MAPPING THE ENCROACHMENT STATUS OF THE OVERHEAD HIGH VOLTAGE TRANSMISSION LINES' CORRIDOR IN ALIMOSHO LOCAL GOVERNMENT AREA, LAGOS STATE, NIGERIA

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ABSTRACT

One feature shared by developing countries is urban sprawl, which frequently encroaches on exclusive physical planning provisions such as the right-of-way for overhead high voltage transmission lines (HVTLs). Geospatial techniques were used in the study to assess the encroachment status of the overhead high voltage transmission lines corridor's Right-of-Way (RoW) in Alimosho LGA, Lagos State, Nigeria. The gazetted setbacks of 15 m and 25 m for 132 kV and 330 kV HVTLs respectively from the Transmission Company of Nigeria (TCN) were used to generate the RoW extent. Topographic maps and Ikonos high-resolution imageries were used to extract the landuse and landcover (LULC) of the RoW for 1983, 2002, 2008, 2014, and 2022 at a minimum mapping unit (MMU) of 1:1,500 to assess the level of encroachment. According to the study, the HVTLs RoW has been increasingly encroached upon, 5% (1983), 57.54% (2002), 66.09% (2008), 72.56% (2014), and 82.60% (2022). Within the RoW, commercial and residential LULC are the most prevalent. Mechanic workshops, block industries, small scale trading businesses (kiosks and containers), welding workshops, and car wash sheds were also identified as dominant human activities directly beneath the 330 kV and 132 kV towers. The study concluded that there was little or no encroachment enforcement and that built-up areas around the HVTL posed health and safety risks. The study therefore recommends that the enforcement of the control laws and regulations on setbacks for HVTLs be followed strictly to discourage any further encroachment, while all existing buildings and activities on the RoW be removed.

Keywords: Encroachment; GIS, Mapping, Overhead High Voltage Transmission Lines**,** Right-of-Way

INTRODUCTION

Globally, there has been growing electricity demand, and to reduce the electrical transmission losses, countries have massively constructed high voltage transmission lines (HVTLs) including pylons or towers (Bamigbola et al., 2014; Li & Lin, 2019; Xu et al., 2016) which have become vital components of electrical power transmission infrastructure; predicted to cover about 6.8 million km by 2020 (Qin et al., 2017). HVTLs are electrical lines used to transmit electric power over a relatively long distance. Electric power transmission is the bulk movement of electric power from a generating site to an electrical substation. All over the world, generated electrical power is transmitted and distributed through various systems and at different voltages. In Nigeria, power is transmitted using HVTLs – 330 kV and 132 kV - running from generating stations to transmission substations (Wunude et al., 2021). In Nigeria, HVTLs covered roughly 12.3 thousand km as at 2018 (Amuta et al., 2018) and still counting. The transmission of electricity covers large areas and can produce negative impacts on the environment and people staying close to it (Tempesta et al., 2014).

Studies on the possible negative impacts of HVTLs have attracted considerable public and scientific attention (Priya & Anbalagan, 2016; Ukhurebor et al., 2019). These negative impacts include risks to health and safety due to electric and magnetic fields (Jon-Nwakalo et al., 2019; Seomun et al., 2021; Tong et al., 2016), environmental risks from electromagnetic fields (Porsius et al., 2016; Ramirez-Vazquez et al., 2019), biological effects of electromagnetic fields (Wu et al., 2017), visual and perception impacts (Mueller, 2020), noise impacts (Piana et al., 2018), wildfires (Liang et al., 2020) and property values (Akinjare et al., 2014; Chalmers, 2019). Presently in Nigeria, the HVTLs which once transverse mainly lagoons, forests and cultivated lands are now conspicuously exposed due to rapid uncontrolled development (Eze & Richard, 2018); causing negative effects in urban functions and services, as well as critical human-environmental problems (Algohary, 2016; Fasona et al., 2021). In Finland, between 1980 – 2019, 157 fatal cases of electrical accidents were recorded (Linja-aho, 2020); 103 cases were recorded in South Africa between 2013 – 2016 (Lack et al., 2020) while in Nigeria between 2014 – 2019, a total of 259 deaths, 1,085 accidents and 126 injuries were recorded from electrical accidents across some states of the country (Obi et al., 2020).

Alimosho Local Government Area (LGA) in Lagos State accommodates the highest number of HVTLs corridors presently in Nigeria (Akinjare et al., 2014); thus, making the area one of the most exposed to hazards and risks associated with the presence of HVTLs in Lagos and the country at large. One common feature of developing countries is urban sprawl which often encroach on exclusive physical planning provision. These days HVTLs which were far from residential areas are now neighbouring to buildings (Badru et al., 2019). In other words, urban landuse had been progressively characterised by changes with the most menacing concern of the effect of encroachment on areas zoned for special purposes that are risk prone. Nigeria is also experiencing such with Lagos State not spared. Urban residential expansion in Lagos has metamorphosed into full urban sprawl such that every available space is considered residentially or commercially useful and this is clearly the case in Alimosho LGA. A RoW is a strip of land, usually owned by the government, that is reserved for the purpose of public access and the construction and maintenance of public utilities and safety. The safety benchmark for HVTLs referred to as RoW often seemed nonexistence in Alimosho LGA.. Therefore, the critical need to assessing the spatial status of the HVTLs' Right-of-way (RoW).

There is, however, a general concern that despite various studies, the level of encroachment on the HVTL RoW remains unabated especially in Nigeria, and by extension Alimosho LGA in Lagos State. There have also been some studies on the encroachment of the HVTLs RoW in Nigeria, but mostly focused on the effect on property values and rents (Akinbogun et al., 2020; Akinjare et al., 2013; Eze & Richard, 2018; Nkeki, 2013). Relatively missing in most of the studies on the encroachment of HVTL RoW is the dearth of extensive assessment of baseline landuse change at a finer scale within the study area whose careful considerations are required in the development of a planning and management option. Therefore, this research intends to map the encroachment status of the 330 kV and 132 kV overhead HVTLs from 1983 to 2022 in Alimosho LGA using geospatial techniques.

THE STUDY AREA

The study area stretches approximately between Latitudes 6°28' and 6°42' North of the equator and Longitudes 3°11' and 3°19' East of the Greenwich meridian occupying a land area of about 180.7km^2. The River Owo delineates the study area from Ado-Odo/Ota LGA of Ogun State on the northern and western axis; bounded by Ifako/Ijaiye, Agege and Ikeja LGAs toward the east and Oshodi/Isolo, Amuwo Odofin and Ojo LGAs on the southern part as presented in Fig. 1. It is the most populated LGA in Lagos State, with 1,288,714 inhabitants with population growth rate of 7.52% (NPC, 2006).

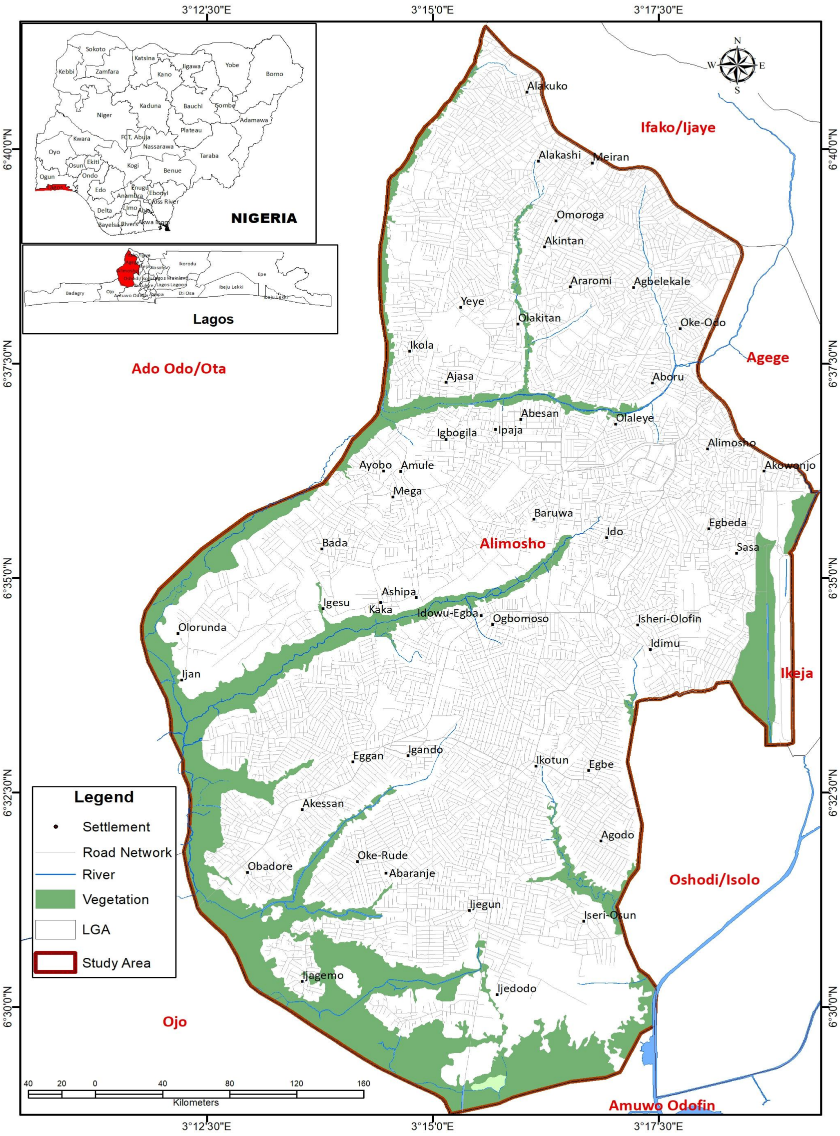

Figure 1: The Study Area
Source: Adapted from Administrative Map of Lagos State

MATERIALS AND METHODS

The characteristics of the data type, scale and resolution, coverage, year and sources used for this study are presented in Table 1. The study employed Remote sensing (RS) and Geographic Information System (GIS) techniques to interpret and classify the topographic maps and other satellite images (Ikonos, GeoEye-1 and Pleiades) that were used for the study. This is to generate the spatial characteristics of the HVTLs RoW for 1983, 2002, 2008, 2014 and 2022 and classify the area into LULC classes. The selected years are based on the availability of base maps data. Assessing the RoW LULC for the year 1983, the topographic maps were converted from analogue to digital format and identified LULC were extracted using the on-screen digitizing method, while LULC for the years 2002, 2008, 2014 and 2022 were extracted from the acquired high-resolution images using the supervised classification method with ArcGIS Pro software within the at a minimum mapping scale (MMU) of 1:1,500.

The landuse/landcover classification schema of Anderson et al. (1976) was adopted for this study as presented in Table 2.

Table 1: Data Characteristics

S/n	Data	Scale and Resolution	Identification and Coverage	Year	Sources
1	HVTLs and Tower characteristics and location	330/132kV Schematic Diagram Documents, Literatures, Reports, etc.	Study Area	1983-2022	Transmission Company of Nigeria (TCN), Ikeja West Sub Region, Lagos; TCN, Power House, Abuja; Field survey
3	Administrative Map	1:250,000	Study Area		Laboratory for Remote Sensing and GIS, Department of Geography, University of Lagos.
4	Topographic Maps	1:25,000	Ilaro SE 1 Sheet 279, Ilaro SW 2 Sheet 279, Ilaro SW 3 Sheet 279, Ilaro SW 4 Sheet 279, Lagos NE 1 Sheet 279A	1983	Laboratory for Remote Sensing and GIS, Department of Geography, University of Lagos.
5	Ikonos GeoEye-1 Pleiades	0.8 m 0.5 m 0.7 m	Study Area	2002 2008 2014 2022	Google Earth Pro (Maxar Technologies) https://earth.google.com/web/

Table 2: LULC Classification Schema

S/N	Level I	Code	Level II	Code
1	Builtup	1	Residential	11
			Commercial/Service Area	12
			Transmission Sub-Station	13
			Educational	14
			Religious	15
			Industrial	16
			Institutional	17
			Transport	18
			Recreational	19
			Cemetery	110
			Urban Open/Non-Dedicated Recreational	111
			Road Network	112
2	Agricultural	2	Animal Husbandry	21
			Subsistence Agriculture	22
3	Forest	3	Light forest	3
4	Grassland	4	Grassland	4
5	Waterbody	5	Waterbody	5
6	Wetland	6	Wetland	6

Source: Adapted from Anderson et al. (1976)

Accuracy assessment is vital in image classification to ascertain the level of inconsistency between the classified imagery data and the actual ground data. Accuracy assessment was conducted on RoW LULC 2014 data with field data gathered in July 2019. Fieldwork was conducted using existing data from the study as well as in situ knowledge; 526 samples points were gathered swathing the six LULC classes using Trimble Juno SC GPS with 1m accuracy. Kappa index of agreement was calculated using equation (1) (Congalton, 1991):

$$K_{index} = (P_0 - P_e)/(1 - P_e) \qquad [1]$$

Where $P_0 = \sum_{i=1}^{c} P_{ij}$ (P_{ij} is the *i-th* and *j-th* cell of the contingency table)
$P_e = \sum_{i=1}^{c} P_i T.PT_j$ ($P_i T$ is the sum of all cells in i-th row)
PT_j = sum of all cells in *j-th* column, and *c* is the pixel count within the multispectral space.

Table 3: **RoW Status Schema**

S/n	LULC Class	RoW LULC Status
1	Residential	Encroachment
2	Commercial/Service Area	
3	Educational	
4	Religious	
5	Industrial	
6	Institution	
7	Recreational	
8	Cemetery	
9	Transport	
10	Road Network	
11	Urban Open/Non-Dedicated Recreational	
12	Animal Husbandry	
13	Transmission Sub-Station	Non-Encroachment
14	Grassland	
15	Waterbody	
16	Wetland	

For the assessment of the encroachment status, RoW Status Schema (Table 3) was developed for this study to determine and categorize the identified LULC into encroachment and non-encroachment. Participatory approach such as interview was also carried out with research and development officials of Transmission Company of Nigeria (TCN) to ascertain the fitness of the categorization of the different landuse and landcover into the schema. The results from the RoW status schema were overlaid and analyzed in the GIS environment using the ArcGIS Pro software to determine the level of encroachment on the HVTLs RoW.

RESULTS AND DISCUSSION

The study revealed that as of 1983, natural resources like the forest, waterbody, wetland, and cultivated area (agricultural), including the transmission station that are the only permissible LULC or human activities within the HVTLs RoW occupied a total of 230.05 ha which account for about 94.35% of the approved setback, while 13.79 ha (5.65%) has been encroached on by builtup landuse as presented in Table 4. The builtup landuse identified to have encroached the RoW in the year 1983 were residential, educational and road network (Fig. 2).

Table 4: HVTLs RoW Status for 1983

Sn	RoW LULC Class	Area (M^2)	Area (Ha)	%	RoW Status
1	Residential	105,029.77	10.50	4.31	Encroached Area (5.65%)
2	Educational	10,433.29	1.04	0.43	
3	Road Network	22,417.31	2.24	0.92	
		137,880.38	**13.79**	**5.65**	
4	Transmission Sub-Station	152,548.41	15.25	6.26	Non-encroached Area (94.35%)
5	Cultivation	1,908,273.62	190.83	78.26	
6	Light Forest	145,819.23	14.58	5.98	
7	Waterbody	3,719.78	0.37	0.16	
8	Wetland	90,187.46	9.02	3.70	
		2,300,548.50	**230.05**	**94.35**	

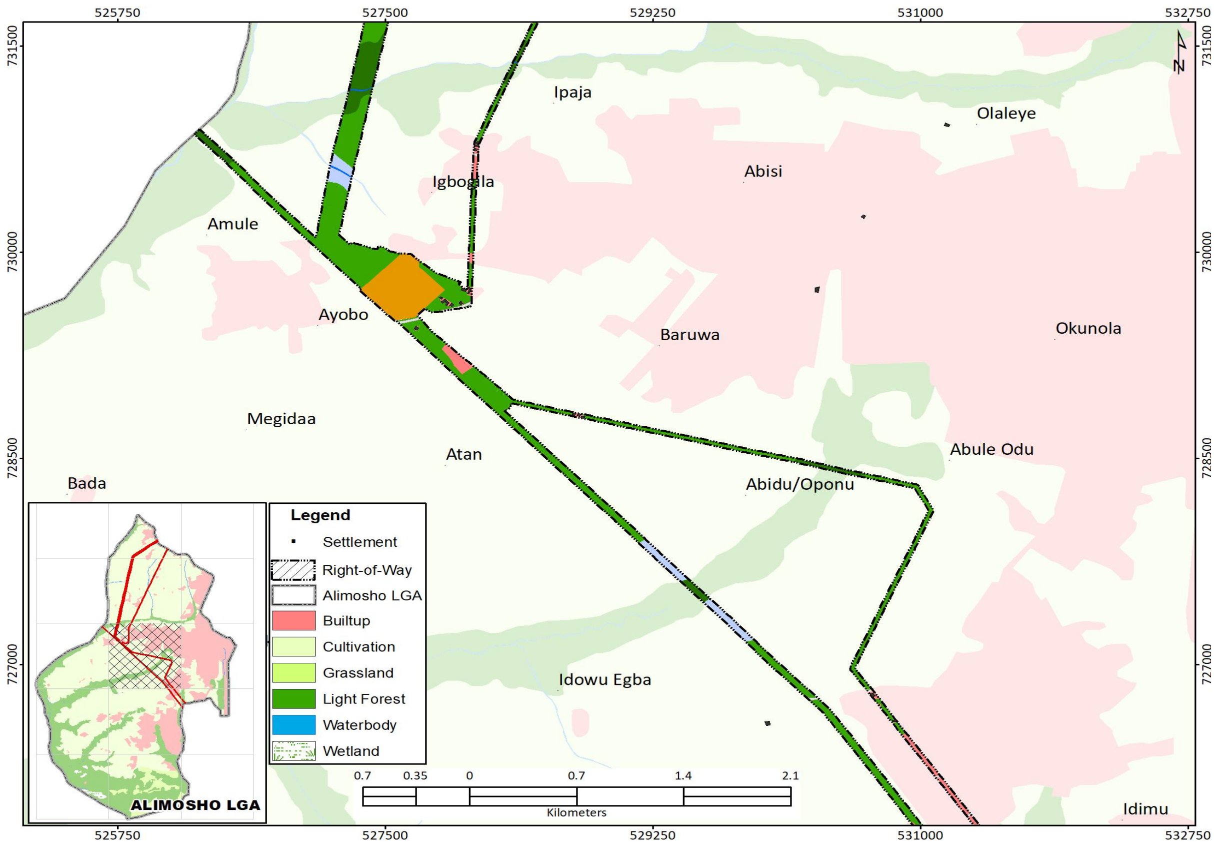

Figure 2: Section of RoW Encroachment in 1983

As presented in Table 5, in 2002, the encroached area of the RoW was about 225.45 ha which represents 57.54% of the allotted area. This encroached area is mainly occupied by residential (75.07 ha), commercial (50.62 ha) and urban open/open space (47.90 ha) which represent 19.16%, 12.92% and 12.22% respectively. The non-encroached area with approximately 166.40 ha accounts for the remaining 42.46% of the area. Transmission sub-station, grassland, cultivation, waterbody and wetland occupied the non-encroached area in the following proportions 17.54 ha (4.48%), 13.85 ha (3.54%), 105.37 ha (26.89%), 0.14 ha (0.04%) and 29.48 ha (7.52%) respectively. The study further revealed that there are two thousand, three hundred and twenty-seven (2,327) building/structures within the RoW. The spatial distribution of the RoW status is presented in Fig. 3.

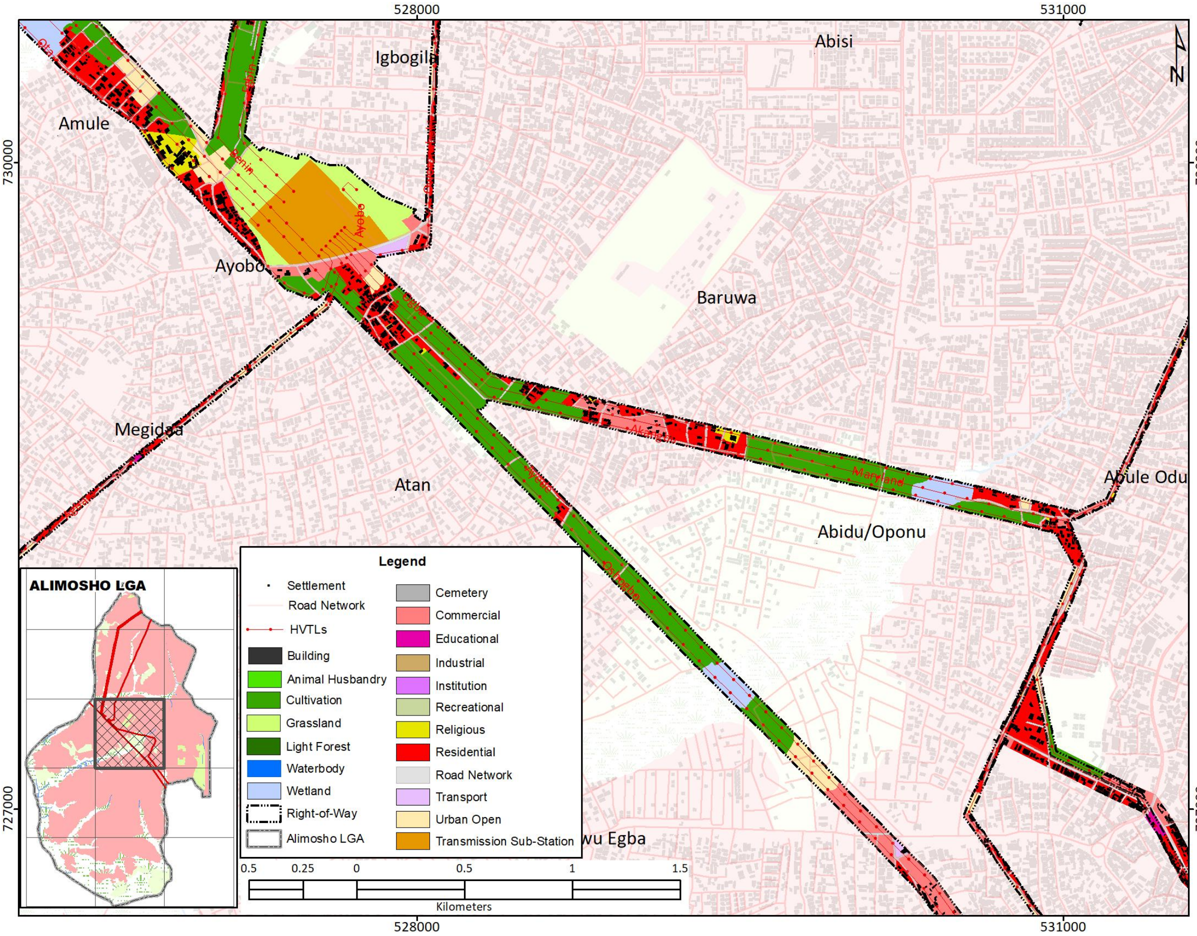

Figure 3: **Section of RoW Encroachment in 2002**

Table 5: **HVTLs RoW Status in 2002**

Sn	RoW LULC Class	Area (M^2)	Area (Ha)	%	RoW Status
1	Residential	750,664.21	75.07	19.16	Encroached Area (57.54%)
2	Commercial	506,153.63	50.62	12.92	
3	Educational	37,209.74	3.72	0.95	
4	Industrial	1,976.26	0.20	0.05	
5	Institution	3,549.50	0.35	0.09	
6	Recreational	26,620.93	2.66	0.68	
7	Religious	54,167.20	5.42	1.38	
8	Transportation	22,744.84	2.27	0.58	
9	Urban Open/Open Space	478,985.87	47.90	12.22	
10	Road Network	372,449.69	37.24	9.50	
		2,254,521.88	**225.45**	**57.54**	
11	Transmission Sub-Station	175,437.52	17.54	4.48	Non-encroached Area (42.46%)
12	Grassland	138,541.99	13.85	3.54	
13	Cultivation	1,053,740.73	105.37	26.89	
14	Waterbody	1,424.51	0.14	0.04	
15	Wetland	294,806.58	29.48	7.52	
		1,663,951.33	**166.40**	**42.46**	

In 2008, as presented in Table 6, the encroached area increased from 224.45 ha to 258.98 ha, which represents 66.09%, while the non-encroached area reduced further to approximately 132.87 ha which account for the remaining 33.91%. The encroached area was majorly occupied by residential, commercial, open space and road network which covered 109.26 ha (27.88%), 62.56 ha (15.97%), 29.15 ha (7.44%) and 40.61 ha (10.36%) respectively, while the non-encroached area was covered majorly by cultivation, approximately 74.42 ha, which represents 18.99% of the area (Fig. 4). The study further revealed that there were three thousand, three hundred and seventy-seven (3,377) buildings/structures within the RoW.

Table 6: **HVTLs RoW Status in 2008**

Sn	RoW LULC Class	Area (M^2)	Area (Ha)	%	RoW LULC Status
1	Residential	1,092,582.04	109.26	27.88	Encroached Area (66.09%)
2	Cemetery	3,490.38	0.35	0.09	
3	Commercial	625,585.34	62.56	15.97	
4	Educational	36,928.02	3.69	0.94	
5	Industrial	3,691.56	0.37	0.09	
6	Institution	4,139.24	0.41	0.11	
7	Recreational	48,982.69	4.90	1.25	
8	Religious	54,025.83	5.40	1.38	
9	Transportation	22,763.34	2.28	0.58	
10	Urban Open/Open Space	291,496.29	29.15	7.44	
11	Road Network	406,118.95	40.61	10.36	
		2,589,803.68	**258.98**	**66.09**	
12	Transmission Sub-Station	175,437.52	17.54	4.48	Non-encroached Area (33.91%)
13	Cultivation	744,162.65	74.42	18.99	
14	Grassland	132,857.72	13.29	3.39	
15	Waterbody	2,504.21	0.25	0.06	
16	Wetland	273,707.41	27.37	6.99	
		1,328,669.50	**132.87**	**33.91**	

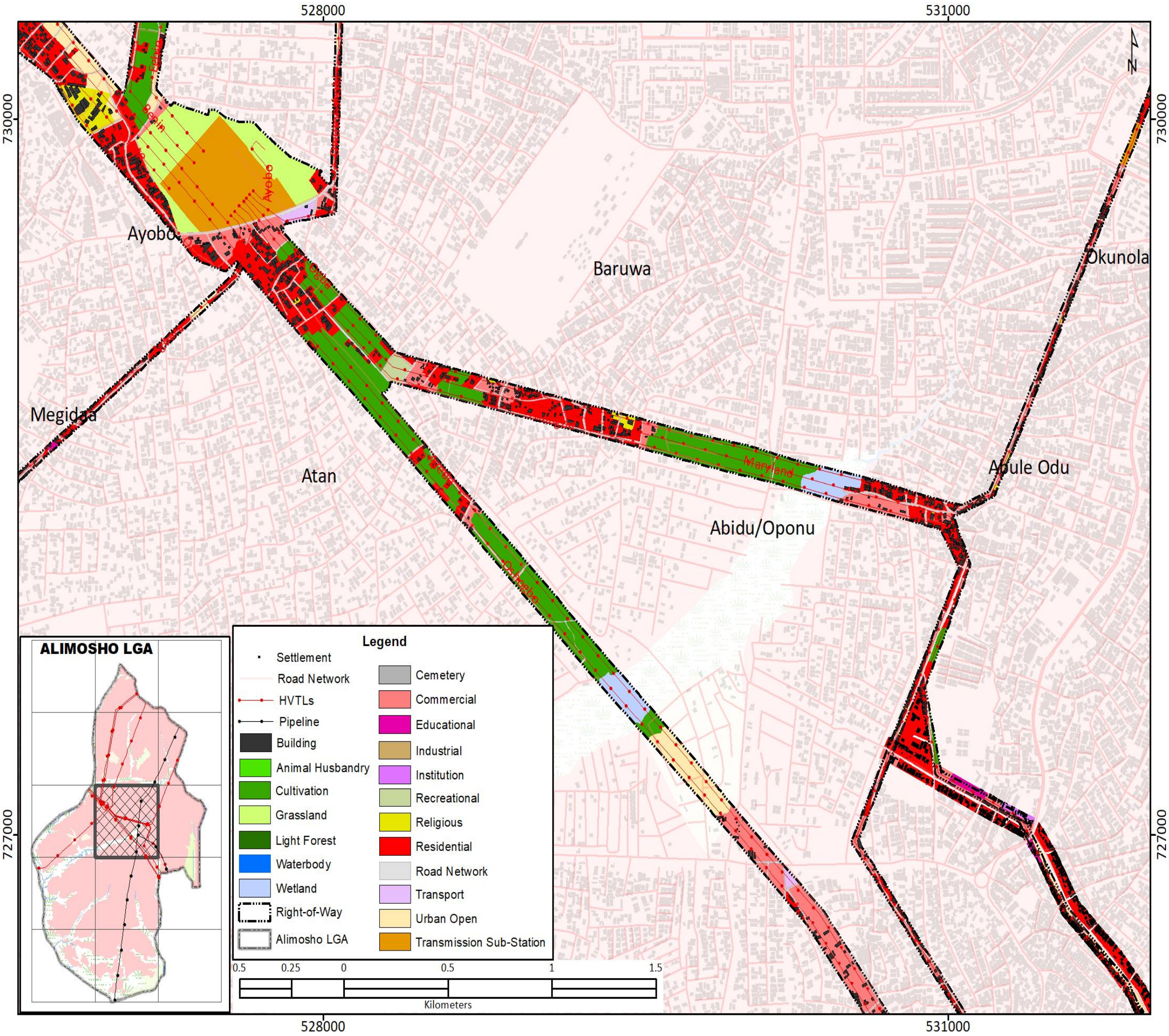

Figure 4: **Section of RoW Encroachment in 2008**

As presented in Table 7 and Fig. 5, in 2014, the study revealed that encroachment level of the HVTL RoW continued to increase. The encroached area of the RoW covered about 284.32 ha which represents 72.56%. Residential, commercial and road network remained the major LULC that encroached on the RoW in the following proportion 33.01%, 19.67% and 10.98% respectively. Other LULC that encroached on the RoW noteworthy of mention are recreational and religious which represent 1.88% and 1.38% respectively. The remaining 107.53 ha (27.44%) of the RoW that were encroached, in the order of size are cultivation, wetland, transmission sub-station, grassland and waterbody. The study further revealed that there were four thousand, one hundred and twenty-six (4,126) buildings within the RoW.

Table 7: HVTLs RoW Status in 2014

Sn	RoW LULC Class	Area (M^2)	Area (Ha)	%	RoW LULC Status
1	Residential	1,293,381.43	129.34	33.01	Encroached Area (72.56%)
2	Cemetery	3,490.38	0.35	0.09	
3	Commercial	770,785.81	77.08	19.67	
4	Educational	37,524.89	3.75	0.96	
5	Industrial	2,499.74	0.25	0.06	
6	Institution	4,271.09	0.43	0.11	
7	Recreational	73,812.45	7.38	1.88	
8	Religious	53,940.24	5.39	1.38	
9	Transportation	26,038.56	2.60	0.66	
10	Urban Open/Open Space	147,274.36	14.73	3.76	
11	Road Network	430,147.25	43.01	10.98	
		2,843,166.21	**284.32**	**72.56**	
12	Transmission Sub-Station	175,437.52	17.54	4.48	Non-encroached Area (27.44%)
13	Cultivation	512,491.66	51.25	13.08	
14	Grassland	130,856.69	13.09	3.34	
15	Waterbody	3,562.82	0.36	0.09	
16	Wetland	252,958.30	25.30	6.46	
		1,075,306.98	**107.53**	**27.44**	

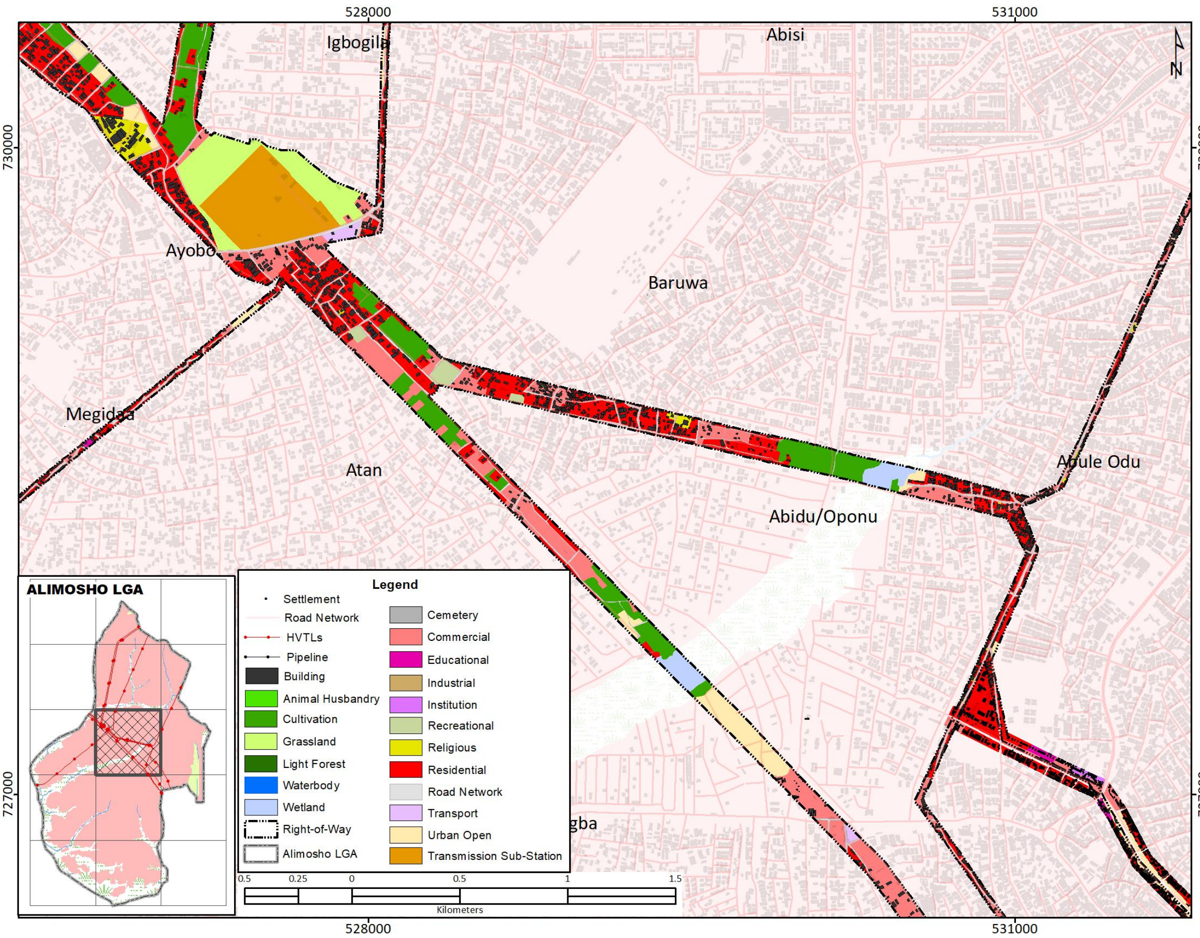

Figure 5: Section of RoW Encroachment in 2014

The level of encroachment on the RoW in 2022 is shown in Fig. 6 and Table 8. The statistics revealed that the level of encroachment on the HVTLs RoW continued to increase rapidly; while the encroached area covered about 323.67 ha which represents 82.60%, the non-encroached area covered 68.17 ha which accounts the remaining 17.40%.

Table 8: **HVTLs RoW Status in 2022**

Sn	RoW LULC Class	Area (M^2)	Area (Ha)	%	RoW LULC Status
1	Residential	1,415,961.00	141.60	36.14	Encroached Area (82.60%)
2	Cemetery	21,401.78	2.14	0.55	
3	Commercial	929,961.90	93.00	23.73	
4	Educational	46,101.00	4.61	1.18	
5	Industrial	13,738.48	1.37	0.35	
6	Institution	3,759.70	0.38	0.10	
7	Recreational	56,308.99	5.63	1.44	
8	Religious	127,053.56	12.71	3.24	
9	Transportation	34,536.75	3.45	0.88	
10	Urban Open/Open Space	64,525.84	6.45	1.65	
11	Animal Husbandry	12,057.16	1.21	0.31	
12	Road Network	511,341.94	51.13	13.05	
		3,236,748.10	323.67	82.60	
13	Transmission Sub-Station	202,596.69	20.26	5.17	Non-encroached Area (17.40%)
14	Cultivation	153,454.54	15.35	3.92	
15	Grassland	109,570.77	10.96	2.80	
16	Waterbody	6,736.81	0.67	0.17	
17	Wetland	209,366.31	20.94	5.34	
		681,725.12	68.17	17.40	

Residential landuse constituted the highest level of encroachment on the HVTLs RoW. It covered an area of 141.60 ha, which represents about 36.14% of the total encroachment, while the least is animal husbandry (0.31%). The study also revealed that there are Six thousand, four hundred and eighty-two (6,482) buildings/structures that are within the HVTLs RoW in Alimosho LGA.

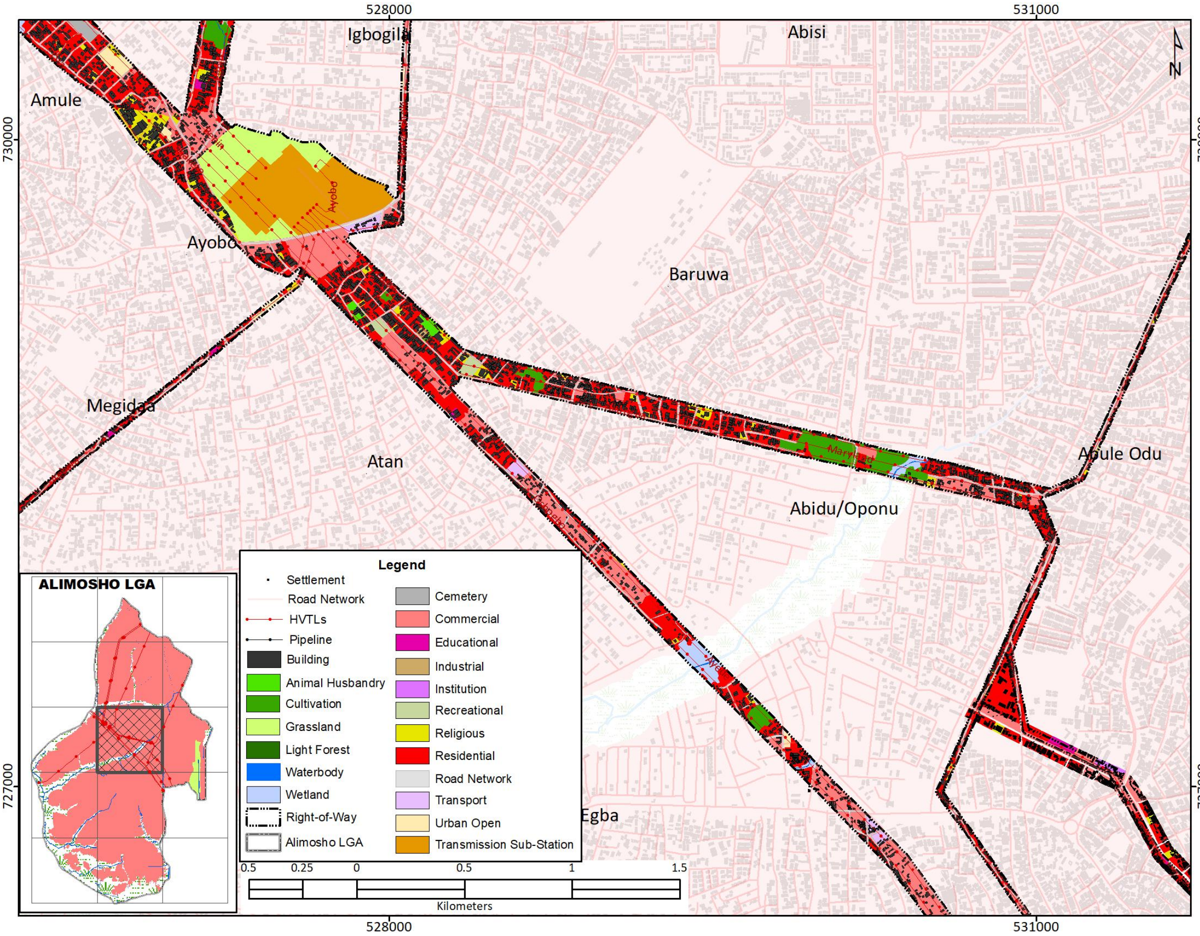

Figure 6: **Section of RoW Encroachment in 2022**

Overhead high voltage transmission lines and other linear infrastructure such as oil and gas pipelines due to the risk posed, have their RoWs which are meant to be for safety purpose to the environment and the people. Mostly in developing countries, encroachment on this exclusive physical planning provision has been one major concern. This study revealed that from 1983 to 2022 within the Alimosho LGA, there had been and increasingly steady encroachment of the RoW by majorly residential and commercial landuse. These two major landuses account for the larger percentage of the encroached area. This shows the negligence of proper developmental planning and little or no existence of planning authorities and agencies in the enforcement of the setback within the LGA. It is equally evident that the risk perception of people living or working within the overhead HVTLs RoW is very low. In other words, people assume there is little or no risk staying or working close to the overhead HVTLs. This study further corroborates with some of the studies that were carried out on RoW encroachment in some other parts of Nigeria, revealing people's poor attitude to risk associated with staying close to HVTLs. Olamiju and Oyinloye (2015) carried out a study on characterizing houses under a 10 km overhead 330 kV high tension powerline in Akure, Ondo State using GIS. The study revealed that 126 buildings encroached on the setbacks. Furthermore, Eze and Richard (2018) also conducted a geospatial analysis of encroachments on the HVTL RoW (2007 – 2017) in parts of Port Harcourt, Rivers State. Results showed that there were persistent encroachment of residential buildings and commercial activities within the RoW. And that residential and commercial landuse are the major human activities on the encroached RoW (Eze & Richard, 2018).

CONCLUSION

The encroachment status of dedicated RoW of electrical infrastructure and other linear infrastructures will continue unabated and probably escalate as physical developments such as residential, commercial, industrial, religious, and recreational, and various human activities have continued to increase over the years as shown in this study without recourse to the risks associated with staying or working within it. The huge extent of encroachment of the HVTL RoW can majorly be attributed to the poor enforcement of the setback laws by the authorities or agencies concerned and very low risk perception of the people. The study revealed the rapid and continuous unabated encroachment of the dedicated infrastructure right-of-way within the study area, and this will continue if not checked. Therefore, in view of this, this study recommends that the enforcement of control laws and regulations on setbacks for HVTLs be followed strictly to discourage any further encroachment, while all existing activities on the RoW be removed. There should be continuous public enlightenment and awareness from all the authorities and agencies concerned on the risk associated with living or working within this infrastructure RoW. Additionally, conspicuous signposts/boards and RoW barriers, where necessary, should be erected displaying the approved setbacks for powerlines in areas transverse by this infrastructure. This will serve as a check for illegal encroachments and raise awareness amongst those that may claim ignorance or are enticed by land procurement offers.

REFERENCES

Akinbogun S., Aigbavboa C., Gumbo T., Thwala W. (2020) Housing choice: The application of revealed and stated preference approaches to impacted residential property. In: Modelling the socio-economic implications of sustainability issues in the housing market. *Springer, Cham*. https://doi.org/10.1007/978-3-030-48954-0_5

Akinjare, A., Oloyede, A., Akinjare, A. and Oluwatobi, O. (2013). HVOTL associated risks and real estate investment in Lagos Metropolis, Nigeria. *Journal of Civil Engineering and Urbanism*, *3*(2). 37-47.

Akinjare, O., Oni, A. and Iroham, O. (2014). HVOTL structures and residential property Investments in suburban Lagos, Nigeria. *Transnational Journal of Science and Technology*, *4*(2), 17-29.

Algohary, S. (2016). Risk reduction for people living near and under high voltage powerlines in urban areas in Egypt: The need for new preventive measures. *Global Journal of Engineering Science and Research Management*, *5*(12), 17–26. https://doi.org/10.5281/zenodo.199422

Anderson, J., Hardy, E., Roach, J. and Witmer, R. (1976). A land use and land cover classification system for use with remote sensor data. *Geological survey professional paper 964*, Washington D.C: USGS.

Amuta, E., Wara, S., Agbetuyi, F. & Matthew, S. (2018) Smart grid technology potentials in Nigeria: an overview, International Journal for Applied Engineering Research, *13*(2), 1191-1200

Badru, R., Akinwale, O., Salau, A., Olorunyomi, K., Alwadood, J., & Atijosan, A. (2019). Assessment of geo-spatial proximity and magnetic pollution from 132kV and 330kV power transmission lines to infrastructures in Osogbo, Nigeria. *Eskişehir Technical Univ. J. of Sci. and Tech. B – Theo. Sci.* *7*(1), 81–93. https://doi.org/10.20290/AUBTDB.407794

Bamigbola, O., Ali, M. & Oke, M. (2014) Mathematical modelling of electrical power flow and the minimization of power losses on transmission lines, *Applied Mathematics Computation*, 241, 214-221. https://doi.org/10.1016/j.amc.2014.05.039.

Chalmers, J. (2019). High-Voltage transmission lines and residential property values in New England: What has been learned. *Appraisal Journal*, 87(4), 264-277.

Congalton, R.G. (1991). A review assessing the accuracy of classification of remotely sensed data. *Remote Sensing of Environment, 37*, 35-46. https://doi.org/10.1016/0034-4259(91)90048-B

Eze, P. & Richard, J (2018). Geospatial Analysis of Encroachments on the Nigeria Electricity Grid Right-of-way in Parts of Port Harcourt, Nigeria, *International Journal of Scientific and Research Publications,* *9*(8), 568-573. https://doi.org 10.29322/IJSRP.8.9.2018.p8177

Fasona, M., Ariori, A. & Akintuyi, A. (2021). The challenges of urban evolution and land management in developing countries: Some lessons from the city of Lagos. In Akinyele, R., Nubi, T. & Omirin, M. (Eds) *Land and development in Lagos* (pp 483-508). Lagos, Nigeria: University of Lagos Press.

Jon-Nwakalo, C., Jonas, O., Nnenanya, C. & Mmo, C. (2019). The Hazards of Building in the Vicinity of Electromagnetic Fields: Lessons for Building Code Enforcement in Nigeria. *Journal of Energy Technologies and Policy,* 9, 1-7. https://doi.org/10.7176/JETP

Lack, V., Esteves, M., Nnaji, L., Loveland, J. & Westgarth-Taylor, C. (2020). The epidemiology of paediatric electrical injuries in a South African township. *Burns Open*, *4*(2), 53-59. https://doi.org/10.1016/j.burnso.2020.01.001

Li, X. & Lin, Y. (2019) Do high-voltage power transmission lines affect forest landscape and vegetation growth: Evidence from a case for Southeastern of China. *Forest*, *10*, 162. https://doi.org/10.3390/f10020162

Liang, Y., Zhou, L., Cheng, J. Huang, Y., Wei, R., & Zhou, E. (2020) Monitoring and risk assessment of wildfires in the corridors of high-voltage transmission lines. *IEEE Access*, 8, 170057-170069

Mueller, C. (2020). Why do residents participate in high-voltage transmission line planning procedures? Findings from two power grid expansion regions in Germany, *Energy Policy*, 145, https://doi.org/10.1016/j.enpol.2020.111779.

National Population Commission (NPC) (2006). *Nigeria national census: population distribution by sex, state, LGAs and senatorial district: 2006 census priority tables* (Vol. 3). Retrieved July 1, 2021 from http://www.population.gov.ng/index.php/publication/140-popn-distri-by-sex-state-jgas-and-senatorial-distr-2006

Nkeki, F. N. (2013). Living near high-voltage power lines: GIS-based modelling of the risk in Nigeria's Benin region, *Applied GIS*, 9(1), 1-20.

Obi, P., Okoro, C. & Okonkwo, I. (2020) "Electrocution, Accidents and Electrical Injuries in Nigerian Homes and Work Sites –Causes, Effects and Remedies. *IOSR Journal of Electrical and Electronics Engineering*, *15*(2), 53-61. https://doi.org/10.9790/1676-1502025361

Olamiju, I. O. and Oyinlioye, M. A. (2015). Characteristics and vulnerability of houses under overhead high-tension powerline in Akure, Nigeria. *World Environment*, *5*(3), 121-133. https://doi.org/10.5923/j.env.20150503.04

Piana, E., Bignucolo, F., Donini, A., & Spezie, R. (2018). Maintenance of a high-voltage overhead transmission line: Sustainability and noise impact assessment. *Sustainability*, *10*, 491. https://doi.org/10.3390/su10020491

Porsius, J., Claassen, L., Woudenberg, F., Smid, T. & Timmermans, D. (2016) Nocebo responses to high-voltage power lines: Evidence from a prospective field study. *Sci. Total Environ*., 543, 432–438.

Priya, S. and Anbalagan, P. (2016). Investigation and analysis of electromagnetic radiation on high voltage transmission line. *International Conference on Current Research in Engineering Science and Technology*, pp 62-68

Qin, X.; Wu, G.; Ye, X.; Huang, L.; Lei, J. (2017) Novel method to reconstruct overhead high-voltage power lines using cable inspection robot lidar data. *Remote Sensing, 9* (7), 753. https://doi.org/10.3390/rs9070753

Ramirez-Vazquez, R., Gonzalez-Rubio, J., Arribas, E., & Najera, A. (2019). Characterisation of personal exposure to environmental radiofrequency electromagnetic fields in Albacete (Spain) and assessment of risk perception. *Environmental research*, 172, 109–116. https://doi.org/10.1016/j.envres.2019.02.015

Seomun, G., Lee, J., & Park, J. (2021). Exposure to extremely low-frequency magnetic fields and childhood cancer: A systematic review and meta-analysis. *PloS one*, *16*(5), e0251628. https://doi.org/10.1371/journal.pone.0251628

Tempesta, T.; Vecchiato, D.; Girardi, P. (2014). The landscape benefits of the burial of high voltage power lines: A study in rural areas of Italy. *Landsc. Urban Plan*, 126, 53–64.

Tong, Z.; Dong, Z.; Ashton, T. (2016). Analysis of electric field influence on buildings under high-voltage transmission lines. *IET Sci. Meas. Technol*., 10, 253–258

Ukhurebor, K., Aigbe, E. & Maor, S. (2019). Evaluation of electromagnetic fields from power lines in Irrua, Edo State, Nigeria. *Journal of Scientific Research and Reports*, *22*(1), 1-7. https://doi.org/10.9734/JSRR/2019/33973

Linja-aho, V. (2020). Fatal electrical accidents in Finland 1980-2019- trends and reducing measures. *International Journal of Occupational and Environmental Safety, 4*(2), 37-47. https://doi.org/10.24840/2184-0954_004.002_004

Wu, S.; Di, G.; Li, Z. (2017). Does static electric field from ultra-high voltage direct-current transmission lines affect male reproductive capacity? Evidence from a laboratory study on male mice. *Environ. Sci. Pollut. Res*., 24, 18025–18034.

Wunude, E., Soneye, A., Fasona, M & Akintuyi, A. (2021). Assessment of Encroachments on 132kV High Voltage Transmission Line (HVTL) Right-of-Way (RoW) in Alimosho LGA, Lagos, 1983 – 2020. *Benin Journal of Geography, Planning and Environment*, *1*(1), 39-54

Xu, K., Zhang, X., Chen, Z., Wu, W. & Li, T. (2016) Risk assessment for wildfire occurrence in high-voltage power line corridors by using remote-sensing techniques: a case study in Hubei Province, China, *International Journal of Remote Sensing*, *37*(20), 4818-4837. https://doi.org/10.1080/01431161.2016.1220032