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APPLICATION OF GIS IN ELECTRICITY SAFETY MEASURES IN CHEVY VIEW ESTATE,ETI-OSA LGA, LAGOS STATE

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ABSTRACT

The study used GIS methods to apply laws regarding safety of residents in Chevy View Estate, Eti-Osa Local Government Area of Lagos State regarding compliance to the setbacks to electricity utilities to prevent injuries or deaths from transformers' explosions and electrocutions. The study adopted vector data model. The electric poles, transformers (33KV/415V) and the customers' locations were modelled as points, the various lines carrying current were polylines while the buildings and the study area boundary were polygons. The design and creation of a spatial database were carried out. The data were both primary and secondary data types. The primary data were the ones collected with use of handheld GPS (Transformers, Poles and Customers' locations) while the secondary data (attributes of the Transformers, Poles and Customers locations) were from the Eko Distribution Company, Lekki. The image from where the buildings and roads were digitized was downloaded from Google Earth Pro online and georeferenced. The analyses carried out included spatial query, buffering to indicate those buildings within the setbacks to the electric poles, transformers and hightension lines at 6.0m, 30.0m and 9.0m respectively. A total of 188, 131 and 111 buildings were within the setbacks of electric poles, transformers and high tension lines respectively. Theoverlay (selection by location, selection by attributes) was used to intersect the buffered layers with the building layer to get the buildings intersecting the buffered zones. The aim and objectives were achieved and

recommendations made.

KEYWORDS: Electricity, Transformers, Safety, Chevy View Estate, Geospatial, Setback.

1.0 INTRODUCTION

Power System is a network that provides regions, industries and homes with electrical energy whereas electricity generation, transmission and distribution are the three stages of delivering electricity to consumers (Sule, 2010). This power system is known as the grid and can be broadly divided into the generators that supply the power; the transmission system that carries the power from the generating centres to the load centres and the distribution system that feeds the power to nearby homes and industries. The distribution system is a part of power systems which is dedicated to delivering electrical energy to the end user. The goal of power distribution planning is to satisfy the growing and changing load demand within operational constraints and with minimal costs as found in the study by Sharma, Priyanka and Singhal (2008). The Electric power sector is one of the most important sectors to national development; it is also critical to the developmental reform of any country and that the power sector in Nigeria has multidimensional problems such as bribery, corruption and mismanagement of funds for execution of electricity power projects (Maliki, Chatta & Uwanuakwa, 2019).

Mukhtar and Kantsi (2019) submitted that the most vital innovation ever in the history of mankind is electricity; and it is also instrumental to the growth and development of all facets of human life. Electricity access is a key for sustainable development of any country (Taye *et al*., 2020). The study by Taye *et al.*, (2020) noted that lack of scientific and methodological know- how as regards planning, site selection, distribution, and density of population settlement, economic level, social levels, and distance from the national grid are main factors that inhibits electrification rates in parts of African countries. Jasni *et al*. (2017) opined that adequate supply of electricity is dependent on the conditions of the transformers because they are the backbone of the power supply. Geographic Information System (GIS) was also cited as a technology for the creation, management representation, search, analysis and shearing of geospatial information (Huisman & *de*By, 2009).

Adejoh *et al*., (2015) posited that improving the performance of distribution systems to meet the required target is a matter of selecting the most effective and appropriate technology with right operating practices. It was believed that with the periodic updating and monitoring, GIS mapping of the Electrical Network and Consumer database helps in improved planning, load management, loss reduction, better revenue realization, asset and management standard of the distribution network and possibly better consumer relationship. Geographic Information Systems(GISs) have an essential part to play in the management and planning of electricity distributionas seen in the work of Hamza and Chmit (2022).

On the other hand, in cases where additional source of power generation is required where the main source cannot meet the demands of the consumers as seen in the study area, this can also pose a problem of overvoltage and overloading as seen in the work of Huanga *et al*., (2016) as they noted that the integration of more and more renewable energies, such as wind power (WP) and solar power (SP), into distribution networks becomes a big challenge to distribution system operations. The impacts on the distribution networks due to high penetration of these distributed generators (DG) include overvoltage and overloading issues. These connections can be made at specific points (transformers): at substations for connecting to cable power transmission lines, or at towers to connect to overhead power lines (service lines) as opined by Kosyakov and Sadykov (2015).

The previous studies concentrated mainly on the generation, transmission and distribution without recourse to the safety of the end users or those along the transmission lines. Transmission through a long distance has a lot of health implications on the people along the transmission lines. Lot of lives had been lost to electricity induced deaths and accidents. It was also noted in the study area that most high tension lines are very close to the roofs of residents' buildings hence there is the need for appraisal of the compliance to the set rules and regulations guiding the siting of buildings and utilities away from these life threatening but beneficial utilities. Electricity provides means for luxurious life but it is equally dangerous and hazardous too, if not handled properly (Gore & Mane, 2018). Safety according to Selçuk (2015) is the state of being away from hazards caused by natural forces or human errors randomly. The source of hazard is formed by natural forces and/or human errors.

Safety of the end users of the generated, transmitted and distributed electricity is very paramount to this study. The dangers from electricity are caused by a series of factors. Suleiman and Ali (2013) cited overloading and poor maintenance as factors responsible for the breakdown of electric transformers which are causes of hazards on the end users. The aspect of periodic maintenance and the necessary repairs should not be neglected when any malfunction or damage is discovered in the devices used (Muhsin, Majeed & Almosawy, 2021). The main cause of the constant breakdown of the utilities was traced to negligence on the part of the companies most often times.

The hazards associated with the use of electricity can affect any one. Electricity has long been recognized as a serious workplace hazard, exposing human being to electric shock, electrocution burns, fires and explosions (Gore & Mane, 2018). Safety precaution according to Ghosh *et al.* (2015) means to strictly follow the prescribed rules for safety of self, working personnel and tools to conduct electrical work, otherwise possibility of electric shock or hazards could be experienced. They stressed that safety of an electrical installation could be ensured by proper insulation, good earthing system and adopting adequate protection and control systems.

The study area is Chevy View Estate (Figure 1) in Eti-Osa Local government area of Lagos State. It lies within longitudes 3° 30' 56.658" and 3° 31' 51.048" East of the Greenwich and latitudes 6° 26' 16.942" and 6° 27' 17.423" North of the Equator. It is bounded in the south by the Atlantic Ocean, in the east by Ibeju Lekki local government area, in the northern part by Lagos lagoon and in the western part by Amuwo-Odofin and Lagos Island Local government areas of Lagos State. Eti-Osa Local Government has an area of about 174.9km^2 and with a population of about population of about 283,791 which represents 3.11% of the state's population and made up of 158,858 males and 124, 933 are females with an annual 3.2% of annualpopulation change (NPC, 2006). Within Eti-Osa are several important areas of Lagos State, including Victoria Island before Nigeria capital was moved to Abuja.

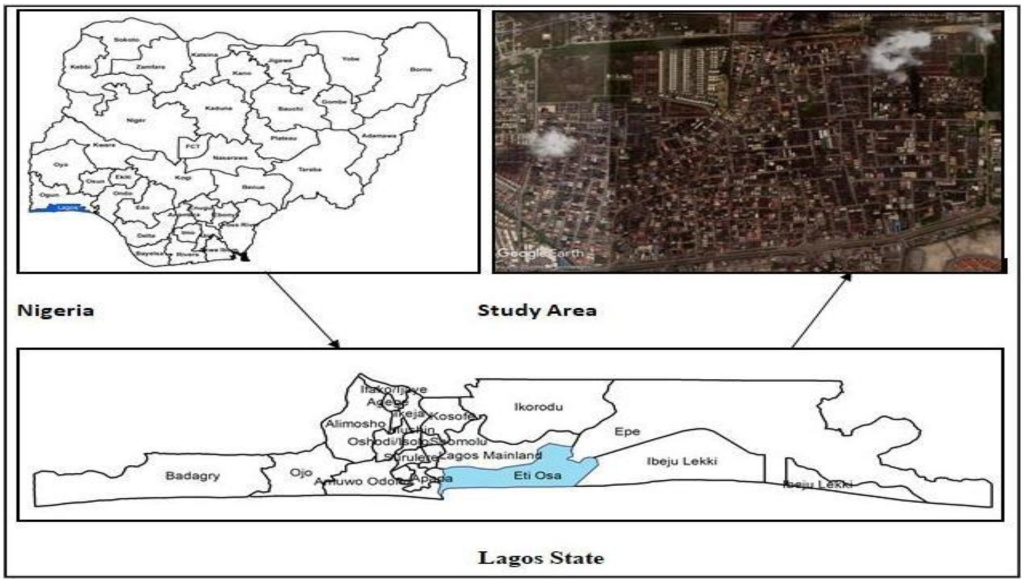

Figure 1: Location of the study area.

2.0 MATERIALS AND METHODS

2.1 Materials

Geospatial data can be acquired using a variety of technologies and can be entered into GIS (Folger, 2009). The data used in the execution of the study were mainly the primary datasets and the secondary datasets. The primary data were the locations of the transformers, electric poles. This was done with a handheld GPS. The secondary data used include high resolution Google Earth imagery of the study area, downloaded and georeferenced from where the roads, the buildings and the study area boundary were digitized; Local Government boundary map from the Office of the Surveyor-General of Lagos State, Ikeja, Lagos State and the customer data, transformer information and other related information were collected from the Eko Distribution Company at Eti-Osa Local Government, Lagos State.

2.2 Methods

GIS methods were adopted by Zeiler (1999); Mathankumar and Loganathan (2015) and a host of scholars in spatial modelling. The secondary data sets were in various geographic coordinate systems. The datasets were converted to common Geographic Coordinate System using ArcGIS 10.8.1 software. The map of Lagos was scanned and georeferenced from where the map of the state was extracted through vectorisation. This was overlaid with the various shapefiles of the entities and projected using WGS 84 Zone 31N coordinate system. The shapefiles were populated with the attribute information from social survey (Oral interview, field observations and data from the Eko Distribution Company). The analyses were guided by the "Lagos State Urban and Regional Planning and Development Law 2010" as reported by Ogbeche (2016) in Daily Post. "The state Urban and Regional Planning and Development Law 2010, not only prohibits building under the centre-line of over-head electricity wires, it also in very clear terms specified the distance to be observed between a property and a public utilitysuch as the PHCN high tension cables". "The required setback for buildings from the centre-line of over-head wires and horizontal distance between such buildings of not less than 6.0 metres for 11KV wire lines, while 9.0 metres is the recommended distance for 33KV wire lines. "Furthermore, the recommended setback for 132KV wire lines is 15 metres, while a 22.5-metre setback is recommended for 330KV power line". In another standard, the underground cables should be buried at least 3.0m below the ground surface. The database created was tested with queries while buffering and intersecting of shapefiles were also carried out and results generated.

3.0 RESULTS AND DISCUSSION

3.1 Spatial query

GIS technology in the view of Yadav (2013) when used in utility sector is emerging as an efficient planning and decision making tool; the ability of GIS to integrate common database operations such as query and statistical analysis make it different from other traditional information systems. Geodatabase plays a key role in GIS analysis (Baba *et al*., 2020). The database was queried for the residential buildings within the study area because the study area is mainly residential. The study was aimed at the safety measures around the electric utilities within the Estate hence the need to know the number of residential buildings within the Estate. The query is shown in Figure 2 and the result is as shown in Figure 3 while the map is in Figure 4.

Figure 2: Generation of query to show residential buldings within the study area.

Figure 3: Result of query to show residential buldings within the study area.

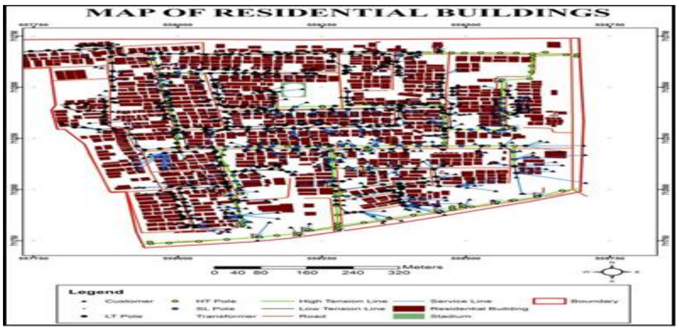

Figure 4: Map showing residential building.

Discussion of query results

The query was a single criterion query issued to show Residential Buldings within the study area. The query returned One Thousand and Two (1002) buildings out of the total of One Thousand and Seventy One (1071) buildings in the Estate. This is 93.56% of the total number of buildings in the Estate. The Estate is primarily residential with the other percentage used for educational, religious, recreational, sporting, banking and commercial purposes. This is an indication that virtually all the buildings within the Estate are occupied at any point in time through out the day. Even the non-residential buildings are occupied during the day especially the ones for commercial, recreational or educational purposes.

3.2 Buffering

Buffering according to Kemp (2008) is the creation of a polygon at a set distance from a selected point, line or area feature; buffers are commonly used for spatial analysis. This was used to find the number of buildings that fall within the setbacks of the transformers, high tension and electric poles. This operation was guided by the law enacted by the Lagos State Urban and Regional Planning and Development Law 2010 summarized in Table 1.

Table 1: Setback from electrical wire lines.

Feature	Setback (m)
11KV wire lines	6.0
33KV wire lines	9.0
132KV wire lines	15.0
330KV wire lines	22.5
Transformer	30.0

Oseni and Durowoju (2020) also applied GIS in Electricity distribution in part of Ashamu Layout in Oyo. They used a buffer distance of 6m between the electric poles and the buildings and a distance of 30m from the Electric Transformers irrespective of the type and capacity. The buffer distance standard was gotten from the Office of Ibadan Electricity Distribution Company, Ibadan. The same buffering distances were applied in the course of this study to show those buildings within the setback distances from the poles and the transformers in the study area.

3.2.1 Buffering of electric poles

The same law by the Lagos State Government was applied to Chevy View Estate, where Eko Distribution Company operates electricity distribution. The electric poles were buffered with a distance of 6.0m (Figure 5). On the other hand, the "Selection by Location" menu was used to select those buildings that are within the 6.0m buffer distance which served as the setback from the poles to the buildings (Figure 6). The result and the map are displayed in Figures 7 and 8.

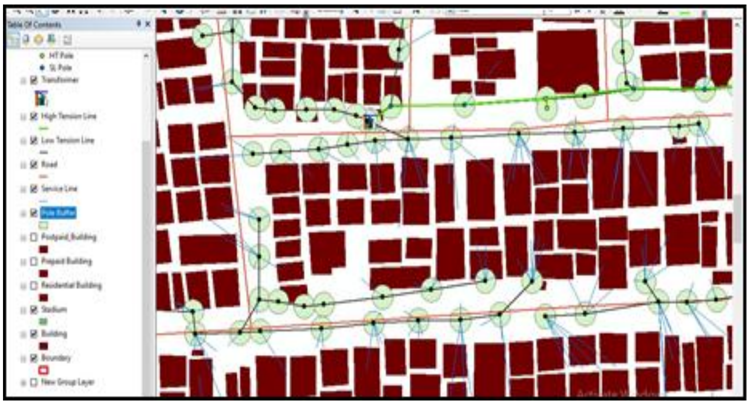

Figure 5: Diagram showing buffered electric poles by 6.0m.

Figure 6: Select by location of buildings within electric pole buffer.

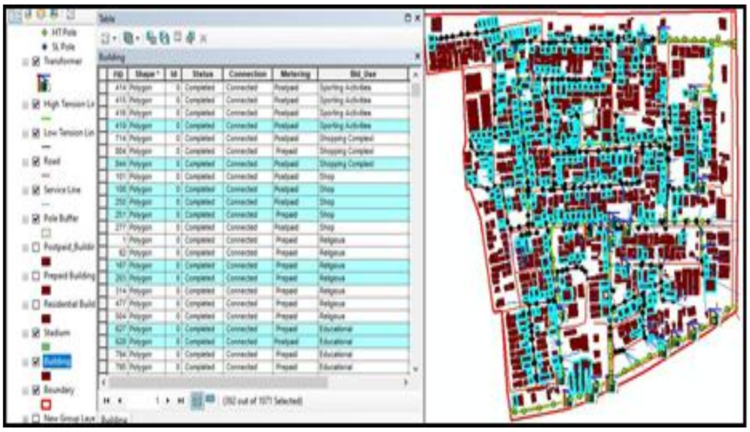

Figure 7: Buildings within the electric poles setback.

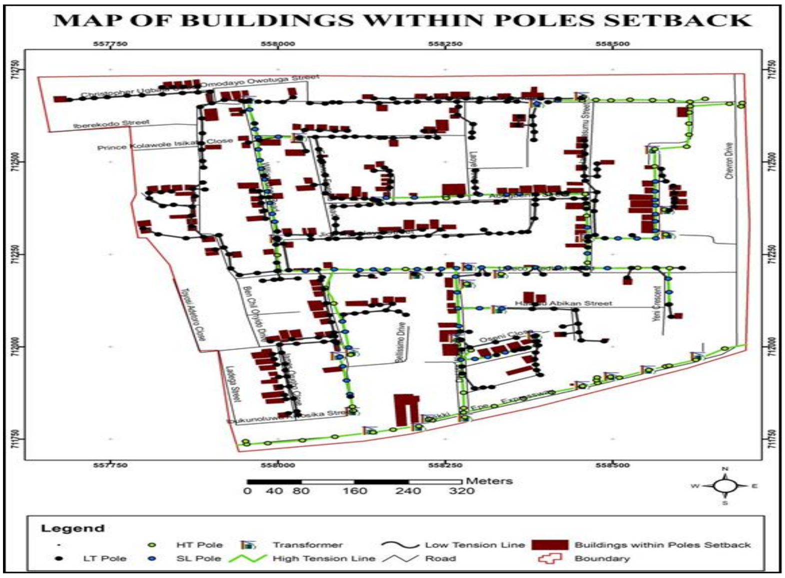

Figure 8: Buildings within the Electric poles setback.

3.2.2 Buffering of transformers

Electricity transformers from the study by Baba et al. (2020) could have the capabilities under normal operating conditions to serve far beyond their required expected years of disposal, nonetheless, the consequences of engaging very old transformers could be enormous including deterioration of insulation materials, power outage, fire incidences, increased temperature of the equipment and explosion among others. This assertion in line with the extant law of Lagos State requires that transformers are dangerous when installed very close to the residential dwellings. The transformers in the study area were buffered by 30m as stipulated by the law in Lagos State (Figure 9). This is in line with the operational rules and for safety in case of explosion and the emission of radiation from the transformers. The result from the operation is shown in Figure 10.

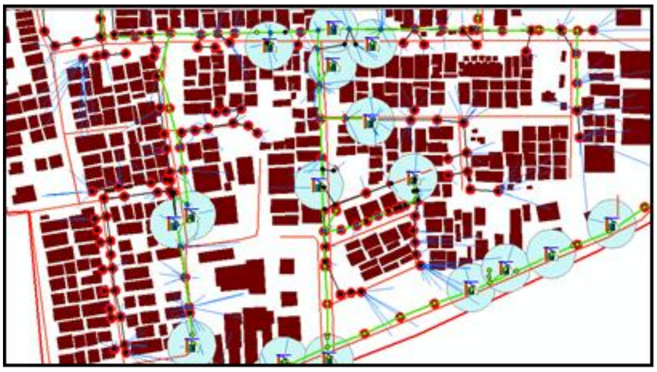

Figure 9: Result of buffering of transformers by 30m.

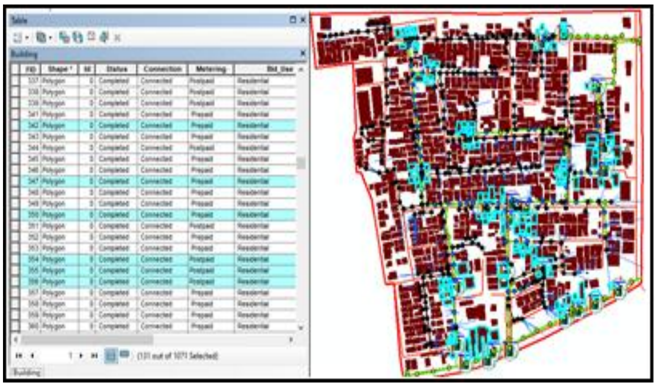

Figure 10: Result of buildings within transformers setback.

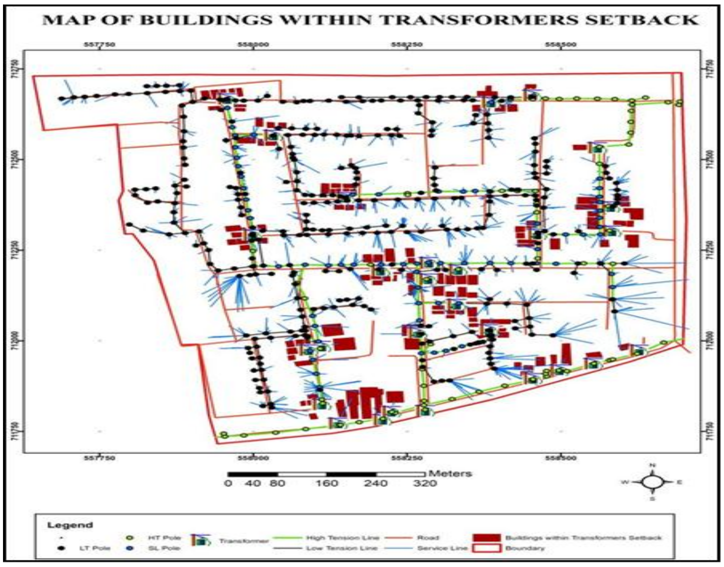

Figure 11: Map of buildings within transformers setback.

3.2.3 Buffering of high tension lines

The high tension line in the Estate is 33KV. It was buffered at the distance of 9.0m according to the Lagos State law on the setback of utilities and it is as shown in Figure 12. The buffered high tension line was intersected with the building layer (Figure 13) to find those buildings that contravene the law using the "Select By Location" tool in ArcGIS software. The result is shown in Figure 14. The embellished map is shown in Figure 15.

Figure 12: Diagram showing buffer of high tension lines by 9.0m.

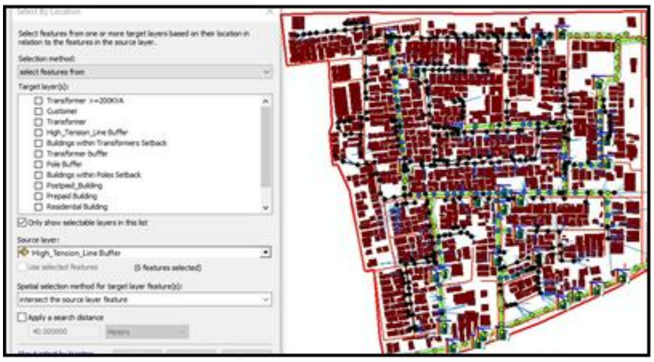

Figure 13: Select by location to show buildings within high tension buffer.

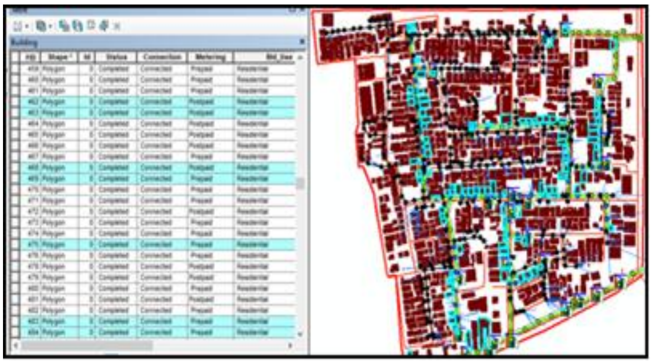

Figure 14: Result showing buildings within high tension buffer.

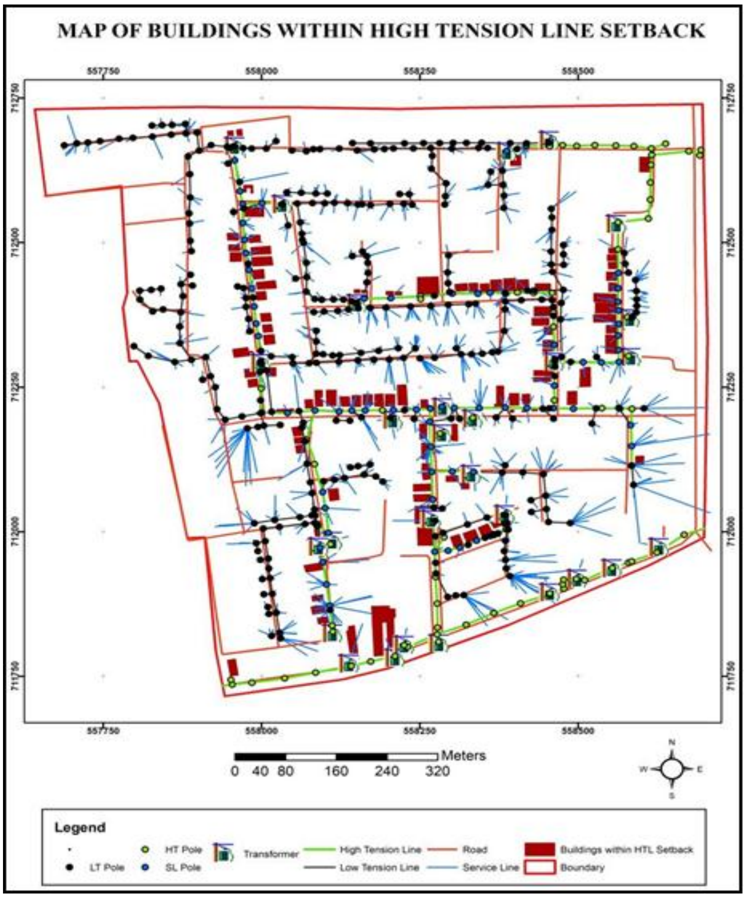

Figure 15: Map of buildings within high tension buffer.

Discussion of buffering operation results

The buffering operation carried out was for safety purposes in order to give a setback of 6.0m, 9.0m and 30m buffer distances to the electric poles, high tension lines and the transformers respectively as guided by the laws of Lagos State in 2010. The results showed that 188 buildings fall within electric poles buffer distance, 131 fall within transformers buffer distance and there are 111 buildings that are within the high tension wires buffer. This showed that those living or using these buildings for one purpose or the other are prone to one form of danger or the other ranging from radiation from the transformers or outright explosion to electrocution in case the high tension lines cut off. This is summarized in Table 2.

Table 2: Setback of features.

S/N	Features	Setback distance (m)	Number of buildings within setback
1	Electric poles	6.0	188
2	Transformers	30.0	131
3	High Tension	9.0	111

3.3 Network analysis

Network analysis is important to this study because it will assist in the navigation round the Estate for attending to emergencies within the Estate. It will also be useful in carrying out routine maintenance of transformers and attending to complaints of customers. The Network Analyst Tool of ArcGIS was used for this analysis.

3.3.1 Best and Alternative routes

The best route (Figure 16) remains the shortest distance travelled. It is the distance with the shortest impedance in terms of time spent (ESRI, 2022). Best route is necessary to save time and cost of navigating round the Estate when certain services like attending to emergencies, bills distribution, transformer maintenance and attendance to complaints are required to be done. The alternative route is necessary because of a barrier on the Best route (Figure 17). The expectation is that the system will create another route that is longer but close to the best route (Table 3).

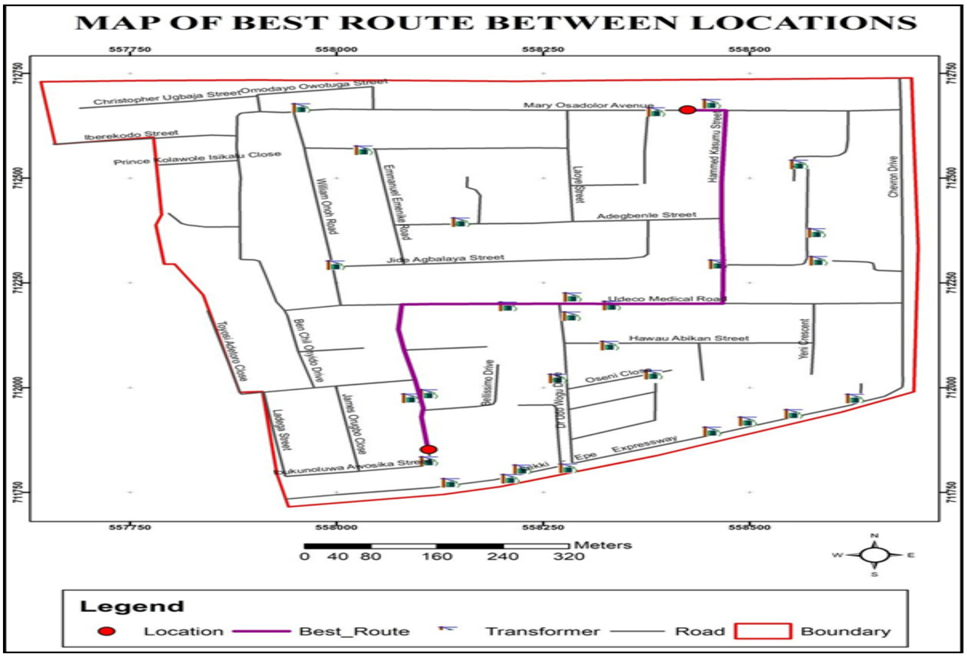

Figure 16: Map of best route between locations.

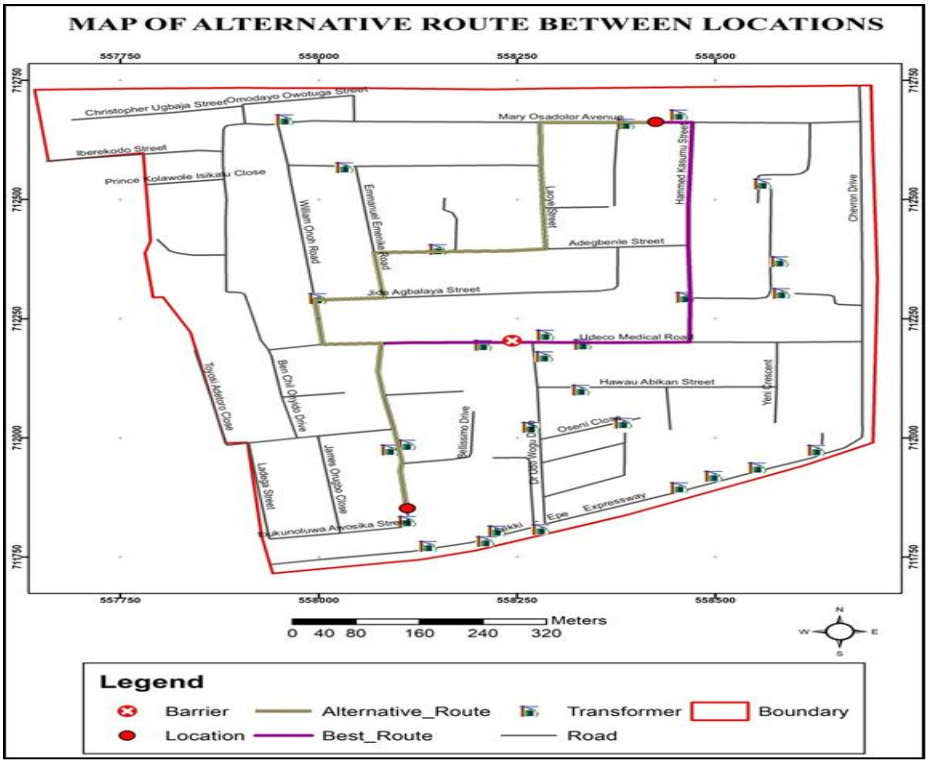

Figure 17: Map of Alternative route between locations.

Table 3: Best and Alternative routes analysis.

Route	Distance travelled (m)
Best Route	1246.30
Alternative Route	1327.30
Difference	**81.00**

Discussion of network analysis results

The analysis of Best route within two points in the Estate was done to know the travel distance in case there is need to move from one point to the other in case of attending to cases of emergencies, transformer repairs, attending to cable complaints, attending to customers' needs etc. The distance travelled on the Best route was calculated by the software as 1246.30m while the alternative route gave a distance of 1327.30m. The difference between the two routes was given as 81.0m as summarized in Table 3.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 CONCLUSION

The study was able to show that a lot can be done with the use of GIS and allied tools like remote sensing and can also be applied to solve electricity distribution problems, safety to life and properties wherever such may be required. The analyses carried out included query of the database to show the efficiency of the database, buffering to check for the setbacks to the utilities(electric poles, high tension lines and the transformers) and the network analyses for the best and alternative routes. The various analyses yielded results for a Spatial Decision Support System.

4.2 Recommendations

Having performed the various analyses and concluded the study successfully, it is hereby recommended that the following should be considered to forestall loss of life to electricity induced accidents and dangers if not deaths from electrocution in the study area. They included but not limited to:

1. GIS technologies should be introduced to manage and monitor the activities of the distribution companies in the study area and around the country;
2. The staff training and retraining on the latest software in the field of Geoinformatics should be encouraged to be able to go with the trend of changes that may occur with the technology because there are new methodologies emerging on regular basis.
3. The data for studies that are life-saving should be accurate and timely so that the results of such findings can be used to support decisions made from those recommendations from the findings by the researchers.
4. The transformers that are within the setback of buildings should be relocated and future installations should follow the laws enacted to forestall future dangers.
5. Finally, it is recommended that further study should be carried out in the study area to

further probe into the life span, state of the health of the transformers and other supporting accessories of electricity distribution in the study area to forestall dangers form explosion and electrocution.

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