POWERLINE ELECTRIC HAZARD VULNERABILITY MAPPING: A CASE STUDY OF FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE, ONDO STATE

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ABSTRACT

Electrical power remain one of the driving forces of any meaningful economic development, but many a times, losses are encountered when disasters befalls as a result of non-compliance to the standard setback and height clearance provisions of the laws, regulations, and guidelines of the state for construction of this important infrastructure even in the most prestigious academic environment like the University. Utilizing the 3-Dimension data gathering surveying traverse method and GIS approach within the 577.97 hectares of Land of Federal University of Technology Akure, this research was able to cover about 241 Medium Tension (MT) poles, 28 Medium Tension/ Low Tension, 365 Low Tension (LT) poles and 6 Transformer. This finding revealed from analysis that the electrical hazard vulnerability (i.e. non-compliance with the guidelines, regulation and laws of Ondo state) level with respect to the MT poles, with standard 30m buffer, were 52%, 84% and 64% for the residential, institutional and educational buildings respectively and for that of LT poles were 64%, 69% and 67% of the residential, institutional and educational buildings respectively with 20m buffer. This study has shown that the compliance level is discouraging and it was recommended that adequate measures must be put in place by all relevant authorities of the University and the Benin Electrical Distribution Companies (BEDC) to forestall possible recurrence of imminent danger therefrom.

Key words: Electricity, Electrocution, Power, Utility Survey, Mapping.

1.0 INTRODUCTION

It is no longer news and on several occasions in different locations in Nigeria, including the revered academic environment and citadel of learning where the elites are domicile, that electrocution has claimed lives and damages resulting from negligence on the parts of residence and majorly non-compliance with the standard for constructing electrification facilities by professionals. Electricity is a vital infrastructure that is very necessary for the smooth and meaningful development of any nation. It has brought many marvels in life and the world would seem so hard without it (Govindaraj and Nailwal, 2013). The prime purpose of an electricity distribution system is to meet the customer's demand for energy after receiving the bulk electrical energy from transmission or sub-transmission substation (Kanmani and Suresh, 2014). Electricity is basically the flow of electric current. This involves first of all, generation of power, then its transmission and finally distribution of the electric power to consumers (Sule, 2010). In India, the electric power industries have been developing power transmission system to follow up with a rapid growth of the power demand due to increasing population pressure on this sector. The electric distribution system is dedicated to delivering electrical energy to end users (Parkpoom, 2013).

Precautionary measures must be put in place while working in an electrical environment to avoid electrocution, as anyone can be exposed to the electrical hazards at home or at work. Workers are exposed to more hazards because job sites can be cluttered with tools and materials, fast-paced, and open to the weather. Electrical trade workers must pay special attention to electrical hazards because they work on electrical circuits. Coming in contact with an electrical voltage can cause current to flow through the body, resulting in electrical shock and burns leading to serious injury or even death. As a source of energy, electricity is used without much thought given to the hazards it can cause. Because electricity is a familiar part of our lives, it is often not treated with enough caution. As a result, an average of one worker is electrocuted on the job every day of the year. According to the Bureau of Labour Statistics Census of Fatal Occupational Injuries 1992–2005, Electrocution is the fifth leading cause of work-related deaths for 16 to 19 year olds, after motor vehicle deaths, contact with objects and equipment, workplace homicide, and falls. Electrocution is the cause of 7% of all workplace deaths among young workers aged 16–19, causing an average of 10 deaths per year. Most people do not realize that overhead power lines are usually not insulated. More than half of all electrocutions are caused by direct worker contact with energized power lines. Power line workers must be especially aware of the dangers of overhead lines. In the past, 80% of all linemen deaths were caused by contacting a live wire with a bare hand. Due to such incidents, all linemen now wear special rubber gloves that protect them up to 36,000 volts.

Today, most electrocutions involving overhead power lines are caused by failure to maintain proper working distances like standard setback and height clearance. Shocks and electrocutions occur where physical barriers are not in place to prevent contact with the wires.

Table 1.1: Power line information

ID	POWER	DISTANCE APART	HEIGHT ABOVE GROUND	HEIGHT BELOW GROUND	THICKNESS
MEDIUM TENSION POLES	33KV	70m	10m	1.8m	70mm
LOW TENSION POLES	11KV	70m	8.5m	1.8m	50mm

When dump trucks, cranes, work platforms, or other conductive materials (such as pipes and ladders) contact overhead wires, the equipment operator or other workers can be killed. Where the minimum required standard setback and height clearance distances from power lines are not maintained, one becomes susceptible to encountering electric shocked or be killed (see Table1.1, source: FUTA and Table1.2). However, to control these imminent danger or to reduce it to the barest minimum, some standard rules and regulation have been put in place to guide the setbacks of various classes of electrical poles or electrical infrastructures to the closest structures which could be a building, a water tank etc. These setback rules and regulation varies from state to state. Setbacks from physical structures of the various classes of electrical poles in Ondo State are listed in Table1.2 (Source: the Town and Country Planning Law CAP 123; the building and subdivision regulations, 1984) below:

Table 1.2: Minimum setback specifications of proposed physical structure.

CLASSES OF ELECTRICAL POLES	MINIMUM SETBACK (m)
High Tension (330/132KV)	50
Medium Tension (33KV)	30
Low Tension (11KV)	20

Electricity distribution is the penultimate stage in the delivery (before retail) of electricity to the end users. It is generally considered to include medium-voltage (less than 50 kV) power lines, electrical substations and pole-mounted transformers, low-voltage (less than 1KV) distribution wiring and sometimes electricity meters. To better understand how the generated power gets to the final consumers a brief comprehensive explanation was given in the International Technical Sciences Journal (ITSJ) in 2014, which stated that the Electric power is normally generated at 11-25kV in the power station and transmit over long distances, it is then stepped-up to 400kV, 220kV or 132kV as necessary. Power is carried through a transmission network of high voltage lines. Usually, these lines run into hundreds of kilometers and deliver the power into a common power pool called the grid. The grid is connected to load centers (cities) through a sub transmission network of normally 33kV (or sometimes 66kV) lines. These lines terminate into a 33kV (or 66kV) substation, where the voltage is stepped-down to 11kV for power distribution to load points through a distribution network of lines at 11kV and lower. The power network, which generally concerns the common man, is the distribution network of 11kV lines or feeders downstream of the 33kV substation. Each 11kV feeder which emanates from the 33kV substation branches further into several subsidiary 11kV feeders to carry power close to the load points (localities, industrial areas, villages, etc.,). At these load points, a transformer further reduces the voltage from 11kV to 415V to provide the last-mile connection through 415V feeders (also called as Low Tension (LT) feeders) to individual customers, either at 240V (as single-phase supply) or at 415V (as three phase supply). A feeder could be either an overhead line or an underground cable. In urban areas, owing to the density of customers, the length of an 11kV feeder is generally up to 3 km. On the other hand, in rural areas, the feeder length is much larger (up to 20 km). A 415V feeder should normally be restricted to about 0.5-1.0 km. unduly long feeder's lead to low voltage at the consumer end. Electrical power lines are usually classified into high, medium and low voltage lines. High voltage lines form the transmission line network that transports energy at over 100kV from generating power plants to electrical substations located near demand centers. Medium voltage lines (typically below 50kV) and low voltage lines (less than 1kV) form the distribution line network, which carries electricity from the transmission system and delivers it to consumers for maximum utilization.

Electrical utilities requires an efficient way to monitor and maintain their infrastructure that enhances the operations and extend the life of their assets or notify them of potential asset failure. For effective asset management, utilities need accurate information feeding of their asset inventory. Electrical power lines mapping, as an aspect of Utility survey, means the act of actual observation of the utilities and the network structure installed for the transmission and or distribution of those utilities within a particular area. The utility in this context is electricity: a public utility that serves useful purposes to the common persons. A utility pole is a column or post used to support overhead power lines and various other public utilities, such as cable, fibre optic cable, and related equipment such as transformers and street lights. It can be referred to as a transmission pole, telephone pole, telecommunication pole, power pole, hydro pole, telegraph pole, or telegraph post, depending on its application. A stobie pole is a multi-purpose pole made of two steel joists held apart by a slab of concrete in the middle, generally found in South Australia.

Electrical cable is routed overhead on utility poles as an inexpensive way to keep it insulated from the ground and out of the way of people and vehicles. Utility poles can be made of wood, metal, concrete, or composites like fiberglass. They are used for two different types of power lines; sub transmission lines, which carry higher voltage power between substations, and distribution lines, which distribute lower voltage power to customers. The standard utility pole, according to Florida Public Service Commission 2008, is about 40 feet (12m) long and is buried about 6 feet (2m) in the ground. However, poles can reach heights of 120 feet (37m) or more to satisfy clearance requirements. They are typically spaced about 125 feet (38m) apart in urban areas, or about 300 feet (91m) in rural areas, but distances vary widely based on terrain. Joint-use poles are usually owned by one utility, which leaves space on it for other cables. In the United States, the National Electrical Safety Code, published by the Institute of Electrical and Electronics Engineers (IEEE) (not to be confused with the National Electrical Code published by the National Fire Protection Agency [NFPA]), sets the standards for construction and maintenance of utility poles and their equipment.

Electrical facilities are installed on daily basis for private, commercial and industrial purposes all over the country, and the location of this infrastructure is of critical importance to those who wish to embark on standard building/structure construction. To the average citizens, the standard setback of these electrical poles to the nearest structure and their frequent maintenance rarely crosses their mind. Meanwhile, any unconscious or deliberate attempt to defy meaningful adherence to the standard required for installation of this facility could be disastrous, causing electrocution and some other incident of electrical accident. Where similar challenges arise, mapping remain a veritable mean of geospatial representation to succinctly depict the real world in a much readable flat or curve surface, depending on the projection surface adopted.

Map is a representation on plane or curve surface showing not only the natural and cultural geospatial features, but also other information on the surface of the earth. A map is a visual representation of an area depicting the geospatial representation of features (i.e. natural and man-made) of the earth's surface on a plane or curve surface at a particular scale. Power line mapping generally deals with the determination of various positions of all possible power line poles of various classifications within an area. Powerlines electric hazard vulnerability mapping thus becomes necessary to demystify the level of threat posed by electricity.

1.1 STUDY AREA

The area of study covers the whole of Federal University of Technology, Akure, Ondo state with the total area of 577.97 hectares whose boundary plan is on a scale of 1:5000, its geographic coordinate lies between latitude 7˚18'55.15'' and 7˚17'42.617'', longitude 5˚07'01.57'' to 5˚08'30.486'' of the WGS84 Zone 31N Minna datum coordinate system (see Fig1.1 and 1.2 below).

Fig1.1*:* Google earth imagery of FUTA in Akure south

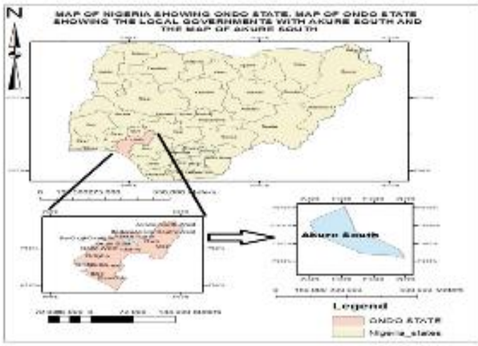


Fig1.2**:** Map showing Akure south in Ondo state in Nigeria.

2.0 STATEMENT OF PROBLEM

Federal University of Technology Akure (FUTA), like many university communities in Nigeria, records consistent increasing population yearly and thus the need for increasing and upgrading of the electrical infrastructures within the community to meet up with the increasing demand. However, this positive development comes with its inherent negative threats as it was recorded in the study area in year 2013 that fire outbreak occurred due to poor connection of electrical network. Similarly in 2015 at the university of Lagos, where a student was electrocuted by a dangling wire from an electrical pole. These series of threat could be resulting from inadequate maintenance of the facilities, damages caused by poor vegetation monitoring, non-compliance to the standard of facility installation, etc. Therefore if efforts are not made to carry out a comprehensive mapping of the electrical powerlines and identification of hotspot within the study area, chances are that disaster recurrence is imminent.

3.0 METHODOLOGY

The methodology used is best summarized in a flow chat of standard surveying operation (see Fig. 3.1). At the preliminary stage where all that was needed for a successful actualization of the project is the reconnaissance operation, followed by the proper control checks on the existing control stations within the study area. The required field geospatial data was acquired using the traverse observation method (traversing), and with the total station on a reflectorless mode for proper execution. In order to bisect physical structures, the needs for the usual reflector mode wasn't necessary except during changing of stations (TP). The 3-Dimention (X, Y and Z) data were acquired using Open traversing techniques. Open traversing is a series of measured distances and angles that is not geometrically nor mathematically close or where such surveying traverse fails to terminate at the starting station. The fundamental principle of working from whole to parts (i.e. *known to unknown*) in any surveying operations prevails at this stage. Thus, the traverse operation commenced from an established control pillars (FUTA SVG/13/02) which serves as the occupied point on which total station was set, necessary temporary adjustment (levelling, centering, and focusing) was carried out, after which the telescope of the instrument was turned to bisect the target set on the back station i.e. (FUTA GPS2.) The instrument was then tilted and rotated to bisect every available and visible electrical infrastructure such as electrical poles(peak and bottom),transformers and electrical wires as well as roads and gutters, inasmuch as they are within the range of 80m: which is the reflectorless mode maximum range. The telescope is again tilted and rotated to bisect a target (reflector) placed on a temporary point (TP1) chosen while ensuring intervisibility. After these, the instrument is packed and carried with care to prevent vibration to TP1, all temporary adjustment carried out on the instrument at this new station. The telescope of the instrument was immediately tilted and rotated to bisect the targets at backsight station (FUTA SVG/13/02). After these, every available electrical infrastructure and other cultural features within the maximum range of the instrument was again bisected while observing the standard setback and height clearance

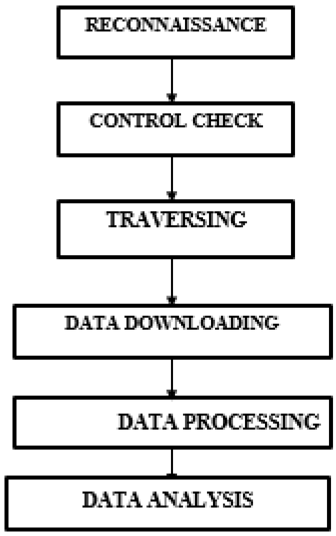


Fig. 3.1: Methodology

Table 3.1: Control Points Used

STATION ID	EASTING	NORTHING	HEIGHT (M)
SVG/13/01	735839.113	807177.113	375.996
SVG/13/02	735414.605	807206.417	369.552

provisions from the poles according to the specification guidelines (see Table 1.1 and Table 1.2). This whole procedure was repeated until the whole study area was covered while carrying out control check on all available controls within the institution. During the field work different ID's were given to the electrical poles depending on their various types with the assistance of the electrical officials and the departmental technicians in order to aid the field procedure within the institution as follows: LT: Low Tension, MT: Medium Tension, LTB: Low Tension Bottom, LTP: Low Tension Peak, WLT: Wire Low Tension, LTE: Low Tension Earthen, MTP: Medium Tension Peak, MTB: Medium Tension Bottom, MTE: Medium Tension Earthen, WMT: Wire Medium Tension, RD: Road, ST: Setback, TP: Temporary Point, and TR: Transformer. This prefixes was what informs the point's identification for data processing.

4.0 RESULT AND DISCUSSION

Data were downloaded, processed and plotted in the AutoCAD 2015 and ArcScene 10.2 software environment to produce the 2-dimentional and 3-dimentional geospatial map of the study area respectively (see Fig 4.1 and Fig. 4.2 below).

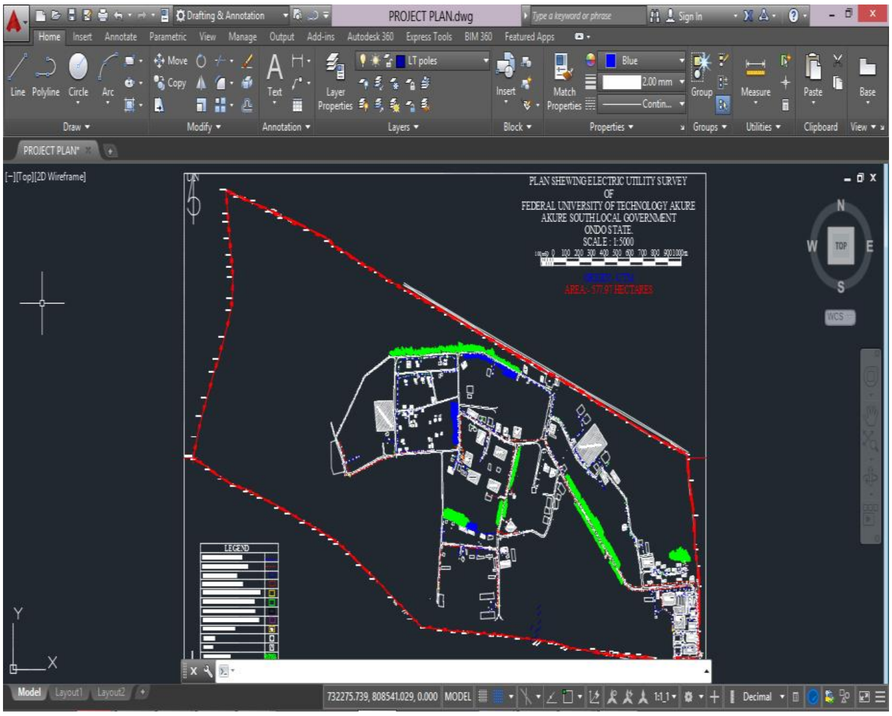


Fig 4.1: 2-D planimetric map of powerline within FUTA using AutoCAD2015

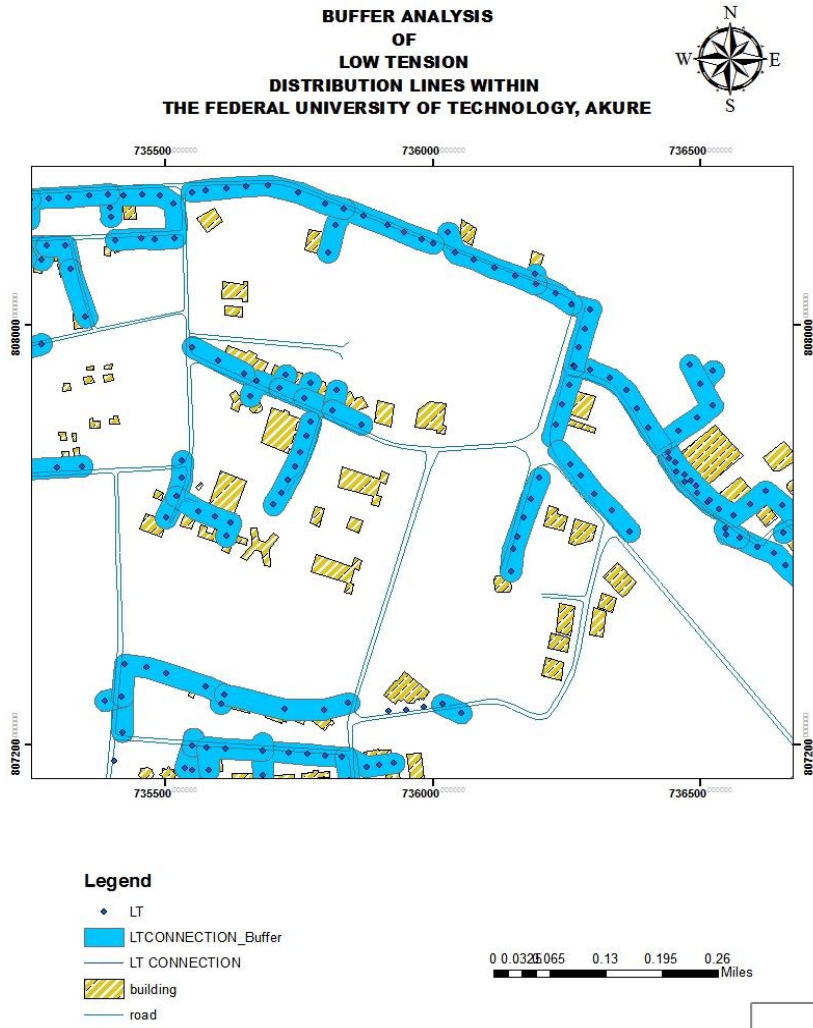
Fig 4.2: 3-D Model of powerline within FUTA using Arcscene 10.2.

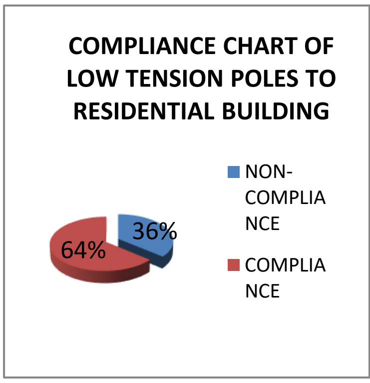
Buffering analysis remain a veritable tool to spatially depict and check the level of vulnerability or compliance and influence of the poles (i.e. point features) and electrical cables (i.e. linear features) source within a specified radius. Thus by taking cognizance of the setback and height clearance specification, a 30m and 20m setback buffer radius of influence from both Medium Tension (MT) poles and Low Tension (LT) associated poles to the building respectively were done using ARCGIS 10.2 software (See Fig. 4.3- 4.5 below). This to determine whether the available structures within the institution comply with the standard guidelines guiding the various classification of electrical poles within Ondo State (See Table 1.1 and Table 1.2 above**)**. The respective setback results have shown that within the 30m MT buffer, 25 buildings were identified which were in conformity with the standard guidelines, while 36 buildings fall within the 20m LT buffer. At this point, it is important to note that the building structures were classified into three based on their usage; Residential, Institutional, and Educational building. Table 1.4 below shows the empirical analysis of buildings within the buffered distances for compliance or otherwise. From this analysis, out of the 133 buildings which setbacks were observed to each poles within the project site, there are 61 Residential buildings, 34 Institutional buildings, and 38 Educational buildings.

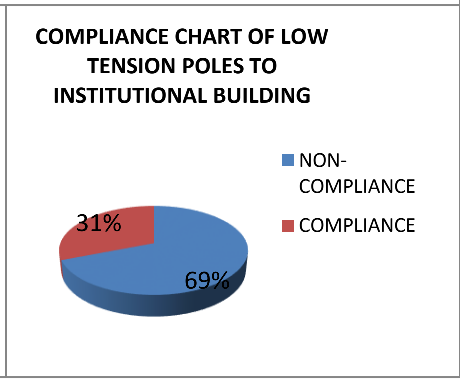
Table 4.1: Analysis of Building Types & Vulnerability percentile within the Buffered zones

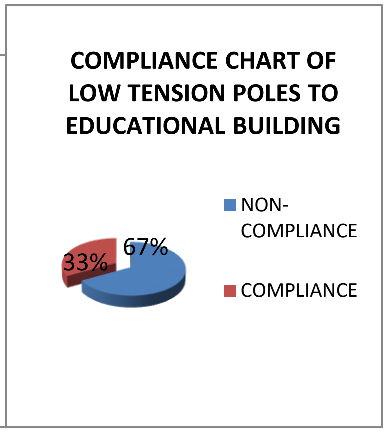
Building Type (Total)	No of MT Poles Out of 30m setback	Compliance Percentage (%)	Non-compliance (Vulnerability) Percentage (%)	Total (%)	No of LT Poles Out of 20m setback	Compliance Percentage (%)	Non-compliance (Vulnerability) Percentage (%)	Total (%)
Residential(61)	12	48	52	100	13	36	64	100
Institutional(34)	4	16	84	100	11	31	69	100
Educational(38)	9	36	64	100	12	33	67	100

For LT Poles; Around Residential Buildings, total of 13 LT Poles complies with 20m buffer i.e. 36% not vulnerable (compliance) with the acquired setback guidelines of the state and 64% vulnerable (non-compliance). Around Institutional Buildings, 11 LT Poles complies with 20m buffer i.e. 31% not vulnerable (compliance) and 69% vulnerable (non-compliance). Around Educational Buildings, 12 LT Poles complies with 20m buffer i.e. 33% not vulnerable (compliance) and 67% vulnerable (non-compliance). **Fig 4.3**: Vulnerability Buffer Analysis Map of Low Tension Distribution within FUTA









For MT Poles; Around Residential Buildings, total of 12 MT Poles complies with 30m buffer i.e. 48% not vulnerable (compliance) with the acquired setback guidelines of the state and 52% vulnerable (non-compliance). Around Institutional Buildings, 4 MT Poles complies with 30m buffer (i.e. 16% not vulnerable (compliance) and 84% vulnerable (non-compliance). Around Educational Buildings, 9 MT Poles complies with 30m buffer i.e. 36% not vulnerable (compliance) and 64% vulnerable (non-compliance).

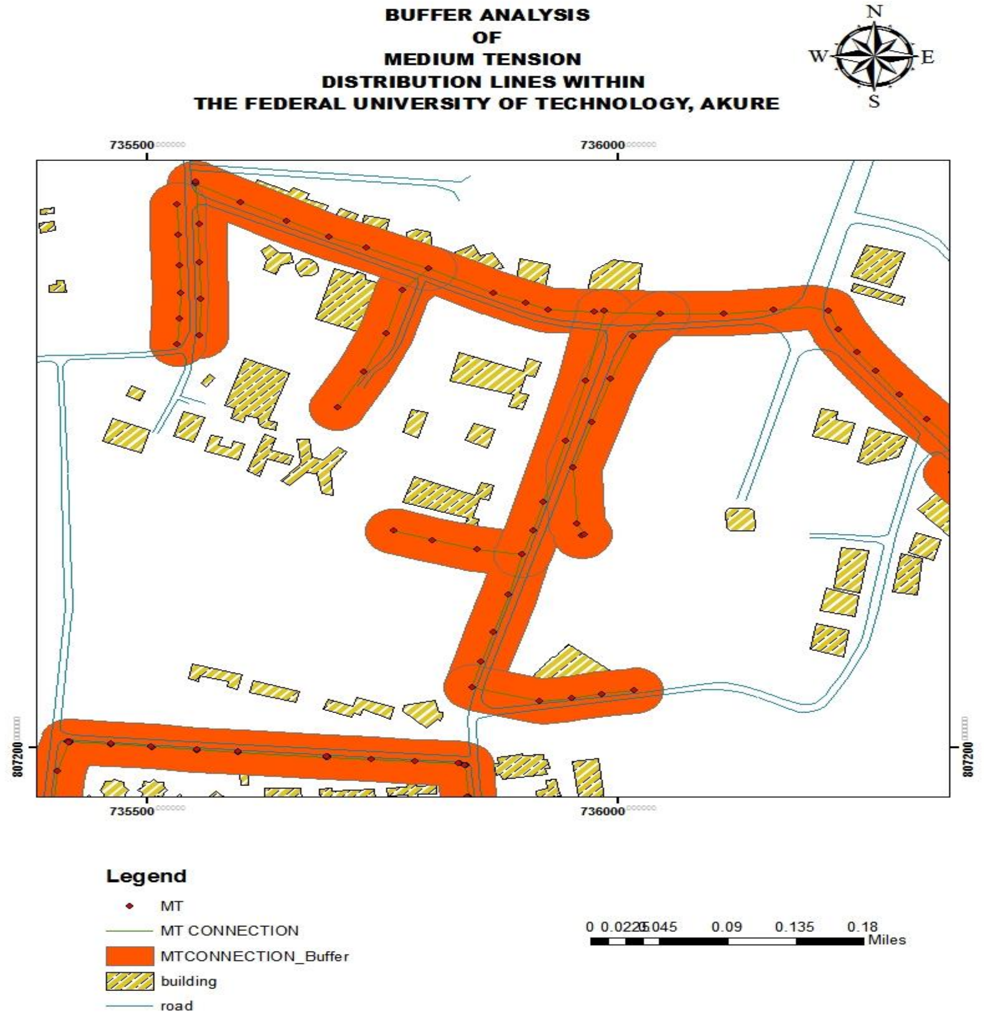
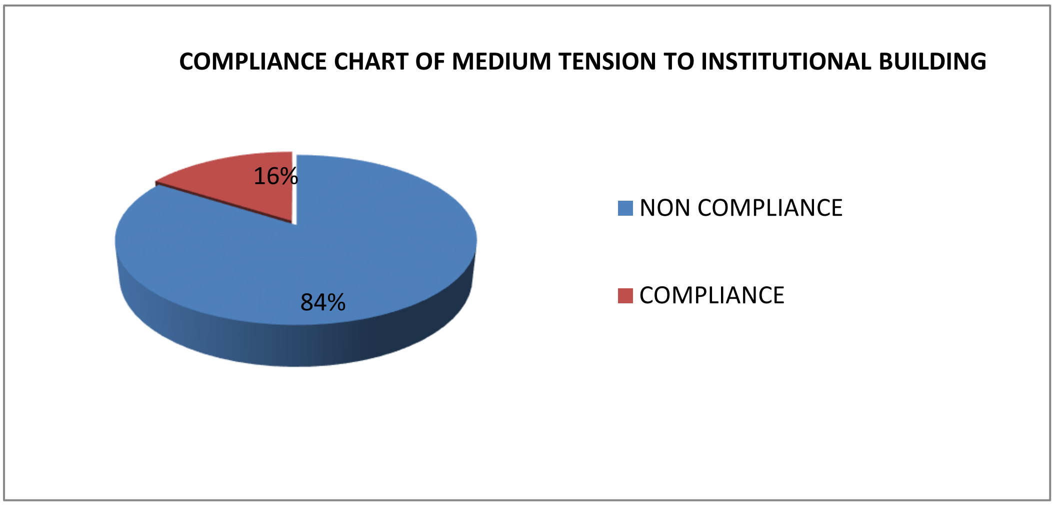
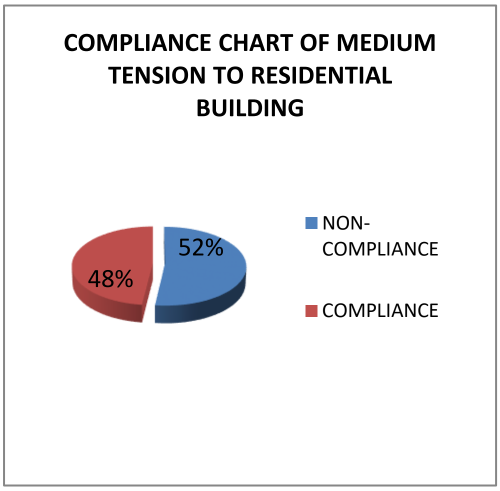
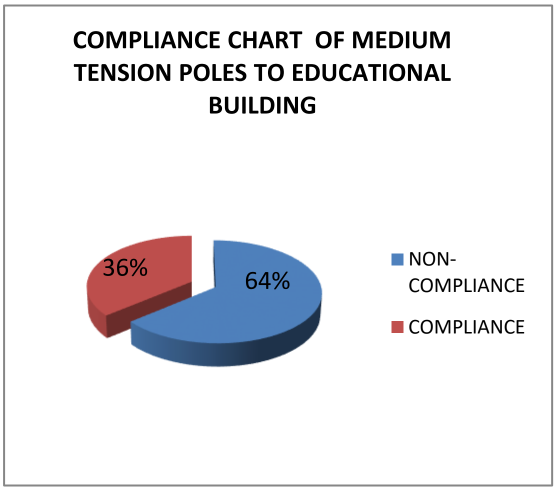


Fig 4.4: Vulnerability Buffer Analysis Map of MT Poles Distribution Line & Building Types compliance, FUTA


COMPLIANCE CHART OF MEDIUM TENSION TO INSTITUTIONAL BUILDING
16%
84%
NON COMPLIANCE
COMPLIANCE


COMPLIANCE CHART OF MEDIUM TENSION TO RESIDENTIAL BUILDING
52%
48%
NON-COMPLIANCE
COMPLIANCE


COMPLIANCE CHART OF MEDIUM TENSION POLES TO EDUCATIONAL BUILDING
36%
64%
NON-COMPLIANCE
COMPLIANCE

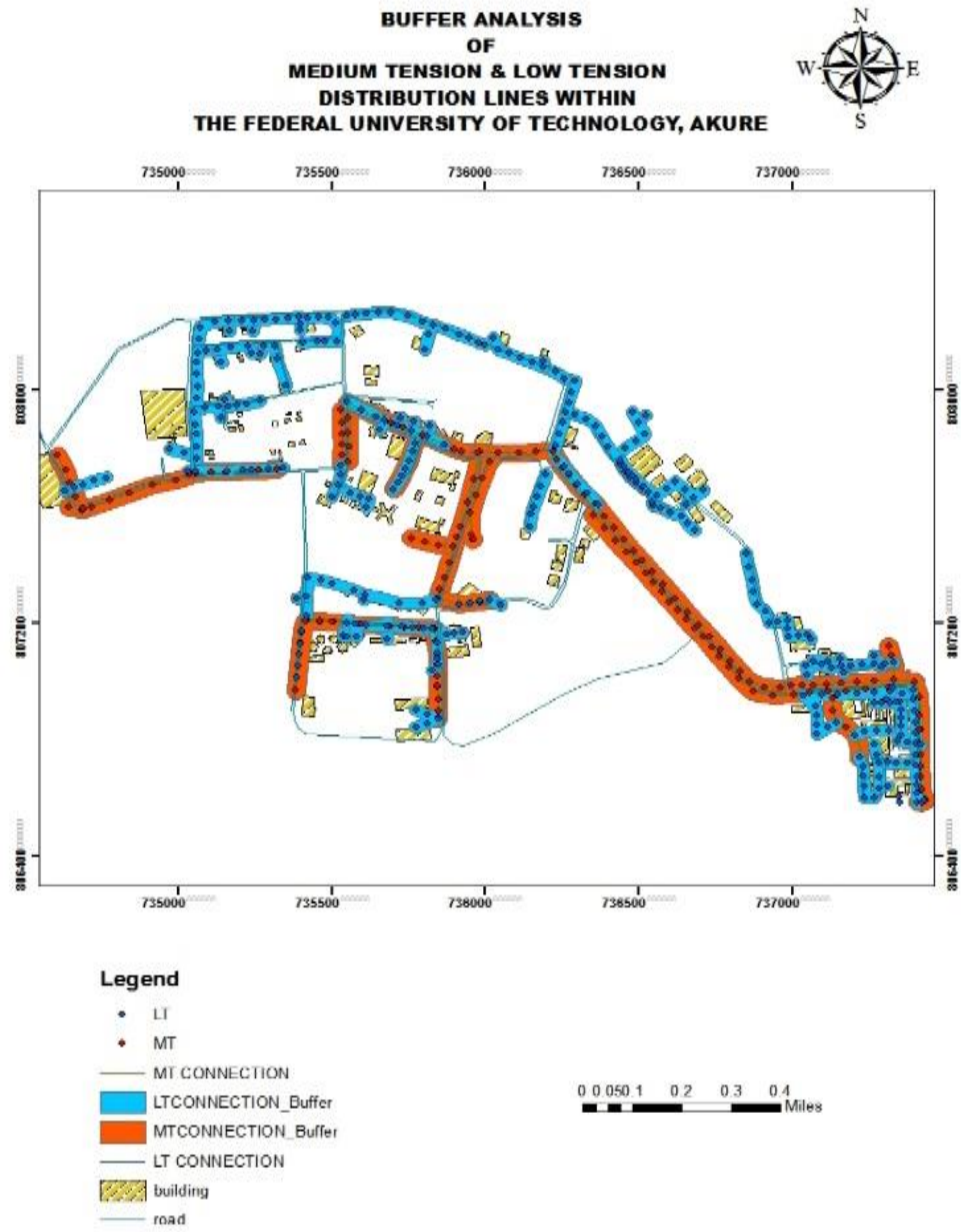


Figure 4.5: Composite Buffer Analysis Map of MT & LT electrification Poles Distribution Lines in FUTA

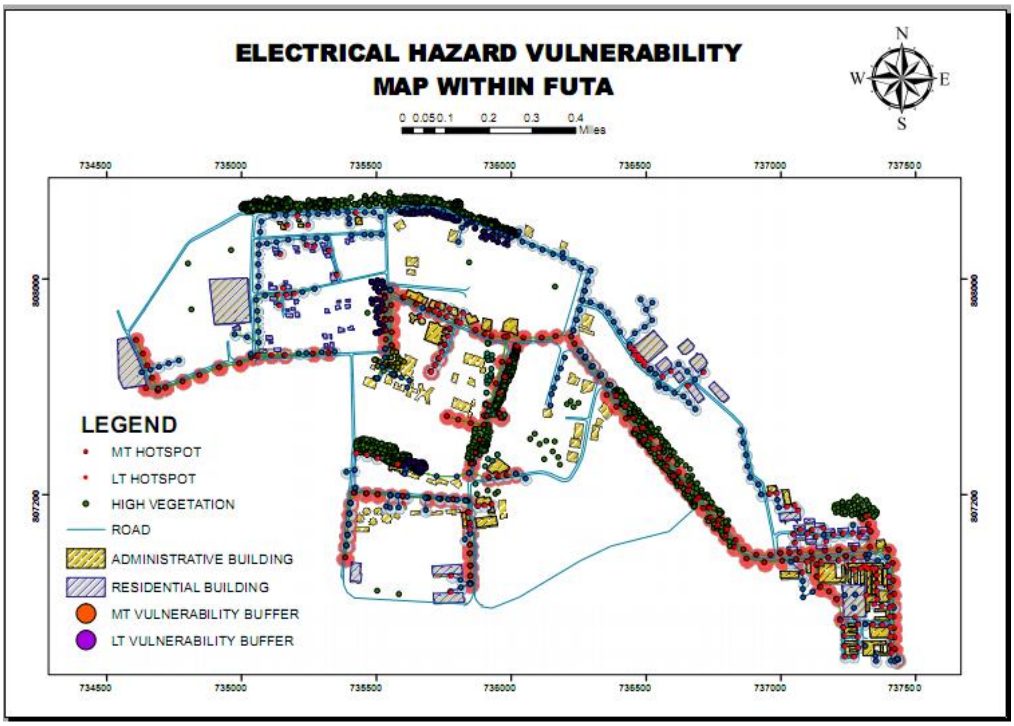


Figure 4.6: Electricity Hazard Vulnerability Map within FUTA

5.0 CONCLUSION AND RECOMMENDATION

In all, the spatial analysis has shown that there is electrical hazard vulnerability in the study area is on the high side because of non-compliance with the guidelines, laws and regulatory provisions. It is hereby recommended that physical barriers should be placed to prevent direct contact with the electric wires at some identified hot-zones, while other adequate measures must be put in place by all relevant authorities of the university and the Benin Electric Distribution Company (BEDC) to forestall possible recurrence of imminent danger which could result therefrom.

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