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ASSESSMENT OF HIGH TENSION POWER TRANSMISSION LINE IN IGABI LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA

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Abstract

The unprecedented growth in cities in Nigeria, which is most times unguided, had culminated in a variety of problems such as encroachment of transmission lines right of way. This study assessed the extent of high tension power transmission line using Geospatial techniques and determined the buildings that are within the right of way of the high tension power transmission using high resolution satellite images for year 2003, 2011 and 2021 in Igabi Local Government Area of Kaduna State. The Google Earth map was used to digitize and identify the buildings within the corridor of high tension power transmission lines in 2003, 2011 and 2021. Open street map shape files were used to produce the base map and the power transmission lines in the study area. Thereafter, buffer analysis was performed by using the Proximity Analyst Tools in ArcGIS 10.6 software to delineate the Right of Way (ROW) of high tension power lines. Google Earth was also used to count all the buildings that fell within the corridors. The findings revealed that the area extent of the corridor of high tension power transmission lines in Igabi LGA was 13,014,590 square metres (1,301.459 square hectares). The total length of the transmission line in the area was 129.41km. Also, the study found that the number of buildings within the right of way of the high tension power transmission lines in the study area varied from one settlement to another. The study recommended that aerial surveillance of the high tension power transmission lines using remote sensing and GIS technologies should be employed by Transmission Company of Nigeria (TCN) and PHCN for effective development control in the study area.

Keywords: *Right of Way, High-Tension, Power and Transmission.*

Introduction

The unprecedented growth in cities in Nigeria, which is most times unguided, had culminated in a variety of problems such as chaotic land development and haphazard land uses (Olamiju and Oyinloye, 2015). The Land Use Act of 1978 addresses all issues that have to do with compensation or involuntary resettlements due to the exercise of eminent domain (amended 1990). According to the act, all land in Nigeria is vested in the Governor of each state, to be held in trust for the use and common benefit of all people (Oyesiku, 1998). The administration of urban land is directly under the oversee of the Governor, whereas non-urban land is under the control and management of the Local Government Authority. The Governor has the right to grant statutory rights of occupancy to land. Local government has the right to grant customary rights of occupancy. The Land Use Act gives government the right to revoke statutory and customary rights to land for the overriding public interest (Awogbemi, 1978).

Power Transmission Company of Nigeria (TCN), as a federal agency, was also permitted by a land use decree of 1978 and by National Electricity Power Authority (NEPA) Operational Decree No. 24

of 1972 to acquire land for projects that relate to public interests. Since the Land Use Act gives the state the ownership of all land, compensation by NEPA was restricted to structures, installations, and improvements on the land, not the land itself (Olapeju, 2015). However, the act does require the state or Local Government to provide alternative land for affected community who will lose farmland and their houses. NEPA generally did this for hydropower resettlement programs, but not all areas of transmission lines and sub-station projects was considered. For instance, in some areas closer to towns and cities, additional cash compensation was paid on a case-by-case basis, to people who lost building plots, other land, or houses to make way for sub-stations (Olapeju and Farotimi, 2017). Since the previous century, there has been an increase in the number of experience personnel in the field of technology that use electricity that the latter has become a fundamental component of humans' day-to-day activities. This has prompted a high demand for power and consequently, a need for further improvement and diversification. However, the development of that nature has been difficult to take place without its own challenges, the major and most disturbing one being the need for effective transmission (Nkeki, 2013).

Electric transmissions lines are among the projects are that faced with a lot of environmental challenges related to the location and the size of the project. Impacts are principally associated with the creation and maintenance of corridors, the construction of towers, and the health risks from electromagnetic fields. Specific risks include: the fragmentation of habitat and vegetation along the right of way; new access to protected areas and wild habitats along the right of way; loss of land and other assets and physical relocation along the right of way; and electrocution if low slung lines are near human activity (Public Service Commission Wisconsin PSC, 2010).

The National Electrical Code (NEC) mandates 50m acceptable clearances for power lines to keep the public safe and prevent contact with electrical currents. The area covered by this width is the Right of Way (ROW). According to the Nigerian electricity news online, government must act in ensuring safety of life and property by protecting utilities ROW across the states of the nation (Eze and Richard, 2018). Timothy (2017) noted that Overhead electricity transmission power lines are subject to strict guidelines for height clearance (Right of Way) over streets, sidewalks, alleys, drive ways and other traffic areas. A Right of Way is a term used to describe the legal right, established by usage or grant, to pass along a specific route through grounds or property belonging to another. It is also a type of easement granted or reserved over the land for transportation purposes; this can be for highway, public footpath, rail transport, canal, electrical transmission lines, oil and gas pipelines and etcetera.

The Nigeria Electricity Power Transmission Grid is one of the most important parts of the electricity value chain. The operation of the electricity transmission network is vested in the Transmission Company of Nigerian (TCN), one of the companies unbundled from the Power Holding Company of Nigeria Ltd. (Omonfoman, 2016). The National Power Transmission Grid line composed of 132kv and 330kv lines respectively across the country. TCN has continuously advised and warned the public on the dangers of erecting buildings and conducting business on the Electricity Transmission Line Right of Way across the country. The continuous building and erecting of structures on the electricity grid ROW by land developers who are ignorant of the dangers is highly alarming and of serious concern to the Government.

The population explosion brought about by massive institutional, industrial, commercial and infrastructural development in Igabi Local Government Area (LGA) (one of the four LGAs in Kaduna metropolis) experience various kinds of urban problems which include acute housing shortage, poor street layout with little or no consideration for setbacks and open spaces, traffic congestion, disease outbreaks, infrastructural break-down and widespread environmental

deterioration and pollution as well as encroachment on the ROW of high tension power transmission lines.

Igabi LGA had witnessed cases of electrocution. A good example is the incident that occurred on January 16, 1999, in which a surge of electric current within 2 minutes led to the death of thirteen persons and fifty-three persons sustaining injuries (Farakwai, 2010). Since 2015 the Government of Kaduna State have been demolishing illegal buildings across the State. It is important to provide information about buildings that encroached on the high tension power transmission lines right of way. Geographic Information System (GIS) which is defined as a computer system designed to capture, store, manipulate, analyze, manage, and present all types of geographic data, has been used to effectively predict and manage resources toward protecting our environment (Baroš and Stojanović, 2015). GIS and remote sensing are important tools and techniques that can be used to map and estimate areas along the right of ways of high tension power transmission lines exposed to danger of electrocution and electromagnetic radiation.

Despite, the effort been made by researchers to assess risk associated with buildings close to high tension power line in Nigeria. Previous studies reviewed shows that, there is no any available baseline data on the actual extent of land reserved to the ROW of high tension power line in Kaduna metropolis and the pattern of the settlement there. This implies a large gap in knowledge as per as the study of power transmission line is concern which needs to be fill. This study assesses the level of encroachment into ROW of high tension power transmission line in Igabi LGA using Google Earth satellite imageries that allows for accurate identification and digitization of buildings. The study was achieved through the following researcher questions**:**

1. What is the extent of the high tension power transmission line in the study area?
2. How many buildings are within the right of way of the high tension power transmission line in the study area?

Aim and Objectives of the Study

The aim of the study is to assess high tension transmission line in Igabi LGA while this was achieved through the following objectives;

i. delineate the high tension power transmission line in the study area.
ii. identify the number of buildings within the right of way of the high tension power transmission line in the study area.

The Study Area

The research was carried out in Igabi Local Government Area (LGA) area of Kaduna State. It lies within Latitudes 10°20' N and 11°10' N of the Equator and between Longitudes 07°10' E and 08°00' E East of Greenwich Meridian. The LGA shares boundary with Zaria and Giwa and Kazuma LGAs to the North, Soba, Kajuru and Kauru LGAs to the East, Kaduna North, Kaduna South and Chikun LGAs to South and Birnin Gwari LGA to West (Figure1). The researcher measured the area of the LGA in ArcGIS environment and found it to be 3713.15Km^2 (Ajibuah 2008). Igabi LGA lies within the Tropical Continental climate and experiences seasonal alternation of moist maritime air mass and dry continental air mass. The rainy season begins in April and lasts till October while the dry season (hamattan) spans from November to March (Bello, 1993). From May to October each year the rains become steady and an average of 125cm are recorded with peaks in August when the rains are more intense. The highest temperatures for Igabi LGA are recorded in April and the range is between 35^{o}C

and 41°C, the lowest temperatures are recorded in January 7°C - 13°C, when the cold harmattan winds are fierce and dominate the region generally (Ndabula, 2006). It is important to note that rain-induced vibration on high tension power transmission line usually occurs. This kind of vibration can lead to metal fatigue, especially on metal fitting and tower structure (LiLi and Yanping, 2015).

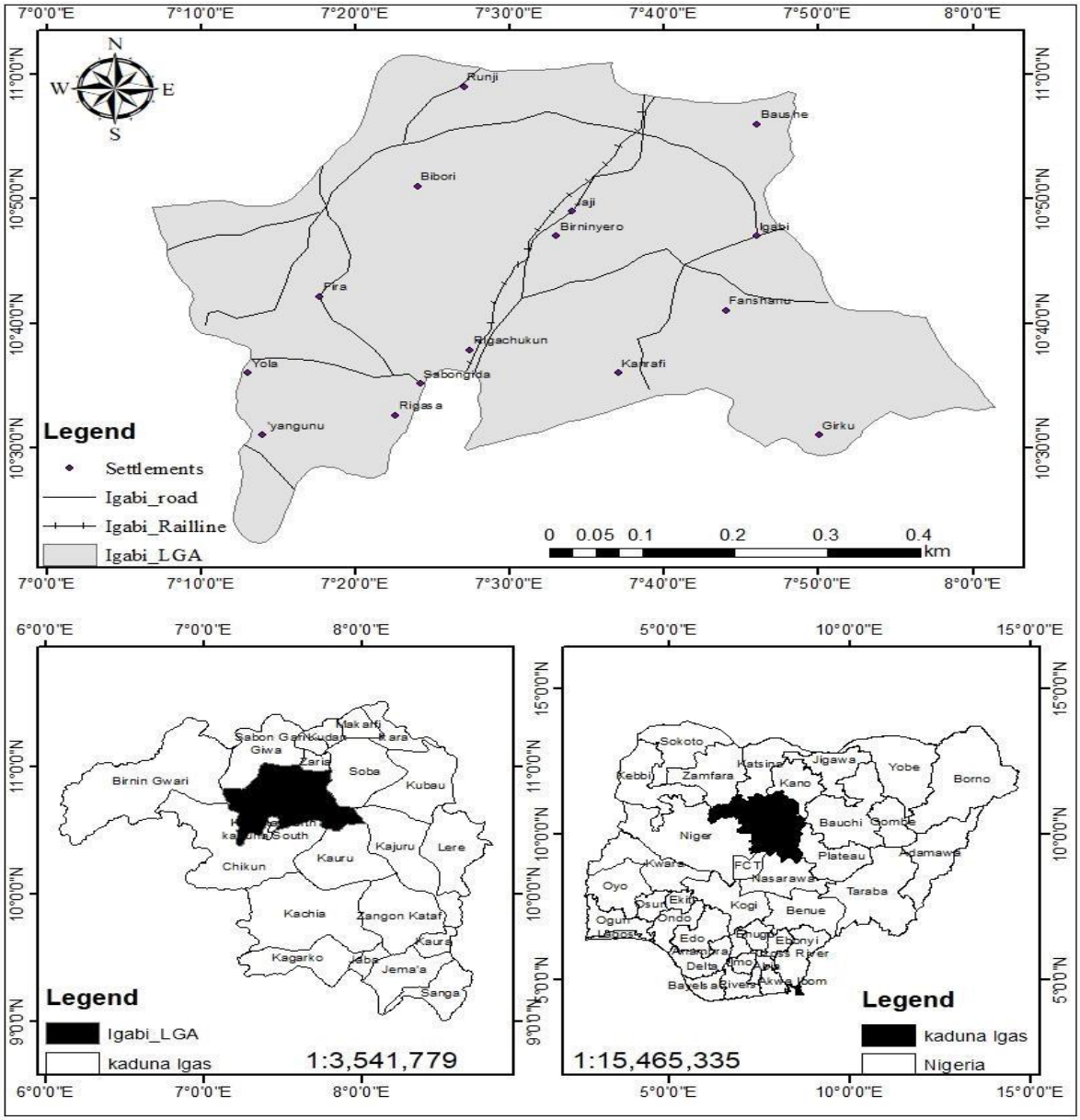

Figure 1: The Study Area
Source: Modified from Administrative Map of Nigeria (2024)

Materials and Methods

Types and Sources of Data

The following types of data (Table 1) were acquired and used to obtain results for the study;

Table 1: Types and Source of Data

S/N	Data	Source	Purpose
1	Study area map	Administrative map of Nigeria	Overly analysis
2	High tension power line	Google Earth	For mapping of the power line and determination of its extent.
3	Buildings	Google Earth	To identify number of buildings within the power line ROW and estimating extent of encroachment.
4	Google earth imagery	Google Earth	To digitize High tension power transmission line.

Source: Field Survey (2024)

Data Processing

1. The administrative map of the study area was scanned from analogue form to a computer-based format using an A4 scanning device. The scanned map was imported into the ArcGIS 10.8 environment for geo-referencing, after which it was digitized.
2. To acquire Google Earth imagery for the study period, the historical imagery slider was used. This involved navigating between acquisition dates of various aerial photo imageries. Once the required date (e.g., 2003) was reached, the imagery for that year was captured using the "Add Control Point" tool. The imagery, along with its captured geographic coordinates, was saved in JPEG format for further analysis.
3. The scanned map of the study area and the Google Earth imagery were registered to a real-world coordinate system. Image geo-referencing involves aligning an image to a real-world coordinate system within a GIS environment. Both the study area map and the Google Earth imagery were projected into the Universal Transverse Mercator (UTM) Minna zone 32 after geo-referencing to ensure their coordinates aligned with the real world.

Data Analysis

Objective one**:** To delineate the high tension power transmission line in the study area. To achieve this objective, the transmission line layer was digitized from Google Earth imagery of the study area. The locations and direction of the power line were identified in Google Earth using the 132KV and 330KV Nigerian high-tension power transmission line map, as presented by the Honourable Minister of Power and Steel and Chairman of the NEPA Technical Committee (2004) during their interaction with the President of Nigeria on the "Power Sector as a Catalyst for Economic Growth and Development." The length of the transmission line and its area coverage were calculated in the ArcGIS 10.8 environment. Finally, the results were presented in a map, and a discussion was provided in the text.

Objective two: To identify the number of buildings within the right-of-way (ROW) of the high-tension power transmission lines in the study area. The Buffer tool in ArcGIS 10.8 was used to create a 50-meter distance from the power line digitized in Objective One, as indicated in the Nigerian Electricity Supply and Installation Standards Regulations (2015). According to these regulations, all buildings within a 50-meter distance of the ROW of 132KV and 330KV high-tension power transmission lines are illegal and are therefore considered encroachments on PHCN

properties. Shapefiles for the settlements under consideration (Jaji, Birnin Yero, Sabongida, Rigachikun, and Rigasa) were created and edited. All buildings that fell within the ROW of the power transmission line for 2003, 2013, and 2023 were digitized. After digitization, the results were presented in maps using different colors to differentiate the years.

Results and Discussions

High tension Power Transmission Lines in the Study Area

The high-tension power line in the study area passes through many settlements, some of which include Jaji, Birnin Yero, Rigachikun, Barakallahu, Sabongida, Mando, Kakuri, and Rigasa. Figure 2 shows the high-tension power transmission line, its extent, and its right-of-way (ROW). The total area of the high-tension power transmission line in the study area was calculated to be 1,550,052.7 square meters. The total length of the transmission line under study was found to be 77,488.03 meters (77.49 kilometers). It stretches across Igabi LGA, running from the southwest to the northern part of the area. The study also estimates the aerial coverage of the ROW of the transmission line to be 9,309,486.86 square meters (9.31 square kilometers). This indicates that the extent covered by the high-tension power line in the study area is significant, which might be associated with the size of the local government area. Igabi LGA is among the largest LGAs in Kaduna State, and the study area also falls within the coverage of Kaduna metropolis. Other reasons might include the fact that the power line cuts across many parts of Northern Nigeria. From the node in the study area, the power line extends to Kano State in the north, while to the south and east; it extends to Plateau, Bauchi, Gombe, Yobe and Borno States.

The length and area of the transmission line in the present study are greater than those found by Eze and Eke (2021), who measured the extent of a high-tension transmission line in Rivers State and found its total length to be about 13 kilometers. The difference may be due to the fact that the current study area covers the entire Igabi LGA. Additionally, most northern LGAs are generally larger in terms of landmass compared to their southern counterparts. Therefore, it is expected that a transmission line passing through an LGA like Igabi would have a longer length.

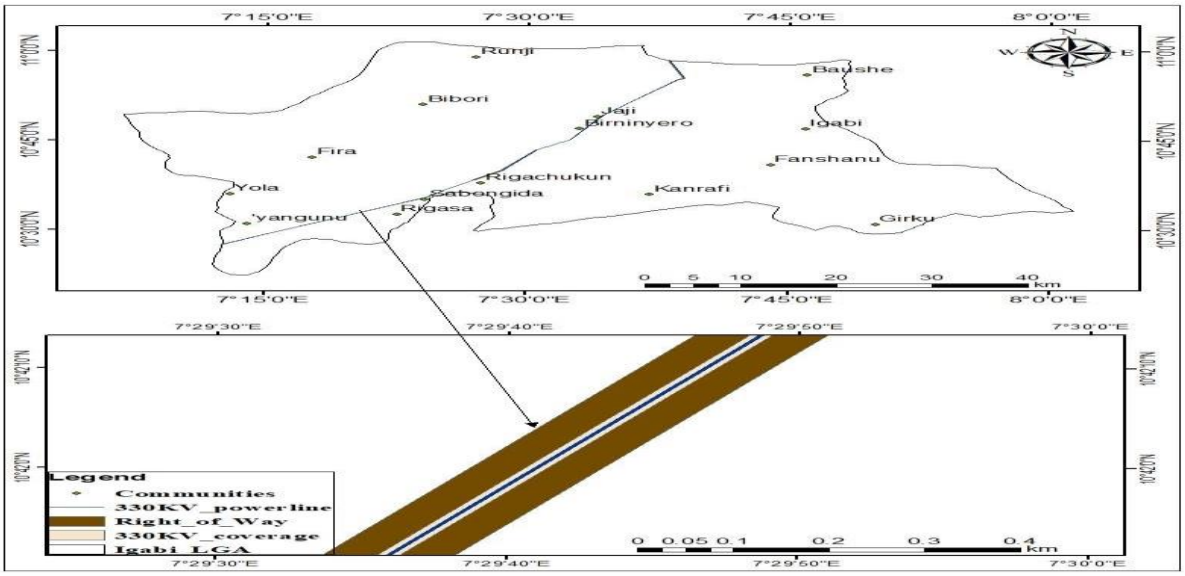

Figure 2: High Tension Power Transmission Lines and its Environment
Source: Field Survey (2024)

The difference may be as a result of the fact that the current study area covers entire Igabi LGA and more also most northern LGA are usually far bigger in term of land mass than their southern counterparts, so it is expected that the transmission line passing through an LGA like Igabi LGA should have longer length.

Buildings within the Right of Way

All the buildings within the right of way of the high tension power transmission line in the study area for 2003, 2013 and 2023 were identified, mapped out and presented in Table 1 and Figure 2.

Table 2: Number of Buildings within the ROW by Settlements

Settlements	2003 Built	%	2013 Built	%	2023 Built	%
Jaji	1634	67.21	217	57.71	472	54.76
Birninyero	0	0	16	4.26	38	4.41
Rigachikun	25	10.25	50	13.3	147	17.05
Sabongida	46	18.85	74	19.68	163	18.91
Rigasa	9	3.69	19	5.05	42	4.87
Total	**244**	**100**	**376**	**100**	**862**	**100**

Source: Field Survey (2024)

Buildings within the Right of Way in Jaji

Table 2 and Figures 3 to 5 reveal that in 2003, there were 244 buildings within the right-of-way (ROW), and 67.2% of them were located in Jaji. In 2013, the total number of buildings within the ROW increased to 376, with those situated in Jaji rising from 164 to 217 buildings, accounting for 57.7% of the total buildings in that year. Similarly, in 2023, the total number of buildings within the ROW of the high-tension power transmission line in the study area increased to 862, with the majority (54.8%) amounting to 472 buildings.

It is clear that between 2003 and 2023, the number of buildings within the ROW in Jaji settlement has been increasing. This rise in the number of buildings within the restricted area might be associated with the high rate of population influx into Kaduna metropolis. However, there is a proportionate decrease in the percentage of buildings in Jaji when compared with the percentages in other studied settlements. This might be associated with the increase in the number of buildings within the ROW of Birnin Yero and other settlements. Many people are seeking settlements at all costs, even within danger zones.

This finding supports Nkeki (2013) in Benin, Nigeria, who stated that the majority of populations exposed to the dangers of high-tension power lines are found in high-density residential areas located on the periphery of a town or city.

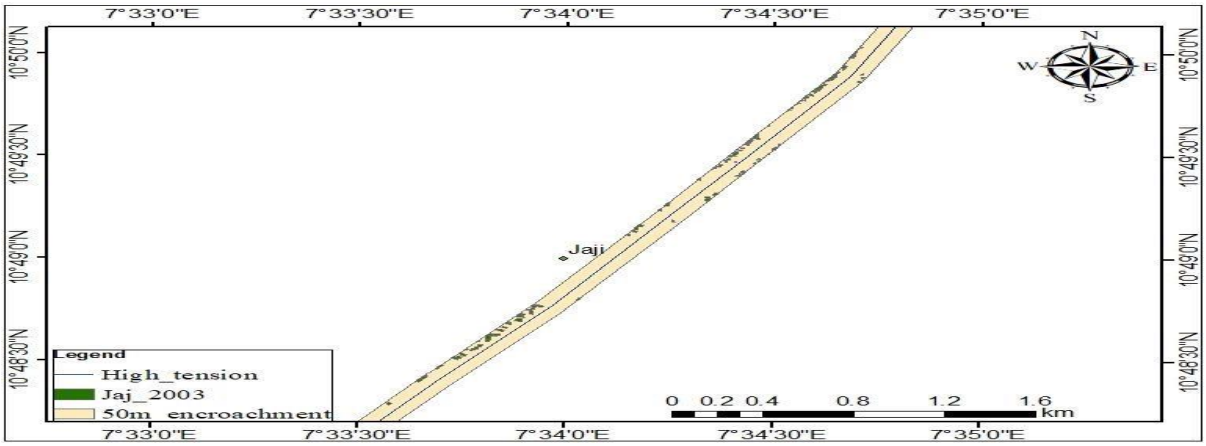

Figure 3: Buildings within the ROW in Jaji (2003)
Source: Field Survey (2024)

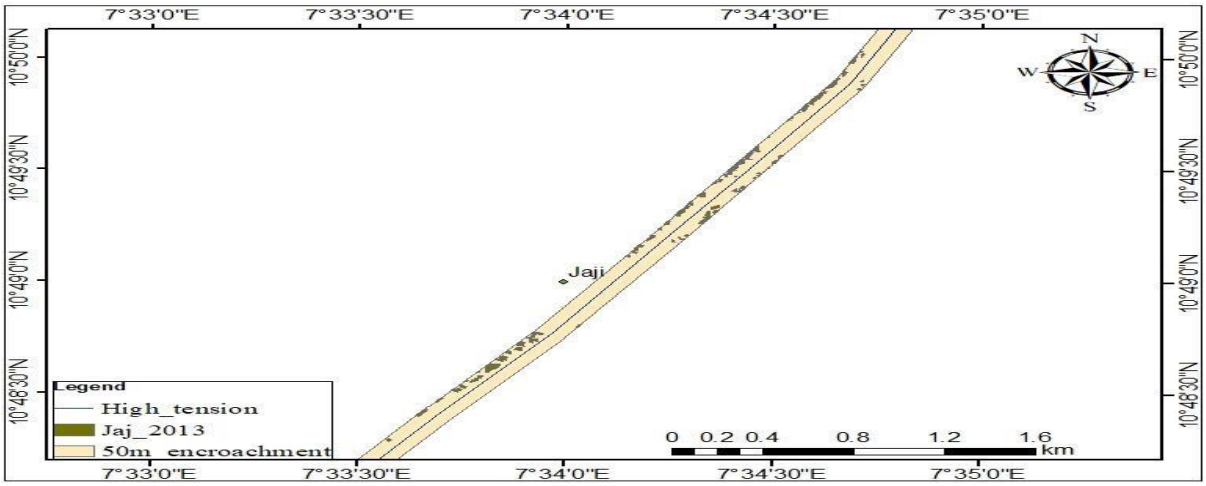

Figure 4: Buildings within the ROW in Jaji (2013)
Source: Field Survey (2024)

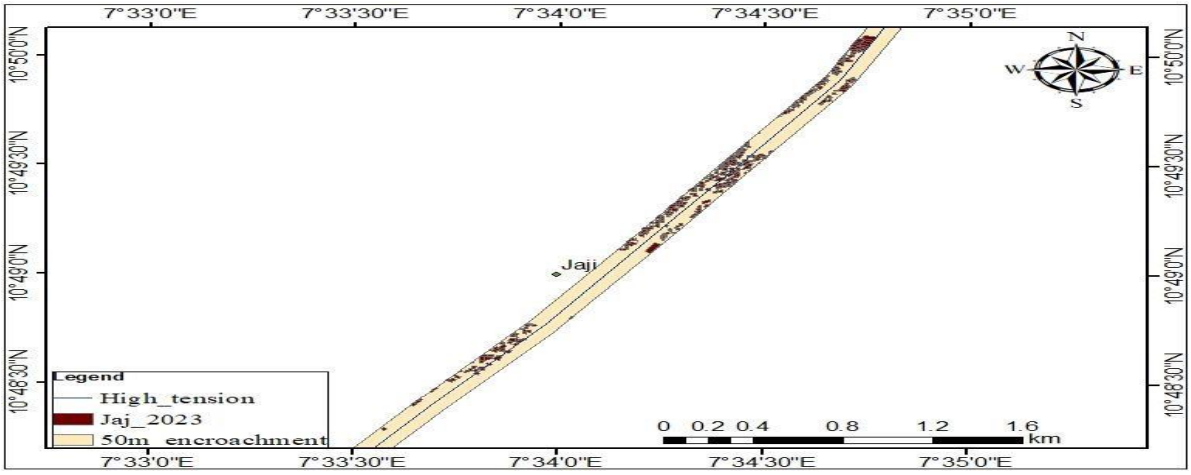

Figure 5: Buildings within the ROW in Jaji (2023)
Source: Field Survey (2024)

Table 2 and Figures 6 to 8 present the results on the buildings within the right-of-way (ROW) along Birnin Yero. The figures show that in 2003, there were no buildings. However, in 2013, the ROW of the high-tension power line along Birnin Yero experienced encroachment, with 16 buildings accounting for 4.3% of the total number of buildings within the ROW that year. By 2023, this number had increased to 38 buildings, representing 4.4% of the total encroachment for that year. These results clearly show that even settlements that previously did not encroach into the ROW of high-tension transmission lines in the study area are now doing so. This might be linked to people's eagerness to own personal houses in the area or the increasing cost of land, which has necessitated the purchase of land even in dangerous areas.

This finding aligns with the work of Wunude et al. (2021) in Alimosho LGA, Lagos State, which revealed that in 1983, encroachments into power line areas were mainly cultivated lands. However, by 2020, about 36.3 hectares (88.7%) of the ROW had been dominated by built-up areas.

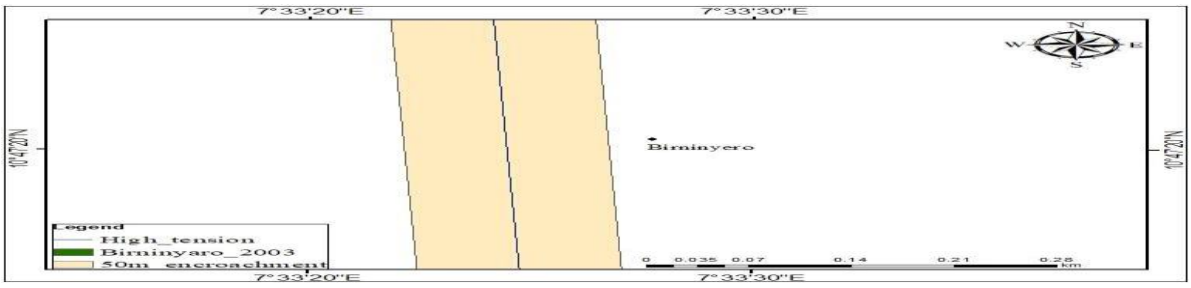

Figure 6: Buildings within the ROW in Birninyero (2003)
Source: Field Survey (2024)

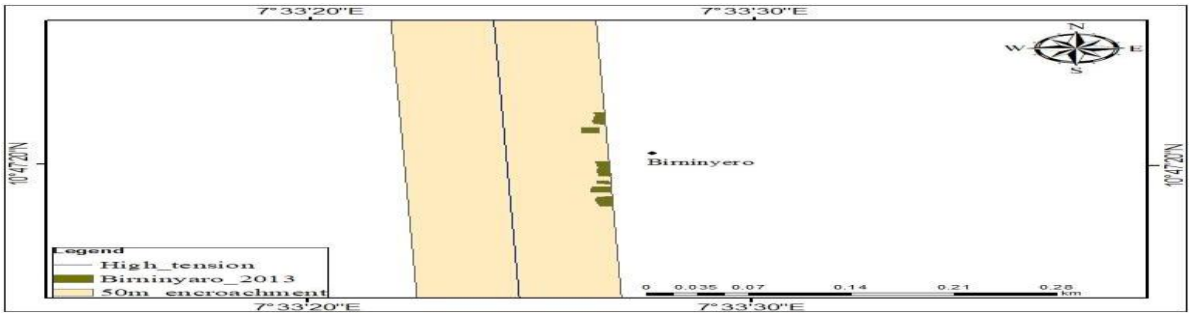

Figure 7: Buildings within the ROW in Birninyero (2013)
Source: Field Survey (2024)

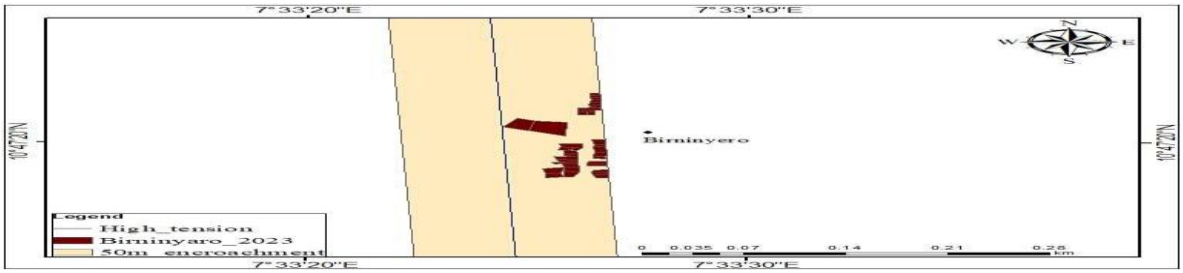

Figure 8: Buildings within the ROW in Birninyero (2023)
Source: Field Survey (2024)

Table 2 and Figure 9 to 11 presents the findings on the number of buildings within the ROW of high-tension transmission line along Rigachikun. The findings revealed that in 2003 there were 25 buildings (10.3%) of the total building in the within the right of way of the study area. This number of buildings increase to 50 in 2013 and 147 (17.1%) of the total buildings in 2023, within the restricted area in the study area. This indicated that encroachment into the right of way of power transmission line in the study area have been on increase. Despite, the effort been made by owners of the land in notifying people that this land belongs to power line company and the danger associated with settlement within the restricted areas. This conforms to the work of Akinlolu and Kazeem (2015) in the major cities of south western Nigeria, which found that right of ways (ROWs) along the power lines are being violated as buildings exist less than 15m and 25m away from the 132kV and 330kV lines respectively.

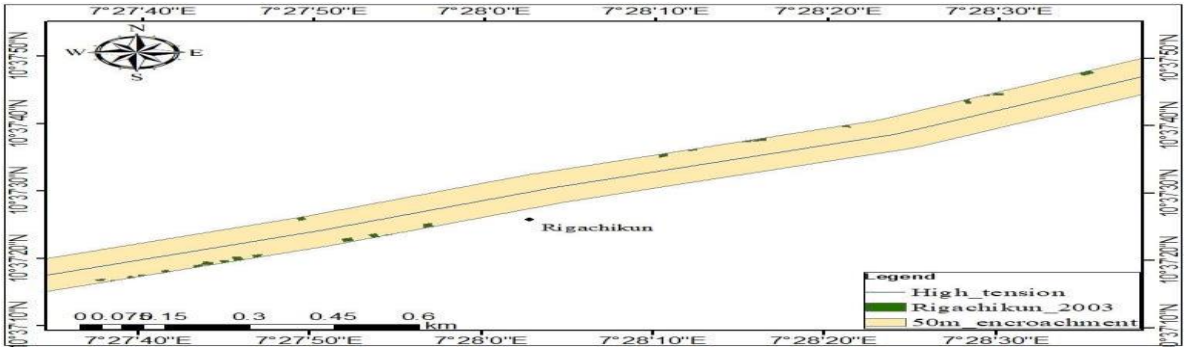

Figure 9: Buildings within the ROW in Rigachikun (2003)
Source: Field Survey (2024)

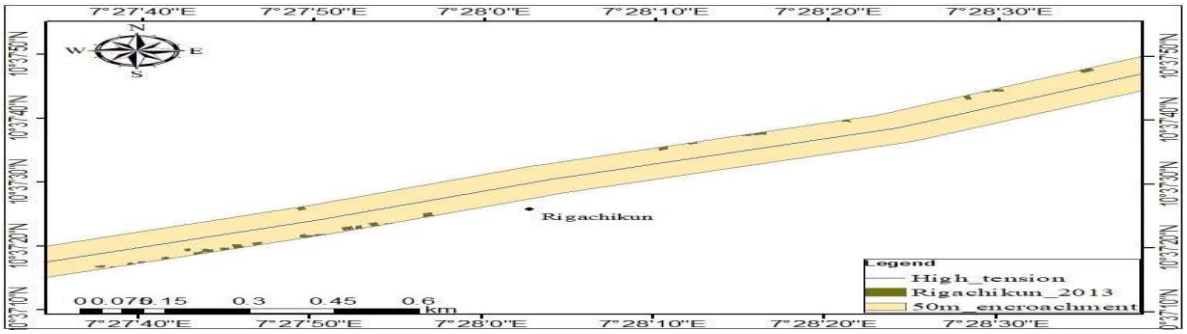

Figure 10: Buildings within the ROW in Rigachikun (2013)
Source: Field Survey (2024)

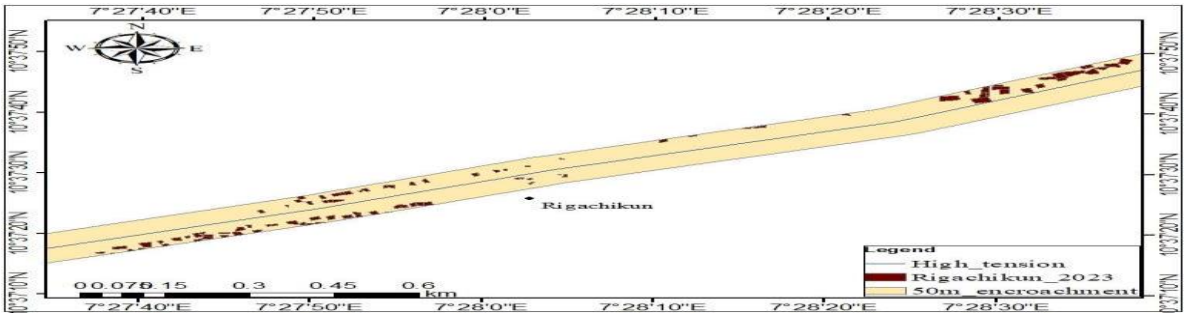

Figure 11: Buildings within the ROW in Rigachikun (2023)
Source: Field Survey (2024)

Table 2 and Figure 12 to 14 presents the results on the buildings with the ROW of high tension transmission line along Sabongida, the Figures shows that, in 2003 there were about 46 building along the area. However, in 2013 the ROW of the high-tension along the area experience encroachment of building amounted 74 (19.7%) of the total number of buildings within the ROW in the year. This amount has been increased to 163 (18.9%) of the total encroachment in the year. It is clear that number of buildings within the ROW along Sabongida have been on increase, which might be associated with how new development are taken place in the area. The finding further shows that no matter what will be done people will still encroach into government property, and this might be associated with population growth and economic situation of the country which force people to migrate into urban centres looking for employment and better way of sustenance.

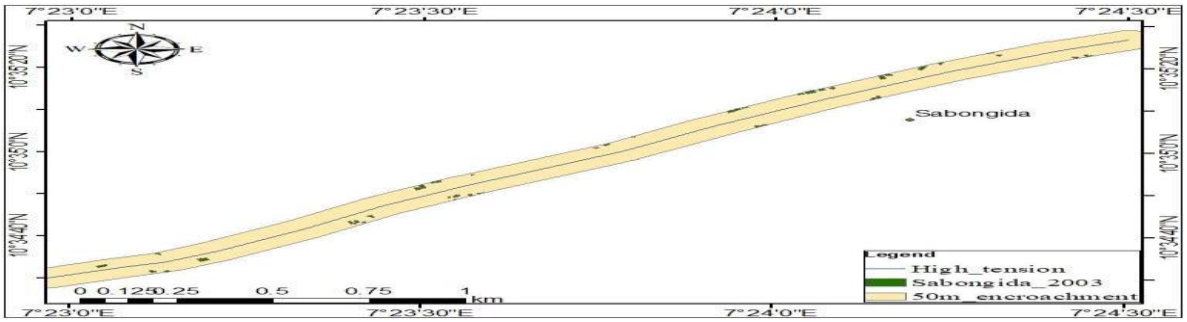

Figure 12: Buildings within the ROW in Sabongida (2003)
Source: Field Survey (2024)

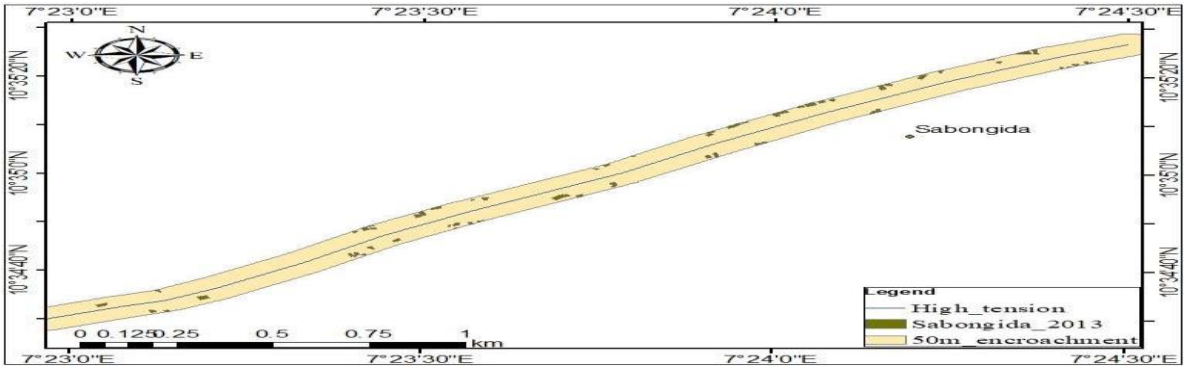

Figure 13: Buildings within the ROW in Sabongida (2013)
Source: Field Survey (2024)

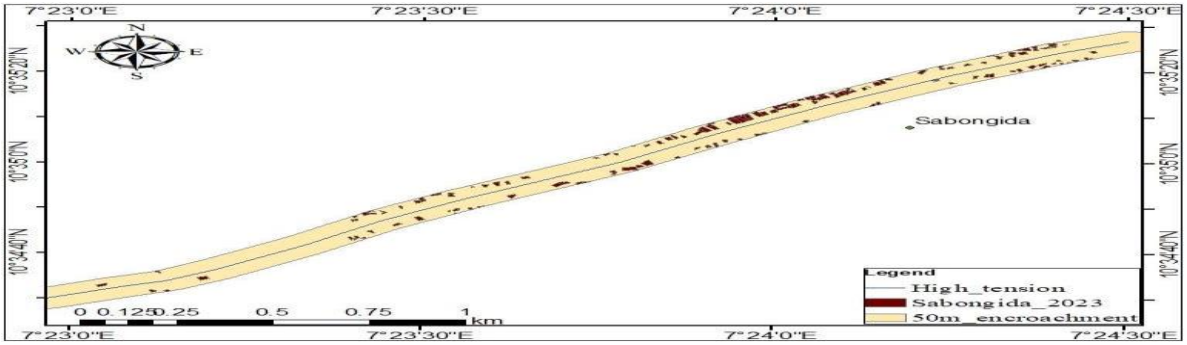

Figure 14: Buildings within the ROW in Sabongida (2023)
Source: Field Survey (2024)

Table 2 and Figures 15 to 17 show the results on the buildings within the right-of-way (ROW) of the high-tension transmission line along Rigasa. The figures indicate that in 2003, there were only 9 buildings in the area. This number doubled to 19 in 2013 and increased again to 42 in 2023. Although the number of buildings within the restricted area along this settlement is low compared to what is found in the other four settlements in the study area, the number might become difficult to control over time as the settlement expands further. Overall, the results show that in 2003, Jaji recorded the highest percentage (67.2%) of buildings within the ROW, followed by Sabongida with 18.9%, while Birnin Yero recorded the lowest (0%). In 2013, the number of buildings within the ROW increased from 244 to 376, with Jaji still recording the highest percentage (57.7%) of the total buildings for that year, followed by Sabongida with 19.7%, while Birnin Yero recorded only 4.3%. However, the results revealed that by 2023, the number of buildings within the ROW had nearly tripled compared to the base year, amounting to 862 buildings. Jaji still recorded the highest percentage (54.8%), while Birnin Yero recorded the lowest (4.4%).

This study clearly indicates that the number of people occupying areas near power lines in the study area has been increasing steadily. This might be linked to the influx of people into the metropolitan part of Kaduna State in search of livelihoods, which has resulted in congestion and insufficient land for building. Consequently, people are compelled to settle even in danger zones, such as the right-of-way of high-tension transmission lines, riverbanks, and similar areas.

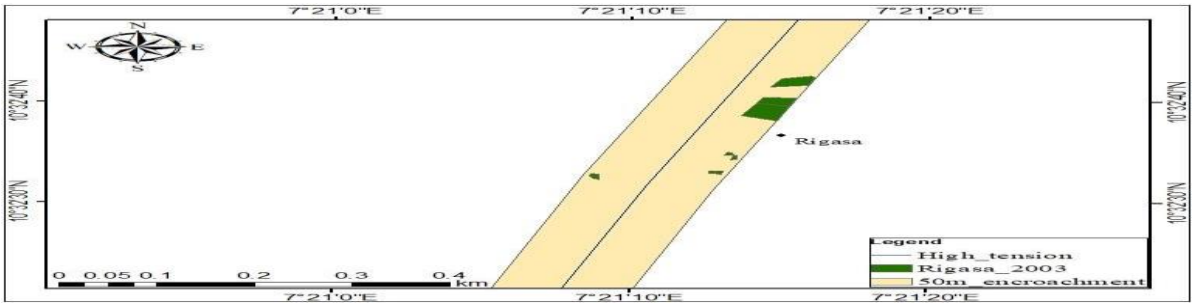

Figure 15: Buildings within the ROW in Rigasa (2003)
Source: Field Survey (2024)

The implications of the development of buildings within the restricted areas of high-tension power lines are numerous. It might affect the lives and properties of people living in these areas. Eze and Eke (2021) in Rivers State, Nigeria, reported that buildings within the right-of-way (ROW) of high-tension power lines make residents vulnerable to the hazards of high-voltage electrical incidents. Additionally, Kheifets et al. (2015) in California reported that the risks of living near power transmission lines include childhood cancer.

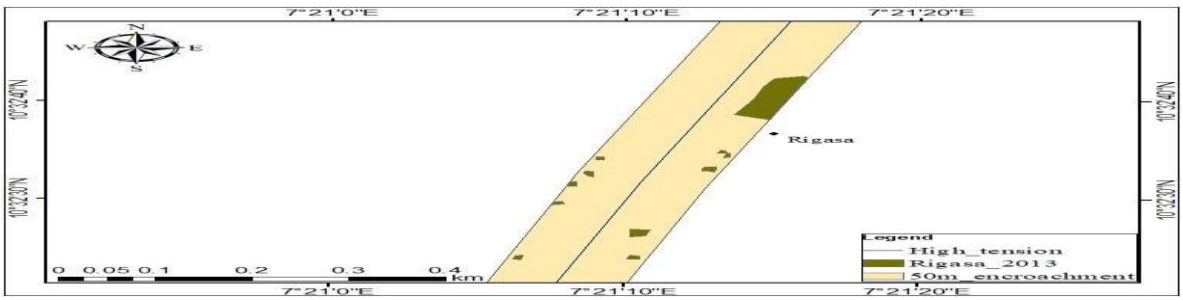

Figure 16: Buildings within the ROW in Rigasa (2013)
Source: Field Survey (2024)

This finding is similar to the results of Olamiju and Oyinloye (2015) which identified 126 buildings that encroached on the setback of the 330 KV overhead Power line in Akure, Power line in Akure, Nigeria. The finding also conforms to that of Olapeju and Farotimi (2016) in Agbado, Ogun State which found that about 602 structures have encroached on the 50 meters' setback from the high-tension line routed of the area. The results also correspond to that of Olerum and Ogoro (2021) in Port Harcourt, Rivers State which showed that about twenty-nine thousand and thirty (29,030) structures in the area were within the environment of overhead power line right of way and so they are under the menace of medium voltage power line hazards.

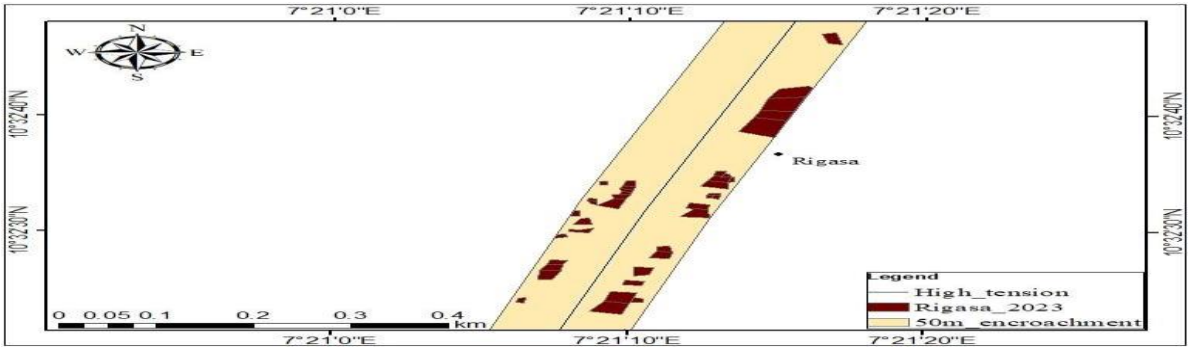

Figure 17: Buildings within the ROW in Rigasa (2023)
Source: Field Survey (2024)

Conclusion and Recommendations

The study has provided comprehensive information on the assessment of high tension power transmission lines in the study area, which was found to be in a progressive trend. Therefore, the study concluded that the total area of the high-tension power transmission lines in the study area is 1,550,052.7 square meters, while the right-of-way (ROW) covers 9,309,486.86 square meters. The total length of the transmission line in the area was found to be 77.49 kilometers**.** The study also concluded that the total number of buildings developed within the right-of-way (ROW) was found to be 244, 376, and 862 in 2003, 2013, and 2023, respectively. In addition, the total built-up area within the right-of-way of the high-tension power transmission lines in the study area was observed to be 50,244 m², 76,049 m², and 200,745 m² in 2003, 2013, and 2023, respectively. This shows an increasing trend that calls for concern. Based on the findings of this study, the following recommendations were made**:**

1. Since Google Earth has the capability of showing the path of high tension power transmission line, the study recommended that, Transmission Company of Nigeria (TCN) and PHCN should employed aerial surveillance of the High tension power transmission lines using remote sensing and GIS technologies for effective development control in the study area.
2. As the study found many buildings in the study area, demolition of these buildings should be carried out by the Kaduna States Urban Planning Development Agency (KASUPDA) to serve as deterrent to others.
3. It has also been observed by the study that there is encroachment into the ROW of the high tension power transmission line. The study therefore recommending the strengthen of enforcement toward adherence to setback regulations by Kaduna State Urban Planning Development Agency (KASUPDA) to ensure the safety of both the residents and high tension power transmission lines.

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