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Analysis of the Potential Effects of the Alaoji - Onitsha 330 kV Transmission line on Environmental Resources

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Abstract

The study analysed the potential effects of the Alaoji-Onitsha 330 kV transmission line on environmental resources. The study made use of landsat satellite imagery for landuse classification, soil nutrient imagery and MODIS for vegetation health. Buffering analysis was used to generate 30 m and 50 m right of way from the transmission line in ArcGIS 7.0 environment and the radii polygons were used to generate the potential spatial extent of the environmental resources considered for the study. Descriptive statistics were used for the data analysis. Results showed that at 30 m ROW, settlements and waterbodies was expected to have more spatial coverage of 0.59 sq km (25.32%) and 1.1 sq km (47.21%). Similarly, 2.61 sq km (47.11%) of settlements and 1.83 sq km (33.03%) were expected to be affected at the 50 m ROW. The mean soil nutrient of 1109.51 mg/kg and 1237.05 mg/kg were to be affected at the 30 m ROW and 50 m ROW respectively. Also, the mean vegetation health of 0.3629 and 0.4788 were to be affected at the 30 m ROW and 50m ROW of the transmission line respectively. The study concluded that the potential effect of the acquisition of the right of way on soil nutrient, landuse and vegetation health increased with increasing distance from the transmission line. It is recommended among others that periodic study is very essential to checkmate the extent of violation of the defaulters and to discover the activities going on in the reserved setback for the transmission lines.

Keywords: Encroachment, Landuse/Land cover, Soil nutrient, Vegetation health, Right of way

Introduction

The historically grown transmission network in most cases cannot cope with the increasing regional discrepancies between generation and demand centres. In the past, power plants were built close to an area with high electricity consumption which only required limited transmission line networks. But as the population increases and urban centers demanding higher electricity need increases, there is a need for a timely development of national infrastructures as a prerequisite for economic growth and is generally associated with significant economic and social returns (Easterly, 2003). Such undertakings include electricity transmission networks, which following ambitious environmental targets need to connect a growing number of energy facilities. Despite their economic benefits, grid development projects often involve adverse environmental impacts and give rise to community opposition. Failing to reach agreement on deployment and siting of projects causes lengthy and costly delays to the planning process and even jeopardize the project altogether (Kunreuther *et al.*, 1994; RGI, 2012).

Electricity is a vital infrastructure that is very necessary for the smooth and meaningful development of any nation (Odunaiya et al., 2018). 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.

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. 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 (Odunaiya et al., 2018).

There are several works on the level of encroachment into the right of way of electricity transmission lines but very few can be seen on the existing 330 kV along the new Alaoji-Onitsha 330 kV SC transmission line project. Against this background, the study is focusing at analyzing the potential effects of the Alaoji - Onitsha 330 kV Transmission line on environmental resources.

Materials and Methods

The study was carried out in the South Eastern Nigeria. South-eastern Nigeria was one of the initial 12 states created during the Nigerian Civil War, then called East Central State, which later broke into the present Abia, Anambra, Ebonyi, Enugu and Imo States. Geopolitical speaking, these five states constitute the south eastern region of Nigeria (Figure 1). It is the home of the Igbo speaking

people of Nigeria. It is located within latitudes 4° 47‟ 35‟N and 7° 7‟ 44‟N, and longitudes 7° 54‟ 26‟E and 8° 27‟ 10‟E. The local language in this region is Igbo. Before the British colonial government, South-eastern Nigeria was home to many ethnic groups such as the Igbo, Ijaw, Ibibo, and Efik.

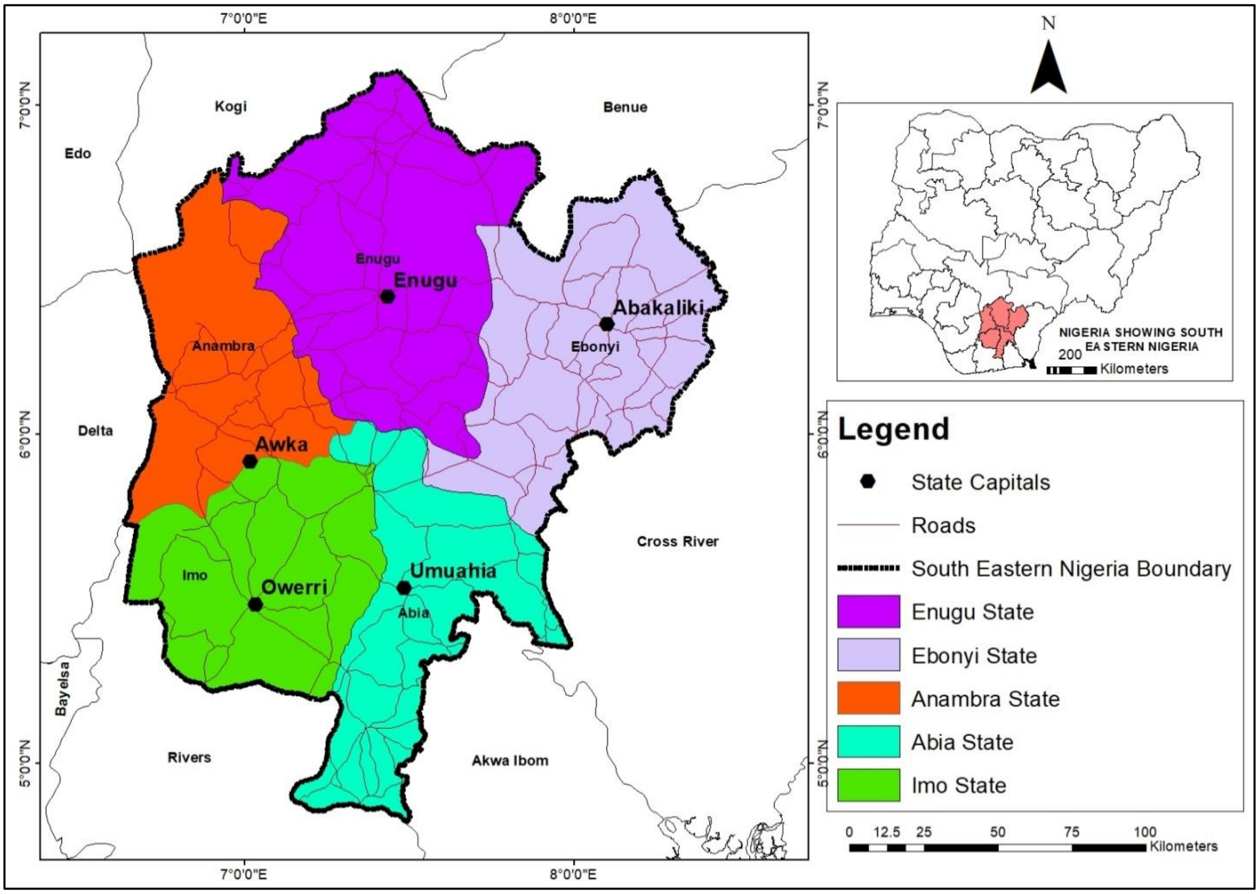

Figure 1: South Eastern Nigeria showing the States

In deep sense, the climate is characterized by the Equatorial type found in Southeastern Nigeria mainly warm and humid, and of two seasons; the dry season and the rainy season. The rainy season begins in April and continues into October while the dry season runs from November to March. During the rainy season, a marked disruption in the rains occurs during August, resulting in a short period of no rains universally referred to as "August break", though, for years now, this has not been consistent in August as a result of climatic changes. The rainfall of South Eastern Nigeria is influenced by the interaction between air-masses blowing over the surface. These are the Tropical Continental (CT) air-mass and the Tropical Maritime (mT) air-mass. The warm, dry and dusty tropical continental air originates over the Sahara, while the warm and humid tropical maritime air originates over the Atlantic Ocean They alternate seasonally with each other. The tropical maritime air is predominant over South-Eastern Nigeria during the rainy season while the tropical continental air is marked by the dry season. The area is known to have the pre Cambrian basement rocks and the lower cretaceous age rock also referred to as the “Albian Formation”. Igneous and metamorphic rocks constitute the Precambrian basement complex which is the oldest, crystalline, solid physical foundation of the country. Sedimentary rocks fill up the basins which are vast depressions between basement landmass. The pre-Cambrian rocks located to the Oban axis of the region and the Obudu region now Cross River State composes rocks such as granite, migmatites, basic and ultra-basic rocks. Generally the region is categorized as a plain with an elevation of 200m above sea level. The study area is characterized by cuesta topography, plateaus, rolling plains, scarp slopes, conical and isolated hills of discontinuous resistant beds where Guinea savannah vegetation occurs. The region is drained by networks of rivers and streams among which is dominated by the Cross River, Anambra-Manu and the Imo River system. The Cross River basin takes its rise from the Mbu Head water Cameroon at an elevation of about 2,236 meters above sea level to its mouth in the Calabar river estuary in the Bight of Biafra and a total stretch/length of about 540kilometers. Within the eastern states, the Cross River tributaries are River Afi, Okpaoko, Konshishe and the Ombi-Npode-Oiyona. South-Eastern Nigeria has a remarkable diversity of vegetation formations (Igbozurike, 1975). The region has maritime stretches, at one end, where the sandy monotony is occasionally broken by the humblest of bushes, or where the scene is one of an intimate partnership of hardy trees and putrid water. The other end has segments of space with plenty of grass that a cursory inspection may mislead one into regarding the area as having a gramineous climax. The dominant vegetal community, however, remains the tropical rainforest. Though no typical case of montane vegetation is strictly found in South-Eastern Nigeria signs of it can be traced at the top of Obudu Plateau. The population of Igbo land stated here is an accumulation of the five (5) States namely Abia, Anambra, Ebonyi, Enugu, and Imo States only. The total population is about 40 million with the population density of 400km^2 (1,000/sq mi), with highest elevation of 1,000m (3,300ft) and lowest elevation of 0m (0ft) (NPC, 2015). The region is largely agrarian and there is thus much dependence on land resources, due to its dense population averaged to about 1000 people/km^2. The acquisition of high tension powerline data in the study area was done using the global positioning system (Etrex instrument), GIS. The GPS was used to acquire the coordinate’s location of the high tension right of way. The GIS software and the image analysis over the study area was enable the determination of the level of encroachment, displacement extent of environmental resource and land cover displacement and the conformity to stipulated distances from the right of way (ROW). Global positioning system (GPS) was also used to collect the actual position of the high tension lines and map the power distribution line across the study area. The landsat imagery of 2022 obtained from the United States Geological Survey was used to generate the landuse/land cover of the study area. The study made use of the near real time data of Moderate Resolution Imaging Spectroradiometer (MODIS) Terra and Aqua Normalized Difference Vegetation Index (NDVI) of 16 Day L3 Global 250m resolution downloaded from https://earthexplorer.usgs.gov. NDVI imagery of 2022 was considered for the study. The soil nutrient imagery (af250m_nutrient_n_m_agg30cm) downloaded from https://maps.isric.org/mapserv?map=/map/af250m_nutrient.map was used to determine the soil nutrient levels of the study locations. The imagery was clipped to only Alaoji-Onitsha 330 kV SC Transmission line project by using the boundary shapefile of South Eastern Nigeria.

Thereafter, the set back of 30 m and 50 m, from the transmission line were used to extract values of soil nutrient within each of the buffers. Buffering analysis on the powerline corridor was used to analyse the spatial distribution and conformity of development and infrastructure across the study area in relation to required standard. Zonal statistics were used to extract the minimum, maximum and mean soil nutrient and vegetation health at the 30 m, 50 m and the entire study area. Descriptive statistics was used to explain the percentage of the frequency trend.

Results and Discussions

The landuse/land cover analysis around the study area is displayed in Figure 2 and Table 1. It is discovered that agriculture/cropland had 727.62 sq km (26.60%), degraded forest had 623.90 sq km (22.80%), forest/plantation had 287.98 sq km (10.53%), swamp forest/riparian had 323.16 sq km (11.81%), savanna had 238.68 sq km (8.72%), settlement had 512.83 sq km (18.75%) and water bodies had 21.64 sq km (0.79%). The higher landuse/land cover is agriculture/cropland, degraded forest and settlements. The potential effects of landuse/land cover analysis around 30m ROW of the existing and new 330 kV transmission line is displayed in Table 2 and Figure 3 whereby it is known that agriculture/cropland covered 0.21 sq km (9.01%), degraded forest covered 0.17 sq km (7.30%), forest/plantation covered 0.07 sq km (3%), savannah covered 0.17 sq km (7.30%), settlements covered 0.59 sq km (25.32%) while waterbodies covered 1.1 sq km (47.21%). In this analysis, it is observed that settlements and waterbodies are the land use types that are more impacting around 30m ROW of the 330 kV transmission line. Similarly, the level of landuse impacting the 330 kV at 50m ROW whereby agriculture/cropland had 0.35 sq km (6.32%), degraded forest 0.29 sq km (5.23%), forest/plantation 0.12 sq km (2.17%), swamp forest/riparian had 0.05 sq km (0.90%), savannah had 0.29 sq km 95.23%), settlements had 2.61 sq km (47.11%), and waterbodies having 1.83 sq km (33.03%). It is observed that settlements took the highest. The analysis has revealed that much impact is being caused by agriculture, degraded forest, and settlements. These are the main human activities that could bring about the opening up the ROW of the 330 kV because the more the people settling down around the location, the first thing to be thought of can be agriculture and they will likely prefer places that are less dense in terms of vegetation.

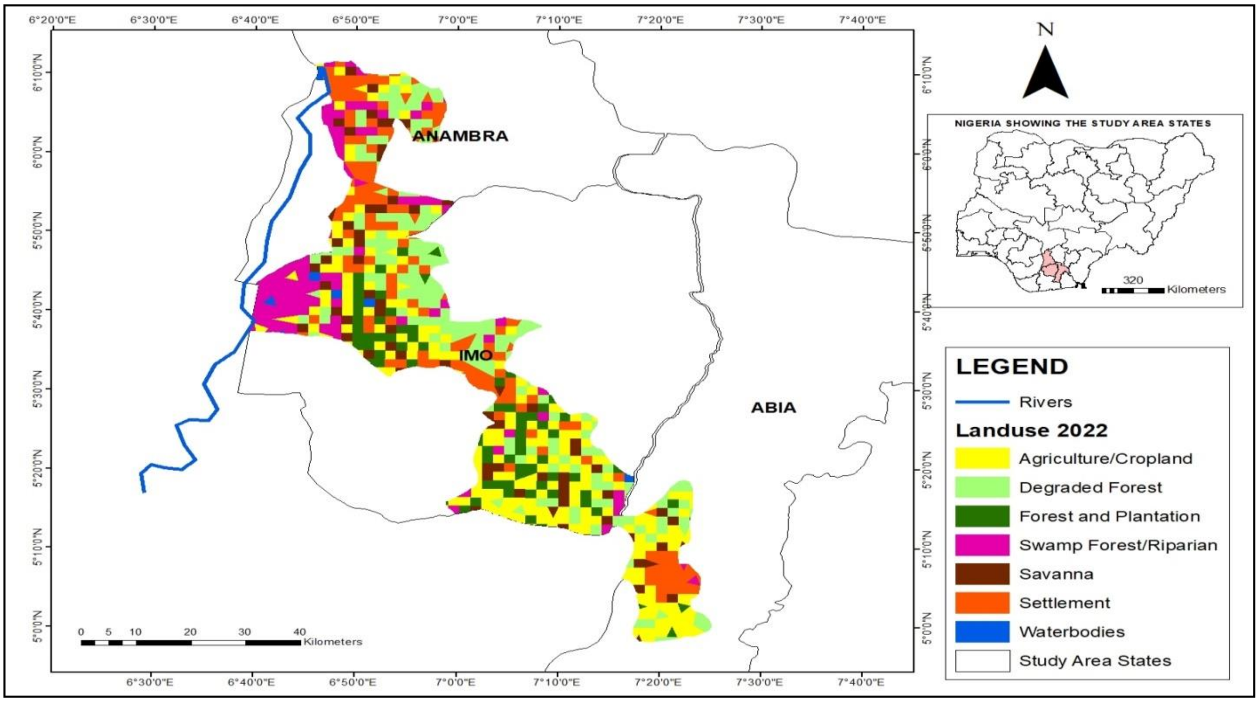

Figure 2: Landuse/Land cover of the Study Area

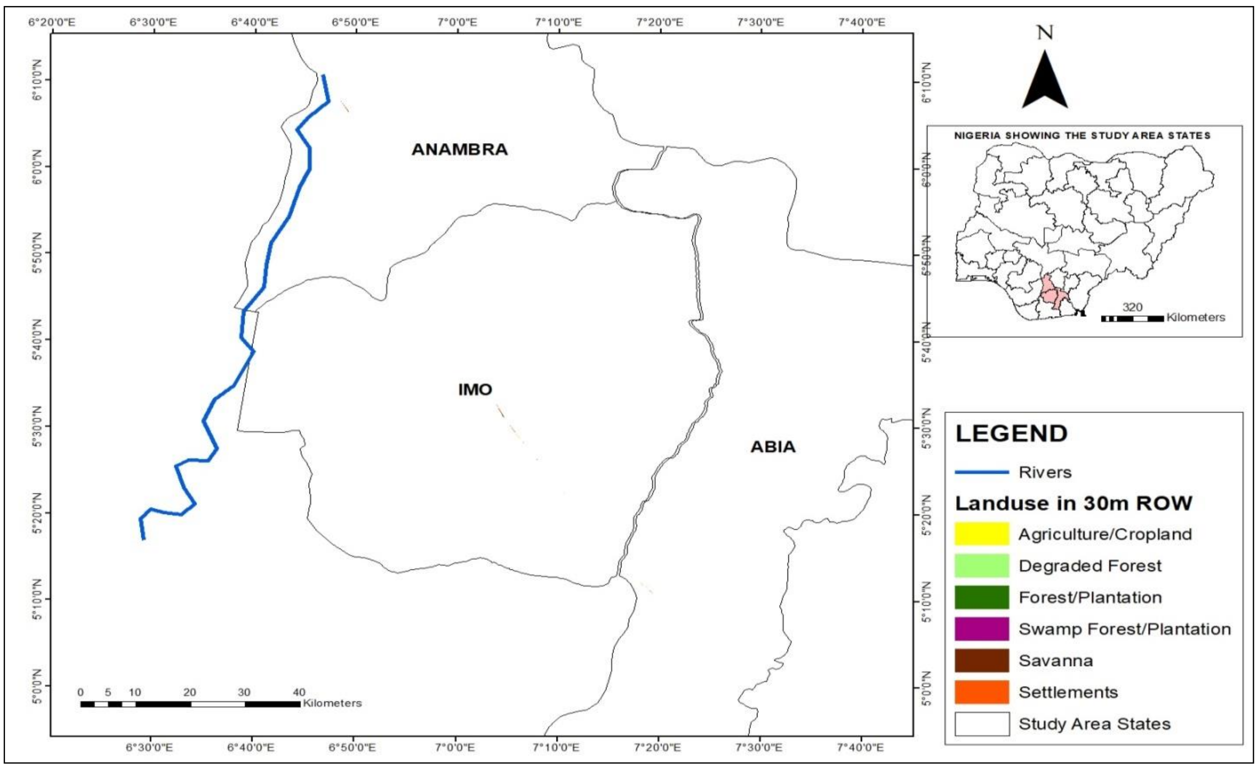

Figure 3: Landuse/Land cover in 30 m

Figure 4: Landuse/Land cover in 50 m

Table 1: Landuse/Land cover of the Study Area

Landuse/Land cover	Spatial Extent (sq. km)	Percentage (%)
Agriculture/Cropland	727.62	26.60
Degraded Forest	623.9	22.80
Forest/Plantation	287.98	10.53
Swamp Forest/Riparian	323.16	11.81
Savanna	238.68	8.72
Settlements	512.83	18.75
Waterbodies	21.64	0.79
Total	2735.81	100.00

Table 2: Landuse/Land cover at 30 m and 50 m ROW

Landuse/Land cover at 30 m ROW	Spatial Extent (sq. km)	Percentage (%)
Agriculture/Cropland	0.21	9.01
Degraded Forest	0.17	7.30
Forest/Plantation	0.07	3.00
Swamp Forest/Riparian	0.02	0.86
Savanna	0.17	7.30
Settlements	0.59	25.32
Waterbodies	1.1	47.21
Total	2.33	100.00
Landuse/Land cover at 50 m ROW	Spatial Extent (sq. km)	Percentage (%)
Agriculture/Cropland	0.35	6.32
Degraded Forest	0.29	5.23
Forest/Plantation	0.12	2.17
Swamp Forest/Riparian	0.05	0.90
Savanna	0.29	5.23
Settlements	2.61	47.11
Waterbodies	1.83	33.03
Total	5.54	100.00

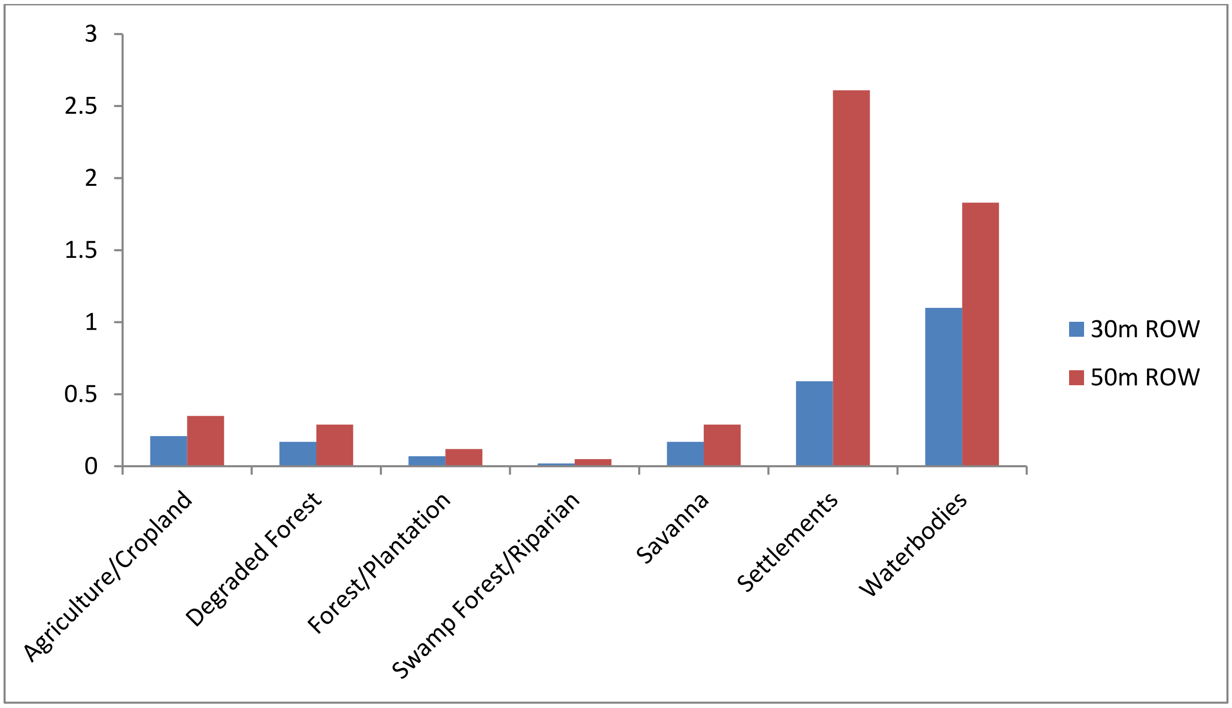

Figure 5: Comparison of the Level of Interference of the Landuse at 30 m and 50 m ROW of the 330 kV Transmission Line

Soil Nutrient

The soil nutrient analysis around the study area is displayed in Figure 6 and Table 3. It is discovered that soil nutrient of the entire study area ranged from 767 mg/kg to 2374 mg/kg with a mean value of 1253.79 mg/kg. The potential effect of nutrient around 30m ROW of the existing and new 330 kV transmission line is displayed in Figure 7 and Table 3 whereby it is discovered that soil nutrient that will be affected ranged between 896 mg/kg and 1495 mg/kg and the mean value of soil nutrient was 1109.51 mg/kg. Similarly, the potential effect of the 330 kV around 50m ROW ranged from 896 mg/kg to 1495 mg/kg with a mean value of 1237.05 mg/kg (Figure 8, Table 3). It is thus found that the soil nutrient reduced with decreasing distance from the ROW which means that the residents may prefer practising their agricultural activities around the 50 m ROW.

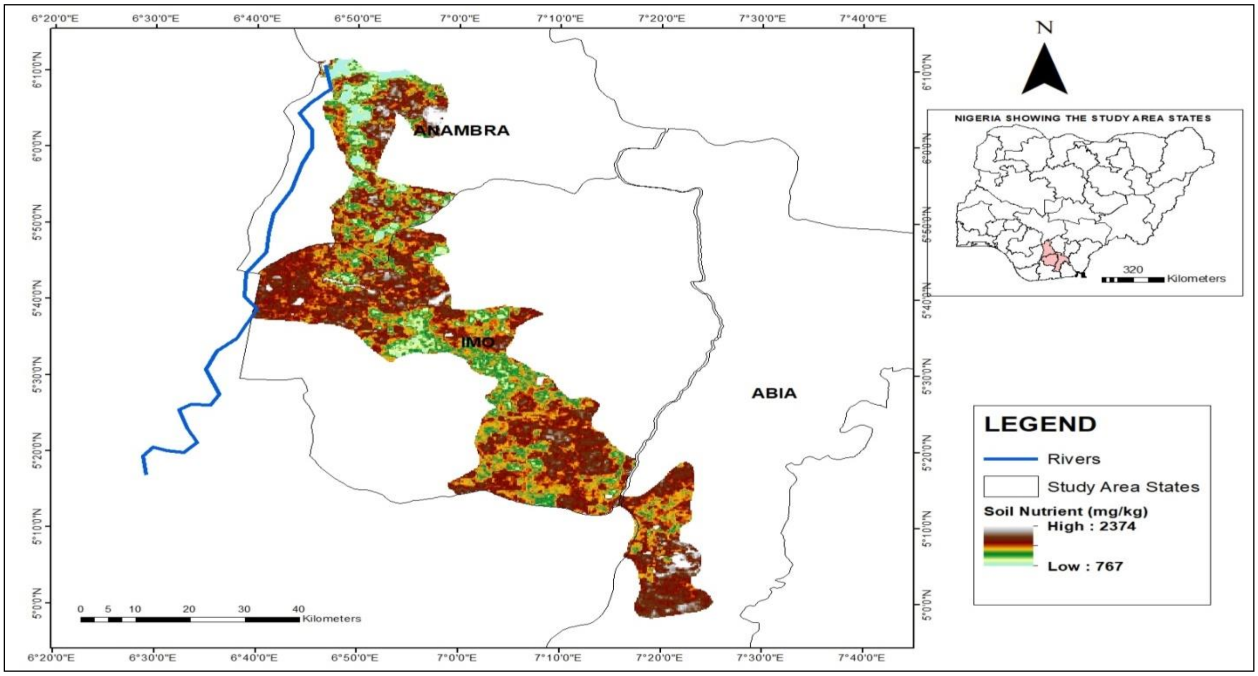

Figure 6: Soil Nutrient in the Study Area

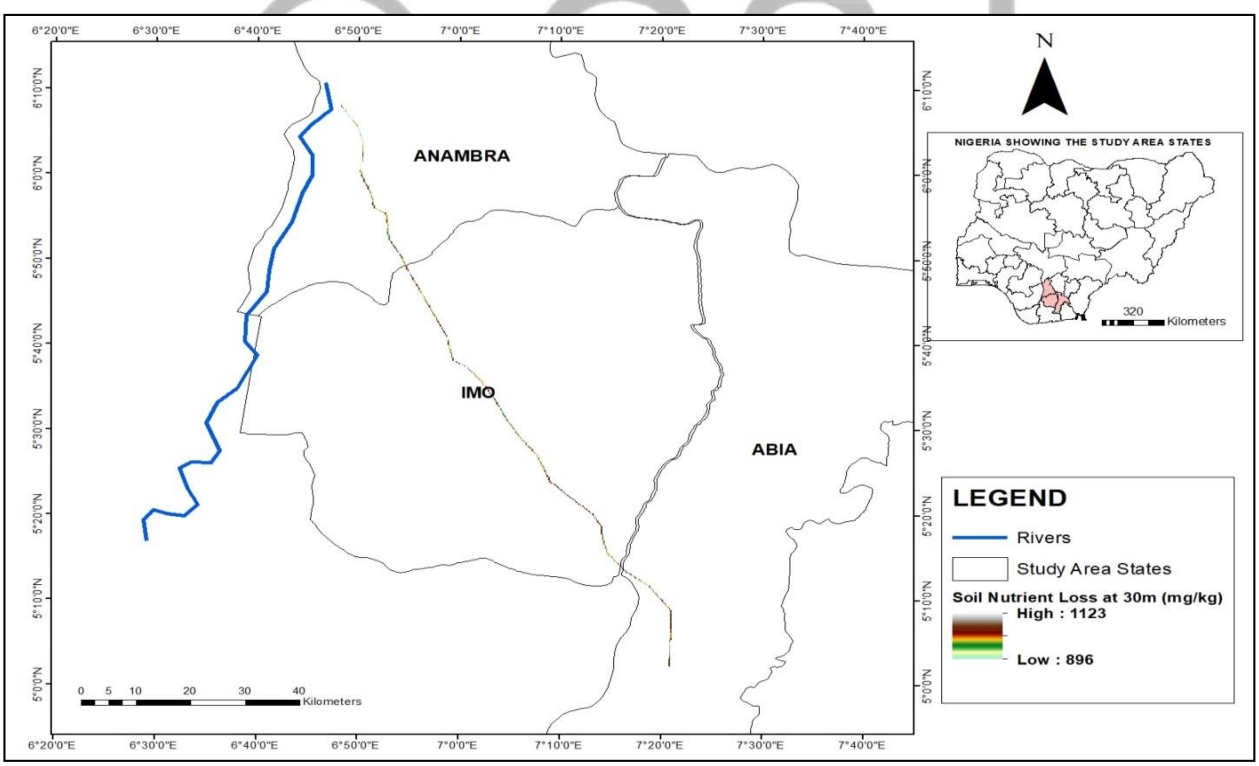

Figure 7: Soil Nutrient impact at the 30m ROW from the Powerline

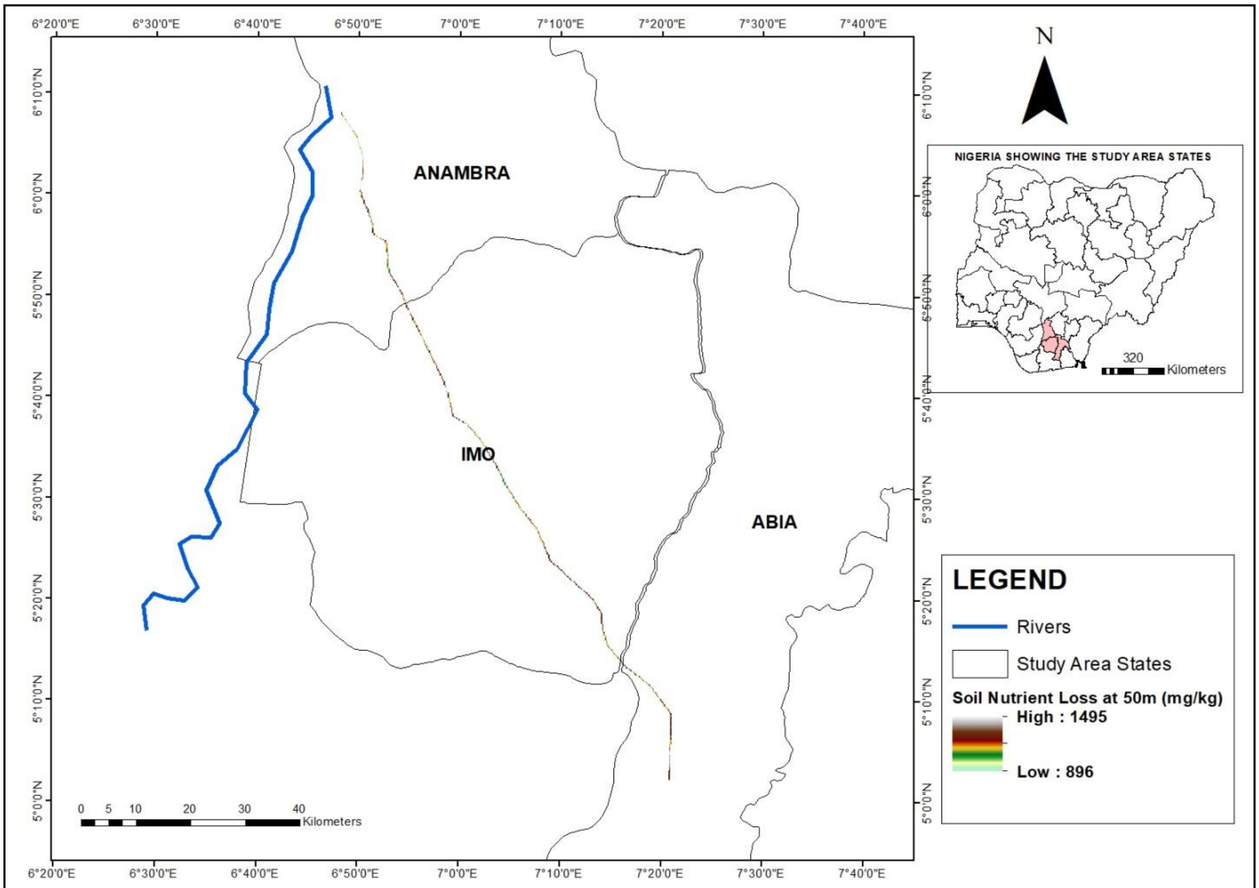

Figure 8: Soil Nutrient impact at the 50m ROW from the Powerline

Table 3: Zonal Statistics of Soil Nutrient at 30m, 50m and entire Study Area

Soil Nutrient	Minimum	Maximum	Mean	SD
Soil Nutrient at 30 m	896	1123	1109.51	0.01
Soil Nutrient at 50 m	896	1495	1237.05	0.02
Soil Nutrient in the Entire Study Area	767	2374	1253.79	0.01

Vegetation Health

The vegetation health around the study area is displayed in Figure 9 and Table 4. It is discovered that the vegetation health of the entire study area ranged from -0.1999 to 0.7160 with a mean value of 0.5144. The potential effect of vegetation health around 30 m ROW of the existing and new 330 kV transmission line is displayed in Figure 10 and Table 4 whereby it is shown that vegetation health that will be affected ranged between 0.1640 and 0.4817 and the mean value of vegetation health was 0.3629. Similarly, the potential effect of the 330 kV around 50 m ROW on the vegetation health ranged from 0.1730 to 0.6829 with a mean value of 0.4788 (Figure 11, Table 4).

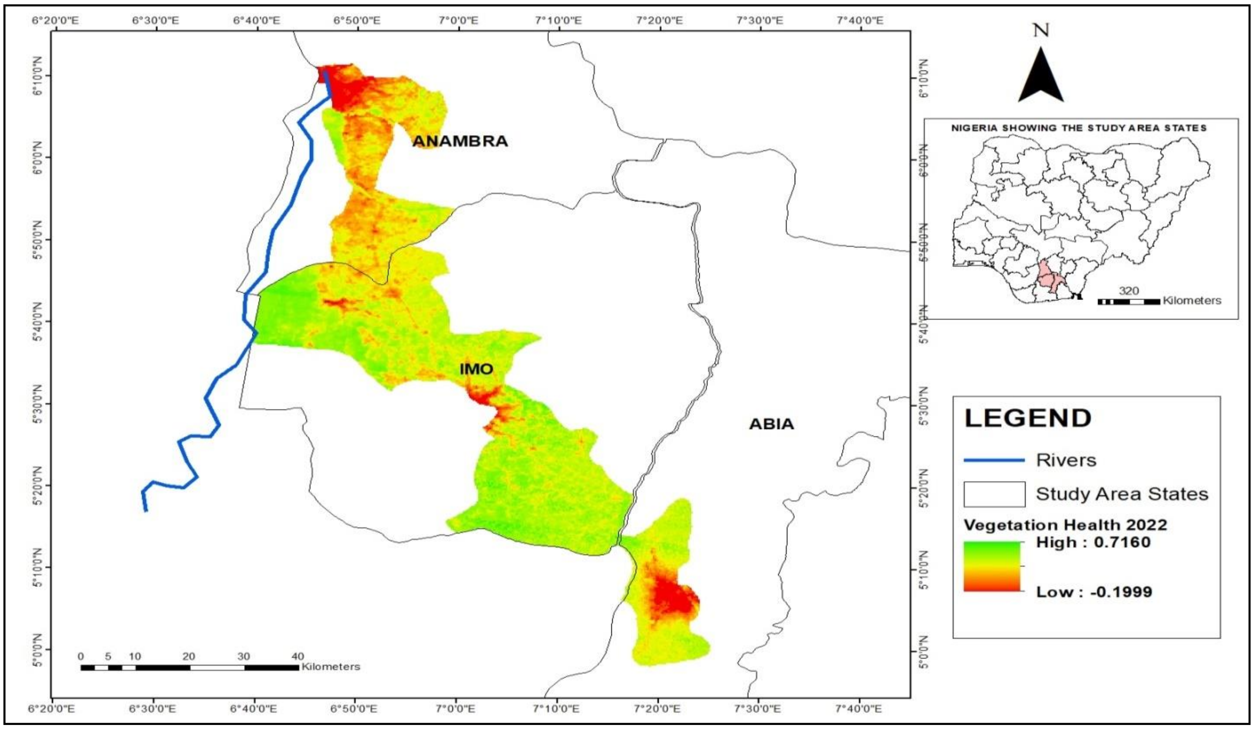

Figure 9: Vegetation Health of the Entire Study Area

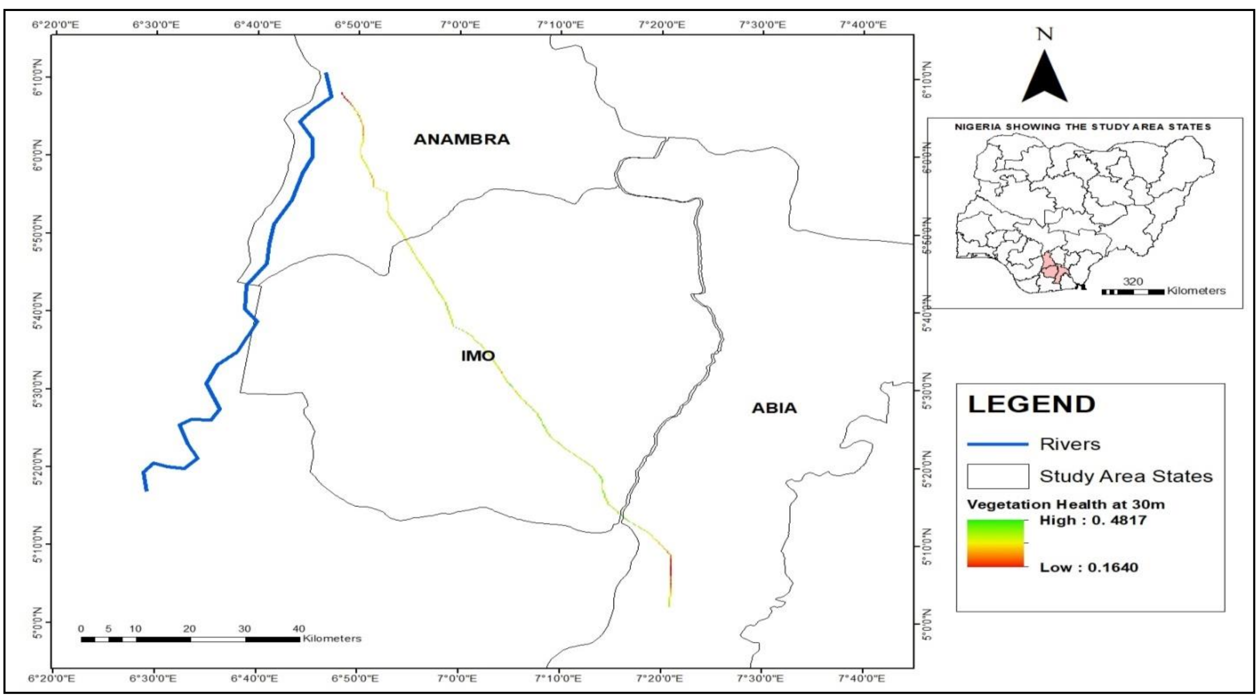

Figure 10: Vegetation Health at the 30m ROW

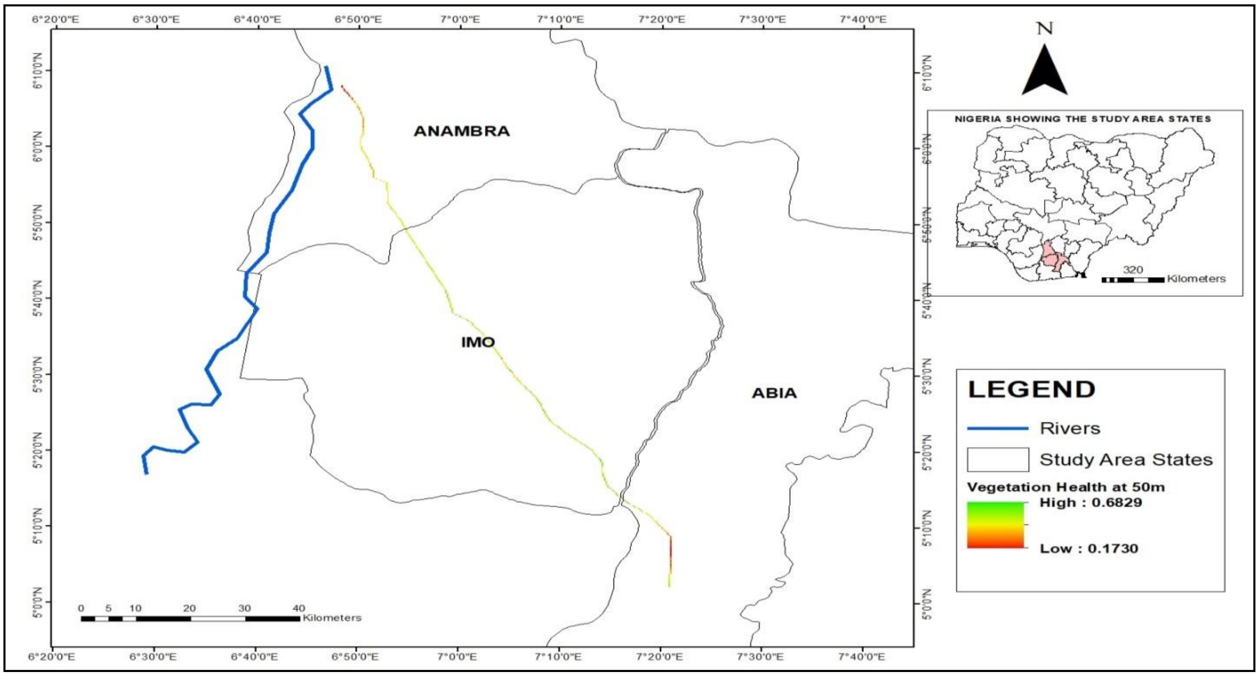

Figure 11: Vegetation Health at the 50 m ROW

Table 4: Zonal Statistics of Vegetation Health at 30 m, 50 m and Entire Study Area

Vegetation Health	Minimum	Maximum	Mean	SD
Vegetation Health at 30 m ROW	0.1640	0.4817	0.3629	0.01
Vegetation Health at 50 m ROW	0.1730	0.6829	0.4788	0.10
Vegetation Health in the Entire Study Area	-0.1999	0.7160	0.5144	0.09

Discussion of Findings

Considering the impact from the landuse, it is found out that most of the impact is being caused by agriculture, degraded forest, and settlements. These are the main human activities that could bring about the opening up the ROW of the 330 kV because the more the people settling down around the location, the first thing to be thought of can be agriculture and they will likely prefer places that are less dense in terms of vegetation. The increase in the built up area could be attributed to the fact that people troop into this place due to possible easy way land acquisition method and low income economy that might have ravaged the lives of the residents staying there. The decrease in the thick vegetation is an indication that the local climate of the study area may be endangered more. This land cover supposed to serve many environmental functions like regulation of flood and temperature of a particular place. This function may remain hindered if there is no corrective measure to be put in place. It is found that the soil nutrient reduced with decreasing distance from the ROW which means that the residents may prefer practising their agricultural activities around the 50 m ROW. Porosity, void ratio, and dry density are soil parameters that can indicate relative changes in soil void system (compactness or degree of compaction). Changes in soil porosity, void ratio, and dry density caused by vehicle traffic on agricultural lands can affect crop yield. Previous research has indicated that increasing soil density -- with concurrent decreases in soil porosity and void space ratios -- can limit crop root growth and restrict transport of nutrients and water. This may result in lower crop yields (Nawaz et al, 2013).The effect of a new transmission line on an area may depend on the topography, land cover, and existing land uses. In forested areas for example, the entire right-of-way (ROW) width is cleared and maintained free of tall-growing trees for the life of the transmission line. The result is a permanent change to the ROW land cover. In agricultural areas, heavy construction vehicles traverse the ROW and temporarily suspend the use of the land for crop production. After construction ends and the fields are properly restored however, the land beneath the line can be cropped or pastured. For this reason, the area permanently affected by the line is usually much smaller than the area temporarily affected during construction. Where transmission lines are routed through areas that are valued for their scenic qualities, the visual impacts of the line (the area affected) may extend well beyond the ROW (Public Service Commission of Wisconsin, 2006). The construction of a transmission line involves both long-term and temporary impacts. Long-term impacts can exist as long as the line is in place and include land use restrictions, loss of woodland, and aesthetic impacts. Temporary impacts occur during construction or at infrequent intervals such as during line repair or ROW maintenance. They can include noise or crop damage during construction. Short-term impacts can become long-term impacts if not properly managed or mitigated. It may be possible to lessen or mitigate potential environmental, landowner, and community impacts by adjusting the proposed route, choosing a different type of pole structure, using different construction methods, or implementing any number of post-construction practices. Corridor-sharing with an existing utility may require some modification to the proposed transmission structures resulting in additional costs to the project. For example, corridor sharing with a railroad may require the installation of underground communication circuits for the railroad. Sharing a corridor with a gas pipeline may require the installation of cathodic protection to prevent (Martinez and Andrade, 2008).

The potential effect of transmission lines is also felt on vegetation health of the study area which must have caused habitat fragmentation and changes in the vegetation richness and diversity. This is in support of the two concepts associated with the long-term presence of transmission line rights-of-way in wildlife habitat: edge effect and habitat fragmentation. While the mixture of habitats created by rights-of-way can allow greater density and diversity of wildlife to be present, transmission lines may also produce a negative edge effect for some species which require large, undisturbed habitat. Rights-of-way can create an edge effect, which refers to the border between different types of habitat and it is regarded as an important component of wildlife habitat. Vegetation composition changes in the newly created edge because plant species that do well in high light conditions become more widespread and abundant while interior species not accustomed to higher light intensity are eliminated. Changes to habitat composition will also change habitat quality for plants and animals which can have a positive, negative or neutral effect depending on the species (Manitoba Hydro, 2003).

Habitat fragmentation refers to plant communities that have become divided or isolated. Individual transmission line projects may fragment the landscape by dividing large blocks of forested habitat into smaller blocks which can result in a decline in species within the remaining forests. The northern spotted owl is one example of a raptor dependant on old growth forest that is negatively affected by fragmentation. Woodland caribou, which require large tracts of relatively undisturbed habitat may also be negatively affected by any habitat fragmentation effects caused by transmission line rights-of-way (Brown et al., 2003).

Following regrowth, habitats in power line ROW can also create novel habitats for forest ungulates through the provision of attractive feeding opportunities (Ricard and Doucet, 1999; Hydro-Québec, 2013). White-tailed deer deposited more pellet groups, foraged more intensely and left more signs in power line ROW as compared to forests adjacent to ROW or control forest (Cavanagh et al., 1976). The ROW provided more stems for browsing. Black-tailed deer (Odocoileus hemionus columbianus) used a power line ROW significantly more than adjacent mature forest, indicated by pellet groups (Loft and Menke, 1984). Deer use increased with shrub and herbaceous cover as well as foraging plants. These results indicate that food availability in power line ROW habitat is important for the use of that habitat by forest ungulates Not only the amount of forage, but also its composition may influence the use of power line ROW for browsing (Milligan and Koricheva, 2013). Moose and white-tailed deer browsing intensity in power line ROW appeared to be influenced by the proportion of preferred browse species rather than browse availability (Garant et al., 1987; Ricard and Doucet, 1999). Trees that have been cut in power line ROW could provide higher quality browse because they prioritize growth instead of defence against herbivore damage through secondary metabolites (Rea and Gillingham, 2001). However, the increased availability of light in power line ROW clearings may promote both growth and defence (Nybakken et al., 2013). Herbs in a power line ROW provided higher concentrations of protein and minerals and contained less fiber as compared to woody browse (Bramble and Byrnes, 1972). Forbs in power line ROW contained more protein and minerals as compared to grasses and woody browse (Harlow et al., 1995). The quality of the forage can be expected to influence the attractiveness of power line ROW habitat for forest ungulates.

Disturbance by power lines may not only affect the use of areas directly under power lines but also habitats adjacent to it. Power lines contributed to a reduction in area use of wild female reindeer within 1 km from pitfall traps and hunting blinds (Panzacchi et al., 2013). The density of semi-domesticated reindeer was significantly (73%) lower within 4 km of a power line (132 kV) than further away during calving in areas of rugged terrain (Vistnes and Nellemann, 2001). However, more favourable snow conditions and lower predation rates at higher elevations further away from power lines may have influenced this result (Reimers and Colman, 2009). Wild reindeer were significantly less abundant than expected within 2.5 km of power lines (300 and 420 kV) in six of eight sampling years (Nellemann et al., 2001). Areas transected by power lines (66 - 420 kV) were also used less than expected (Vistnes et al., 2001). However, the accessibility of lichen forage, provided by an index of snow depth and hardness, was approximately three times lower in areas transected by power lines and other infrastructure (Vistnes et al., 2001). The influence of forage accessibility, although not significantly different between areas, can be discussed Wild reindeer became less abundant within 4 km from power lines (300 and 420 kV) or roads after they were built and more abundant beyond this distance (Nellemann et al., 2003). However, the shift in abundance coincides with the flooding of an area close to power lines and roads following the construction of a dam (Nellemann et al., 2003). According to Uzodinma (2020), the indicators considered in the environmental impact assessment of the transmission line included air quality, noise level, soil and geology, surface and groundwater, vegetation and land use. The impact significance of the indicators revealed that most of the indicators impact is medium except for land use that was high. The residual impact of the indicators revealed that air quality, soil and geology had minor residual impacts, noise level and surface and groundwater have negligible residual impact while biodiversity and land use had medium residual impacts.

Conclusion and Recommendations

The study concluded that the potential effect of the acquisition of the right of way on soil nutrient, landuse and vegetation health increased with increasing distance from the transmission line. It is therefore recommended that periodic study is very essential to checkmate the extent of violation of the defaulters and to discover the activities going on in the reserved setback for the transmission lines. In addition, there should be close monitoring at the ROW of Alaoji-Onitsha 330 kV transmission lines by government to reduce the extent at which the lands are being acquired or occupied at the ROW of the transmission line.

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