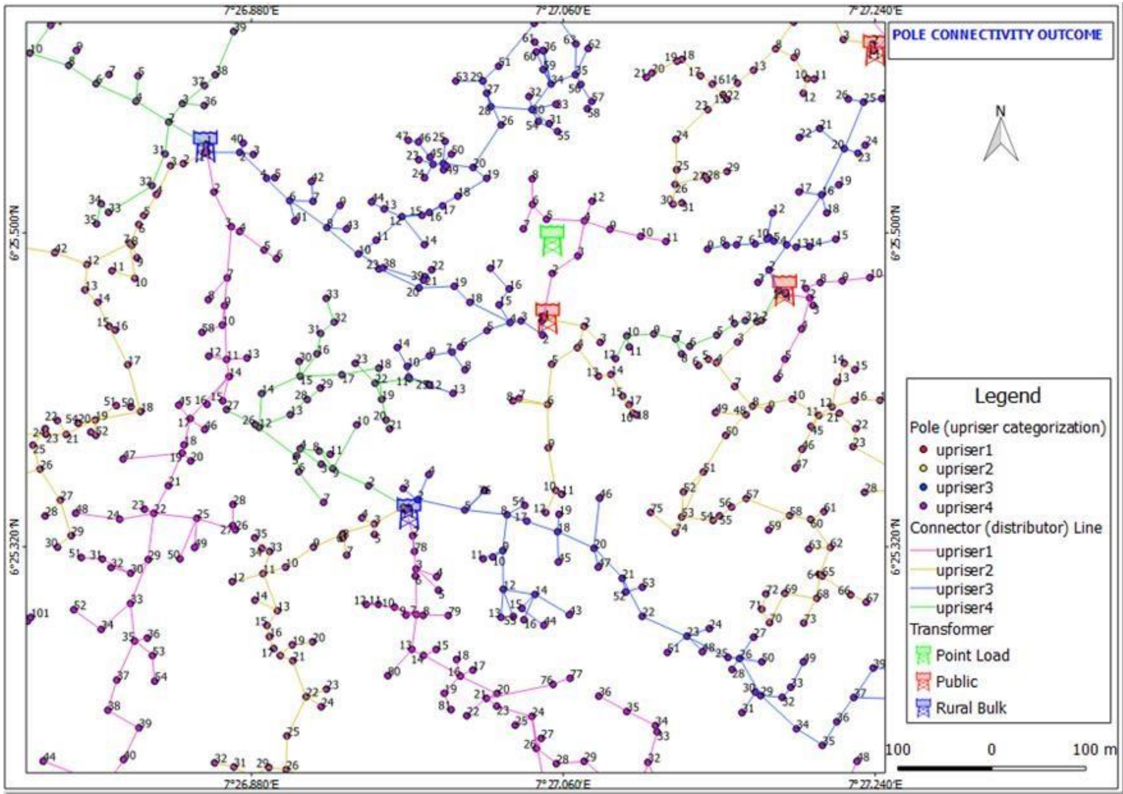

Figure 9 Transformer to pole connectivity

Others are the pole to customer (direct customers) connectivity and customer to consumer (indirect or potential customers) connectivity. The full geospatial model for efficient management of electricity energy distribution as applied to Ngwo transformer in the study area is depicted in Figure 10.

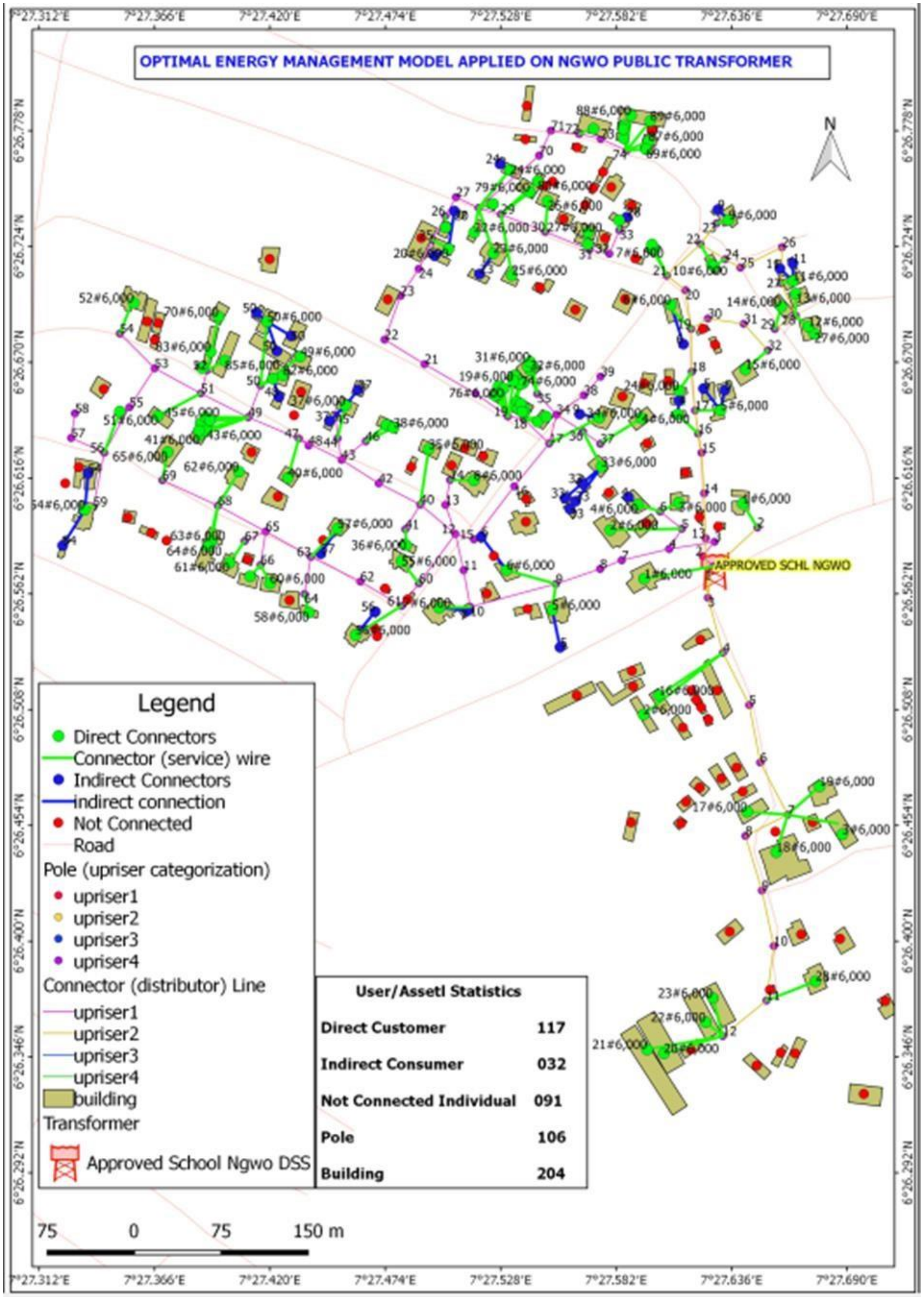

Figure 10 The geospatial model for energy distribution management

Since the model consists of series of connectivity of power assets and user nodes, the model offers a robust means for fault tracing in the power distribution system while detecting locations of legitimate and illegitimate energy losses. one can actually see and go after those individuals who are meant to be direct customers but are on consumer category. On the other hand, this connection through the model exposes areas of energy loss and theft.

4. Model Validation

An experiment was conducted to test the functionality of the model. The test was design to identify fault location and determine extent of users and assets affected. The fault origin was identified on the field as upriser2 pole, the location of upriser2 was queried on the model and the number of pole points and user points as well as categories of users were generated as shown in Figure 11.

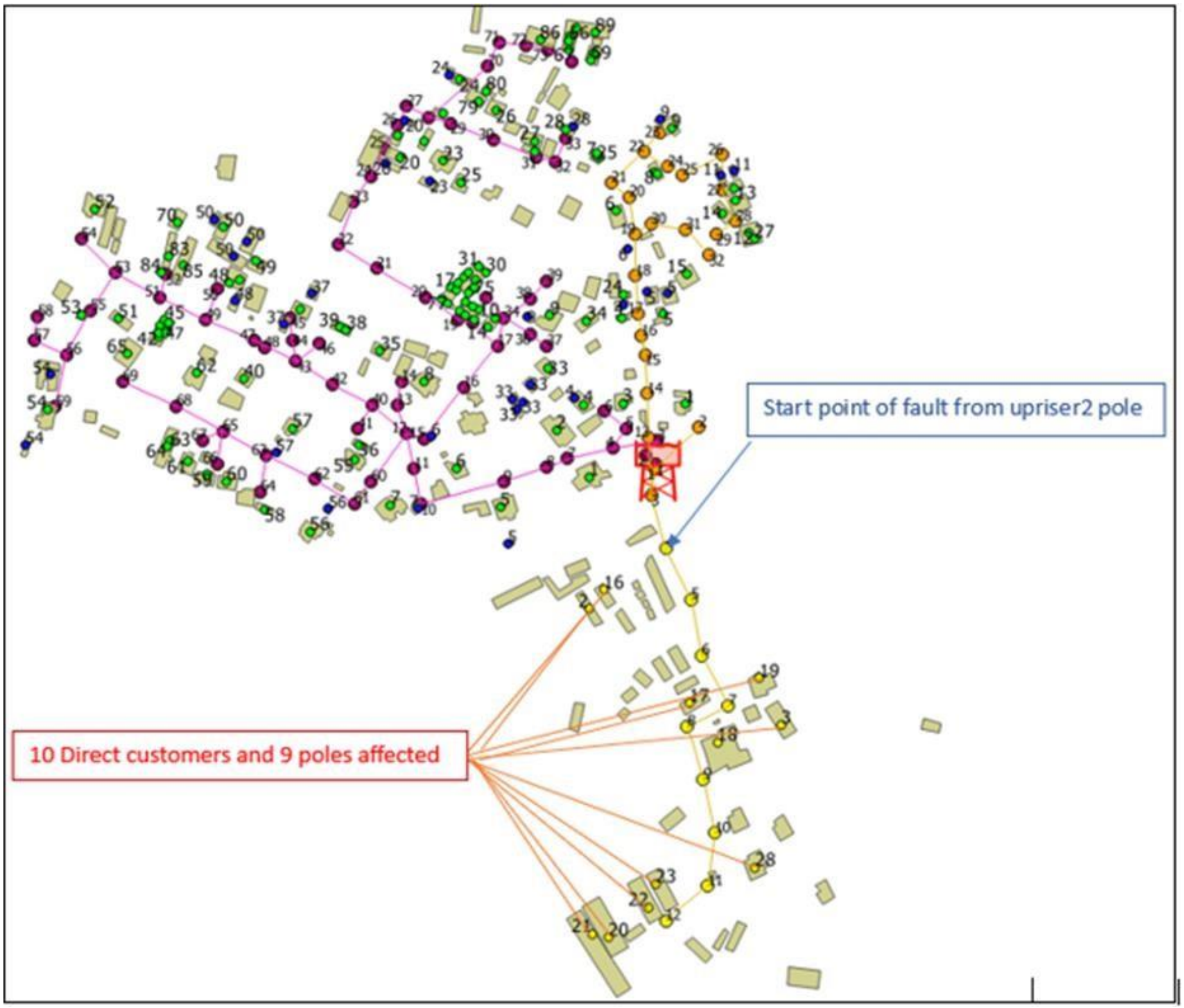

Figure 11 Fault tracing and extent of impact on the power management model.

The output in Figure 11 is essential for cost evaluation and response planning for efficient management of power infrastructure and service delivery.

5. Conclusion

This paper presents the development of a geospatial-based power management model for handling power distribution system in Enugu. Spatial and attribute information about the power assets, user points and building footprints were acquired and manipulated in QGIS environment. Several connectivity models were created which were integrated to realised the desired power management model. The model was validated by performing fault tracing to identify location of faults and detecting poles and user connectivity for evaluation of impact level and enhances planning for maintenance. The results revealed that the model has the ability to minimised the challenges faced by power operators in detecting fault and control power usage. It is recommended that the potential of this model be utilised in mitigating power management challenges in Nigeria.

Acknowledgments

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