EPOCHAL ASSESSMENT AND PREDICTION OF ENCROACHMENT TRENDS ON POWER LINE RIGHT-OF-WAY IN PARTS OF RIVERS STATE, NIGERIA

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Abstract: This study is on epochal assessment and prediction of trends in urban expansion on power line Right of Way (ROW) in parts of Rivers State, Nigeria. The ROW under study stretches from Choba, through Alakahia, Rumuosi, Rumuekini, Rumuagholu to Rukpoku communities of Obio/Akpor Local Government Area of Rivers State of Nigeria. This research work was carried out using ground truth survey and remote sensing techniques. Coordinates of Electric Power Pylons position of the study area were obtained from the Department of Surveying and Geomatics, Rivers State University, Nkporlu Oroworukwo, Port Harcourt. Ground coordinates of some identifiable points on the satellite imageries of the study area were obtained with the use of Garmin 78s Global Positioning System receiver and was used to geo-reference the satellite images for three epochs of 2008, 2013 and 2018 respectively using Arc-GIS 10.1 software and ground positions of the Electric Power Pylon were obtained by vectorization. Thereafter, ROW buffer of 30 meters were created and buildings and undeveloped parcels within buffer zone were clearly identified and digitized, shape length and shape area of built-up for each epoch was computed. Empirical analysis shows that the total number of 86, 268, and 498 buildings were on buffer zone for epochs of 2008, 2014 and 2020 respectively making them vulnerable to the hazards of high voltage electric incidents. The research findings revealed that the total length and area of ROW under study for 30m buffer are 13km, 76.84ha respectively. A total built-up area of 1.38ha, 5.94ha and 12.47ha were recorded for epoch of 2008, 2014 and 2020 respectively with a corresponding percentage encroachment of 1.79%, 7.72% and 16.23%. Linear regression model for trend estimation in times series was used to predict the amount of encroachments for a period of 30 years. A predicted area of 17.59ha, 23.09ha, 28.59ha, 34.09, and 39.59 will be encroached by built-up in the year 2026, 2032, 2038, 2044 and 2050 for ROW buffer of 30m if no action is taking by relevant authorities to forestall further encroachments. The ground truth survey also shows that there is persistence building encroachment and business activities in all directions of the ROW. The study recommends immediate removal of structures on the Power line ROW.

Keywords: Epochal, Encroachment, Prediction, Pylon.

1. Introduction

Electricity is vital for activities of modern day societies. To secure uninterrupted distribution of electricity, effective monitoring and maintenance of power line Right of ways (ROWs) are need. The importance of this topic is increasing daily with the societies increasing dependence on electricity, increasing occurrence of extreme weather conditions, such as storms, and tightening legislation, regulations and ROW laws in many communities including Nigeria (Fabricio, Tulio & Yuri, 2014). Electricity networks typically include a nationwide transmission network, regional networks and distribution networks. The National Power Transmission Grid line covers approximately 6,690km that is composed of 330kv and 132kva lines across the country. Right of Way (ROW) is a legal right of a person, group, or government to pass over another's territory, rights, by grant or long usage: the part or road used by this right. ROW encroachment occurs when an individual unlawfully or illegally trespasses; intrudes on another's territory, rights without their consent, it is a conflict of between adjacent property owner's cause by unlawful violation of property lines. The continuous building and erecting of structures on the national grid ROW by land developers that are ignorant of the dangers has in recent time become an issue of concern as most development and business activities are directly on the power lines and Vulnerable to the incident of Power line damage (oyinloye, oladosu & Olamiju, 2017.

The National Electrical Code (NEC) mandates acceptable clearances for power lines to keep the public safe and prevent contact with electrical shock.

Table 1.0: Recommended and Acceptable ROW

S/N	VOLTAGE	TYPE OF POWER LINE	HEIGHT OF POWER LINE	RECOMMENDED ROW
1.	0 – 150 volts	Low tension	10 meters	6 meters (Horizontal)
2.	300 – 600 volts	High tension sub transmission line	12 meters	8 meters (Horizontal)
3.	11KV	High Tension (Commercial areas)	15 m	30 meters (Horizontal)
4.	33 KV	Power High Tension Transmission line	15m	30 meters (Horizontal)
5.	132 KV	National Grid	30m	60meters (Horizontal)
6.	330KV	National grid	30meters	100meters (Horizontal)

Source: Electric power sector reform Act, No. 6 of 2005 of Federal Republic of Nigeria

Many land developers are ignorant of the stipulated ROW on the National Grid as recommend by the National Electric Code (NEC) and electric power sector reform act, No 6, of 2005 of Nigeria.

Area of Study

The area of study is a section of 30m horizontal distance ROW from the center line of the Nigeria Electricity Transmission Grid which streches from Choba, through Alakahia, Rumuekini, Rumuosi, Rumuagholu, Rukpoku to Eliozu communities of Obio/Akpor Local Government Area, Rivers State, Nigeria. It is situated between projected coordinates of (P1. 541951.085m.N, 268215.891m.E) to (P42. 540277.057m.N, 279689.481m.E) in WGS 84 UTM Zone 32N coordinate system. The total distance of the right-of-way under study is 13km with an approximate enclosed ROW area of 76.84ha. The Power line ROW is undergoing massive development and business activities in all directions which prompted the study.

Figure. 1.0: Aerial View of the Study Area

Statement of the Research Problem

City growth, rapid urban development and increasing land use changes due to increasing population and economic growth is being witnessed in Port Harcourt and much of this growth is unplanned and unregulated ((Nnah, Owei & Ikpoki, 2007). Presently, there is increased urban expansion, infrastructural development and business activities in all directions of the electricity grid lines in parts of Rivers State. Many structures are erected almost at the centre of the Power Transmission grid by illegal occupants and developers who are ignorant of the dangers and consequences associated with such act.

Power line ROWs are supposed to be intact, maintained, monitor and free from all kind of encroachments in rural and urban areas across the states of Nigeria, but the reverse is the case as shown in plate 2.1, 2.2, 2.3, and 2.4 respectively, many structures are erected almost at the center of Power line ROWs across various States in Nigeria

with developments and business activities in all directions, however, these encroachments may be as a result of many factors including Government inability to maintain and monitor these ROWs as well as enforcing ROW laws. Incidentally, Nigeria presently has laws that have become inimical to easy acquisition of ROW by land and property owners. These include, the Land use Act 1978, oil pipeline act 1990, the petroleum Act cap350 of 1990 and the 1999 Nigerian constitution [Section 44] as amended, just to mention a few. The quest for excellence and to be abreast to globally accepted best practices in the acquisition of ROW for public and private sector projects informed a group of Nigerian professionals to come together where they gave birth to the International Right-Of-Way Association, [IRWA] (Anthony, 2016).

Figure 1.1: Building directly under high-tension wire at Ore, Ondo State.

Source: The Punch Newspaper (11 April, 2019),

Figure 1.2: Market activities under high-tension wire on Kayode Street, Lagos.

Source: The Punch Newspaper (11 April, 2019).

Figure1.3: Residential building under high-tension wire on Gaskiya Road, Lagos State

Source: The Punch Newspaper (11 April, 2019),

Aim of the Study

The aim of the study is to assess in epochs and predict encroachments trends for period of 30years.

Objectives of the Study

1. Digitization of built-ups within approved 30m buffer ROW for each epoch.
2. Determination of the rate, percentage and direction of encroachments.
3. Prediction of trends of encroachment for period of 30years using least square method of trends estimation in times series.

Significance of the Study

The study will examine the causes, direction and amount of building encroachments on the Power line under study. It will also awaken government and relevant professional bodies to be proactive as to commence public enlightenment campaign on the dangers of erecting buildings on Power line ROW.

Scope of the Study

The study is limited to epoch based assessment and prediction of building encroachment on Power line ROW in parts of Rivers State, Nigeria.

2. Materials and Methods

The research materials include;

Data sets: the data sets acquired were from Landsat imageries of Rivers State for 2008, 2014 and 2020 with spatial resolution of 30m x 30m. These satellite images were chosen because of its high resolution content, availability as at the time of this research and its capacity to provide the expected results of the research.

The instruments and equipments used were Garmin 76CSx GPS receiver; 50m standardized steel tape, field book, casio fx 991 scientific calculator, etc.

Software/hardware used includes Hp Laptop computer with processor Intel® Core (TM2) Duo CPU P9700, 4.00GB RAM, and 64-bits operating system. ENVI 5.0, ESRI's ArcGIS 10.1 (Arbi and Florjan, 2014) – vector based GIS software.

The choice of ArcGIS 10.1 was based on the ability to support vector analysis. ENVI 5.0 was be used to perform image classification.

Research Methodology

The remote sensing techniques was adopted to achieve the aim of the study using stated objectives, this techniques is a non-contact classical surveying method that is used to observed and measure the characteristics of objects on the earth surface, it is fast, reliable and cost effective

Research Method

The research methods includes

Data Acquisition

Topographic map of the study area with Coordinates of Electric Power Pylon along the ROW obtained from Department Surveying and Geomatics, Rivers State University, Nkporlu Oroworukwo, Port Harcourt, Rivers State. Ground truthing was carried out on the study area. Ground coordinates of six identifiable points on aerial image and coordinates of other power pylon in the ROW of the study area were obtained with the use of Garmin 78s GPS

Receiver. The collection of ground-truth data will enable geo-referencing and calibration of remote sensing data, and aids in the interpretation and analysis of what is being sensed. Coordinates of power pylon were used to vectorize and locate the positions of power pylon on the aerial image.

Table 2.1 Spatial Information of Power line Pylon

S/N	Bearings	Horizontal distances(m)	ΔE (m)	ΔN (m)	Easthings (m)	Northings (m)
p1.	o ‘ “				268215.891	541951.085
p2.	136 50 10	324.97	222.31	-237.03	26843.197	541714.053
p3.	135 47 32	322.69	225.00	-231.31	268663.20	541482.74
p4.	135 16 17	323.77	227.92	-229.96	268891.122	541252.981
p5.	127 23 05	298.30	237.03	-181.12	269128.147	541071.862
p6.	126 19 04	313.99	253.00	-185.97	269381.150	540885.892
p7.	125 42 20	306.87	249.19	-179.10	269630.339	540706.794
p8.	102 08 03	319.69	312.54	-67.24	269942.877	540639.551
p9.	66 52 39	338.86	311.61	133.12	270254.491	540772.673
p10.	59 01 00	337.92	289.68	174.00	270544.173	540946.673
p11.	60 47 17	294.86	257.36	143.90	270801.532	541090.576
p12.	57 28 33	322.35	271.80	173.31	271073.328	541263.890
p13.	54 04 27	348.73	282.39	204.61	271355.721	541468.502
p14.	57 56 29	310.85	263.45	165.00	271619.170	541633.497
p15.	99 27 23	332.54	328.02	-54.64	271947.194	541578.86
p16.	98 09 44	316.28	313.08	-44.91	272260.269	541533.955
p17.	99 22 17	333.61	329.16	-54.32	272589.430	541479.631
p18.	100 17 26	326.43	321.18	-58.31	272910.606	541421.318
p19.	96 29 40	330.26	328.15	-37.36	273238.751	541383.963
p20.	103 08 27	330.69	322.03	-75.18	273560.780	541308.782
p21.	96 05 59	312.96	311.19	-33.14	273871.971	541275.644
p22.	102 35 28	302.42	295.15	-65.93	274312.821	541209.717
p23.	94 03 24	310.34	309.56	-21.34	274476.682	541188.380
p24.	94 04 14	323.37	322.55	-22.96	274799.233	541165.425
p25.	95 22 16	325.44	324.01	-30.46	275123.823	541134.961
p26.	92 25 25	329.88	329.59	-13.95	275453.413	541121.011
p27.	91 49 26	332.09	331.92	-10.57	275785.333	541110.440
p28.	92 26 56	322.39	322.09	-13.78	276174.276	541096.664
p29.	88 03 34	302.03	301.86	10.23	276476.133	541106.891
p30.	86 43 58	298.84	298.35	17.03	276774.485	541123.922
p31.	87 26 43	299.13	298.84	13.33	277066.479	541137.256
p32.	87 44 22	313.90	313.65	12.38	277380.131	541149.638
p33.	78 43 54	299.15	293.38	58.45	277673.410	541208.092
p34.	91 35 32	307.31	307.19	-8.54	277980.597	541199.553
p35.	108 06 37	300.26	285.38	-93.34	278265.981	541106.217
p36.	105 55 47	297.73	286.30	-81.71	278552.273	541024.503
p37.	91 47 59	291.61	291.47	-9.16	278843.741	541015.344
p38.	81 33 06	304.03	300.73	44.67	279144.472	541060.011
p39.	86 49 50	316.42	315.93	17.50	279460.404	541077.506
p40.	131 25 15	277.15	207.82	-183.36	279668.227	540894.150
p41.	176 45 15	284.39	16.10	-283.93	279684.328	540610.224
p42.	179 06 49	333.19	5.15	-333.15	279689.481	540277.075

The spatial information of the Power line Pylons in table 2.1 was computed using basic surveying principles. If we have two AB points in a straight line whose coordinates (Northings and Easthings) are known, the distance and direction can be computed as follows;

Azimuth of AB (θ) = $\tan^{-1}\Delta N/\Delta E$

$$L = \sqrt{(\Delta N^2 + \Delta E^2)} \quad \ldots 2.0$$

Where ;

θ = Bearing of the line AB
L = Horizontal Distance of line AB
ΔN = Change in Northing
ΔE = Change in Easting
N_A = Northing coordinate of point A
N_B = Northing coordinate of point B
E_A = Easting coordinate of point A
E_B= Easting coordinate of point B

Electric Pylon Information: The base of each electric pylon in the ROW as measured in the study during ground truthing was 5m x 5m which gives an area of 25 square meters covered for each pylon, therefore; the total area covered by the forty two electric pylon base in the study area is 1050 square meters. The height of the power pylons is 30 meters and the horizontal distance between the power pylon varies from approximately 300 meters to 350 meters.

Geo-Referencing: The Satellite images were geo-referenced in WGS-84 datum, UTM, ZONE, 32N, to orient the satellite imagery based on its arbitrary state to correspond with the true ground positions, focusing its proper stages to correct the tilt in the relative co-ordinates on the map which is due to the altitude, motion, focal length and relief of the terrain.

Buffer Analysis: In assessing the level of encroachment of the electricity grid, buffer analysis operation was used to determine approved right-of-way from built-up areas. Buffer analysis was performed using approved standard Power line ROW of 30m for 132kva capacity as requirement for the safety of the general public living within the ROW. Buffer analysis was performed from the Analyst Tools in ArcGIS 10.1 software. During the processes of buffer analysis, proximity was clicked in the 3D Analyst Tools, and buffer was double clicked; In the display dialogue box, input features national grid) was selected, output file name was typed and buffer distance of (30m) was specified after which Ok was clicked to generate buffer zone at specified distance. A sample of what buffer means is shown in figure 2.1.

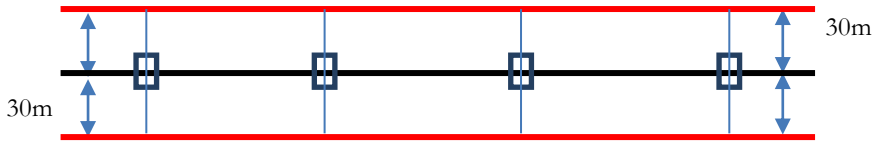

Figure 2.1: Sample of National grid ROW in the study area

Digitization

The process of on-screen digitization started by creating what is like an act of Map production via the use of polygons to form Interior areas which consist of the continuous space within three or more connected lines that form a closed loop from the existing map. On-screen digitizing is the process of creating a map while an existing vector map is displayed as a background in the map window. All buildings, and undeveloped fenced parcels within ROW buffer zone were identified and digitized, thereafter; shape length, shape area, and coordinates of buildings for each epoch were determined using the line and polygon tool, these aided in determining the rate and percentage encroachment for each epoch.

Determination of Rate, Percentage and Directions of Encroachments per epoch

Rate of encroachment

The shape areas of digitized features for each epoch were sum up to determine the rate of encroachment; the polygon tool was used to trace each building and to compute the enclosed area for 30m buffer ROW.
Total area encroached = $\{A_{B1} + A_{B2} + A_{B3} + \ldots\ldots\ldots\ldots A_{Bn}\}$ …2.1
Where A_B = Area covered by buildings on the ROW.

Percentage of building encroached per epoch: this was determined using the formular;

% Area of encroachment per epoch = $\frac{Ye}{YA} x \frac{100}{1}$…2.2
Where YA = Area of 30m ROW under study and Ye= Total area encroached per epoch.

Direction of Encroachment

Since surveying is aim at determining the positions of points on the earth surface by measuring distances and directions of lines, it was necessary to determine the direction of building encroachment in the study area using remotely sensed data. The concept the whole circle bearing and the quadrant system were adopted in determining the direction of Building encroachment. The whole circle bearing is the magnetic bearing of a line measured clockwise from the North Pole towards the line, such bearing may have any value between 0° 360°. The quadrant system consists of four quadrants, each representing the four direction of the earth (Basak, 2004).

In determining the direction of building encroachment for 2018 epoch, the 2018 Landsat satellite image of the study area was divided into for equal quadrant, the direction of encroachments was determined by identifying the quadrant that has more encroachments.

Data Analysis

Table 2.2: Empirical analysis of Encroachment by built-up for epochs of 2008, 2014, & 2020

Year	No. of built-up encroached On Power line ROW	Length(km) / Area(ha) of 30m ROW	Area (ha) encroached
2008	86	13km - 76.84ha	1.38
2014	268	13km - 76.84ha	5.93
2020	498	13km - 76.84ha	12.47

Mean Deviation: M.D = $\frac{\Sigma/X_i - \bar{X}/}{N}$…2.3

$\bar{X} = \frac{1.38+5.93+12.47}{3} = \frac{19.78}{3} = 6.59$

$$M.D = \frac{/1.38 - 6.59/ + /5.93 - 6.59/ + /12.47 - 6.59/}{3}$$

$= \frac{11.53}{3} = 3.92$

Variance:

$\sigma^2 = \frac{\Sigma}{i=1} \frac{(X_i - \bar{X})^2}{n}$ …2.4

Where σ^2 is the population variance,
$/x_i - \bar{X}/$is the absolute value of the deviation of X_i from $\bar{X}$
N is the population size.

$\sigma^2 = \frac{(11.53)^2}{3} = \frac{132.94}{3} = 44.31$

Standard Deviation (S.D) is square root of the variance.

$\therefore$ S.D = $\sqrt{S^2} = \sqrt{\frac{\Sigma(X_i - \bar{X})^2}{n}}$ …2.5

S.D = $\sqrt{44.31}$ = 6.65

PREDICTION OF TRENDS IN TIME SERIES

Time series is a set of observations made at different periods of time, this observation is usually in epochs, annual population, monthly rainfall, daily stock price, etc. The nature of time series is such that it varies with time; and this knowledge enables us to know about the and present, and to predict the future which is very necessary for planning . (Ogam, 2000; Gupta, 2012).

There are two methods of predicting trends in time series, namely; the moving average method and the least square method, hence; the least square method was adopted in this research.

Table 2.3: Computed area (ha) encroached in three epochs for 30m Buffer Row

Year	2008	2014	2020
Area(ha)	1.38	5.93	12.47

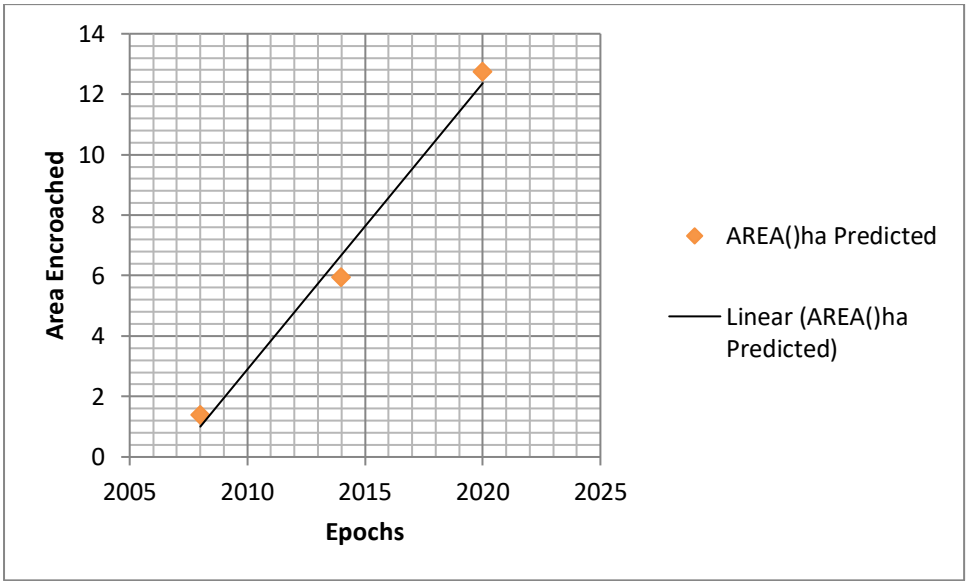

Figure 2.2: Graphical representation of observed data for three epochs

Figure 2.2 shows a linear graphical representation of the observed data, hence; linear regression model for trend prediction in time series will be adopted to predict encroachment trends for period of 30years to minimize the different between the observed data points and data points predicted by the regression equation.

Prediction of encroachments trends

The linear regression model Yt = a + bx was adopted for predicting encroachments trends in time series. The model is a least square method of trend estimation in time series commonly used for calculating a regression equation. The method minimizes the difference between the observed data points and data points predicted by the regression equation. The trend equation Yt = a + bx is the arithmetic straight line representing the series in time t. (Ogam, 2000; Gupta, 2012).

Recall that ; Yt = a + bx …2.6

Where, Yt = the computed trend,
a = the trend value at the origin,
b = the amount of change in trend value per time unit and

x = the independent variable time
To determine the value of the constant a and b, the following normal equation is to be solved;
$\Sigma y = Na + b\Sigma x$ …2.6.1
$\Sigma xy = a\Sigma x + b\Sigma x^2$ …2.6.2

When deviations are taking from the middle period, so that $\Sigma x = 0$, the value of a and b becomes;
$a = \frac{\Sigma y}{N} =$ …2.6.3
$b = \frac{\Sigma yx}{\Sigma x^2}$ …2.6.4

The least square equation Yt = a+bx was used to estimate the trends of encroachments for period of 30years as follows:

Choosing 2014 the middle period as origin, we have;

Table 2.4: Computed values of Constants for x and y variables

Year	x	y	Yx	x^2
2008	-1	1.38	-1.38	-1
2014	0	5.93	0	0
2020	1	12.47	12.47	1

Recall that; $b = \frac{\Sigma yx}{\Sigma x^2} = \frac{11.09}{2} = 5.5$
$a = \frac{\Sigma y}{N} = \frac{19.78}{3} = 6.59$
For 2026, x =2 and the estimated values are:
$\bar{Y}$ = 6.59 + 5.5(2) = 17.593ha
For 2032, x = 3 and the estimate values are:
$\bar{Y}$ = 6.59 + 5.5 (3) = 23.093ha
For 2038, x = 4 and the estimate values are:
$\bar{Y}$= 6.593+5.5(4) = 28.593ha
For 2044, x = 5 and the estimate values are:
$\bar{Y}$= 6.593+5.5(5) = 34.093ha
For 2050, x = 6 and the estimate values are:
$\bar{Y}$= 6.593+5.5(6) = 39.593.ha

3. Results and Discussion

Figure 3.1: Building identified in a section of 30m Power line ROW. Source: Landsat(5) 2008 imagery

Figure 3.2: Building encroached on Power line ROW for 2014 epoch. Source: Landsat(5) 2014 imagery

Result of rate of Building Encroachment per epoch.

Table 3.1: Area of ROW encroachments by built-up computed in Hectares

BUFFER ZONE	AREA OF ROW(ha)	2008	2014	2020
Encroachment at 30m	**76.84**	1.38ha	5.93ha	12.47ha

Result of percentage of ROW encroachment by built-up per epoch

Table 3.2: Encroachment Rate of ROW by built-up computed in Hectares for 30m buffer

YEAR	AREA OF 30m BUFFER ROW (ha)	TOTAL AREA ENCROACHED PER YEAR	PERCENTAGE ENCROACHMENT
2008	76.84	1.38ha	1.79%
2014	76.84	5.93ha	7.72%
2020	76.84	12.49ha	16.23%
Area of ROW not encroached		64.37	83.77%
		Total =	100%

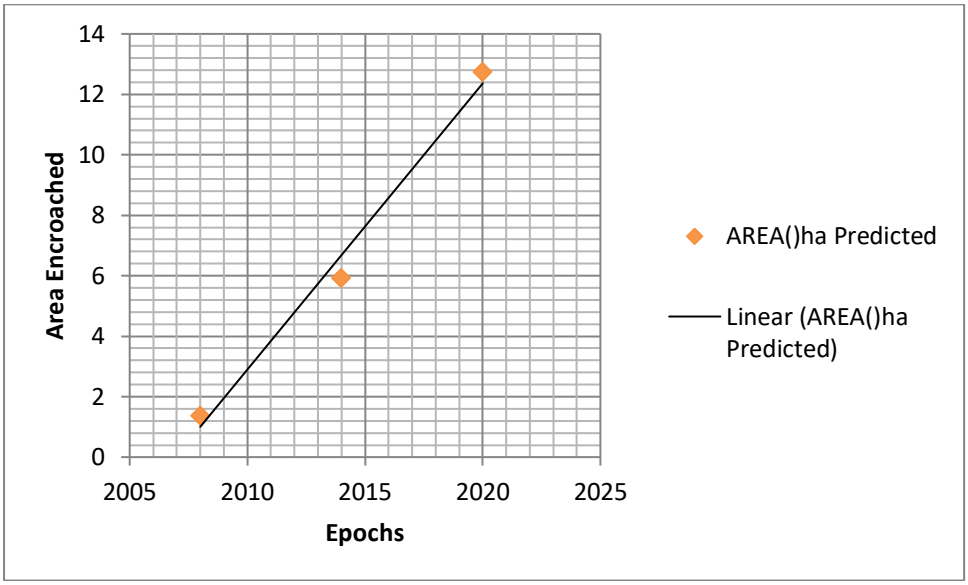

Figure 3.3: Graphical Representation of Built-up of Encroached for each epoch

Result for Prediction of encroachment trend in time series for 30years.

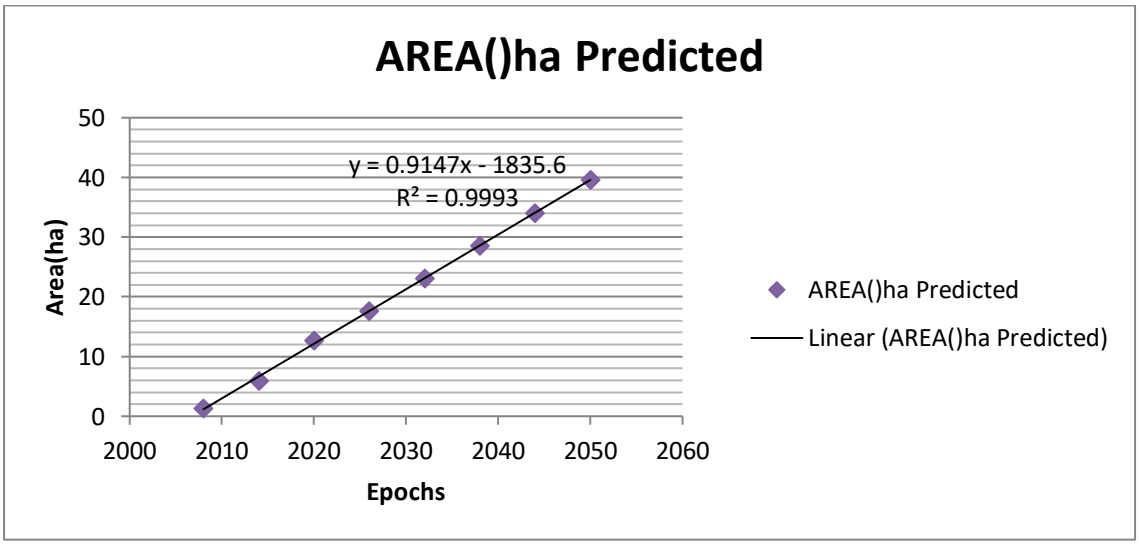

Figure 3.4: Predicted encroachment trend for a period of 30 years

Research Findings and Discussions

The result presented above has proved the justification and necessity of this research work. The rate and percentage of building encroachment is relatively high. The year 2020 Landsat (5) aerial imagery of the study area shows a high and alarming building encroachment. The total area of ROW under study 30m buffer was 76.84ha, as shown in tables 4.1, A total built-up area of 1.38ha, 5.94ha and 12.47ha were recorded in 2008, 2014 and 2020 epochs respectively with a percentage encroachment of 1.79%, 7.72% and 16.23% for 2008, 2014, and 2020 epochs. The model in figure 4.5 shows that a predicted area of 17.59ha, 23.09ha & 28.59ha will be covered by built –up in the year 2026, 2032 & 2038, 2044 and 2050 if nothing is done to forestall further urban expansion on the Power line in the study area. It was also note that the encroachment is more severe on the south east direction which has more urbanized communities like Rukpoku, Rumuagholu, Eliozu and Rumuekini Towns. The low urbanized communities in the North West direction such as Mgbuitanwo and Auu has little built-up incroachments.

4. Conclusion

Remotely sensed data offers an alternative and precise measurement of object characteristics on the earth's surface and provides a more synoptic view to remote Terrain. Conclusively, the obtained satellite imageries data sets were effectively utilized to obtain the results of the research objectives. The ground truth data greatly assisted in identifying points and features on the aerial image such as junction, roads, building, etc, before digitizing which greatly enhanced the research findings. Further epoch based encroachment assessment studies in the study area and other Nigeria electricity grid line in Rivers State and Country in general is recommended to validate the results obtained from this study. Government should also partner with relevant professional bodies relevant government agencies, Community Leaders, etc, to educate the public on the allowable ROW in the national grid and the dangers associated with encroaching on it and pay compensation as recommended by ROW acquisition laws of the Federation.

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