Original Research Article

Analysis andPrediction of Path Loss for Mobile Communication Lines in Nasarawa State Using Propagation Models

ABSTRACT

The design of future-generation mobile communication systems depends critically on the path loss prediction methods and their suitability to various signal propagation regions. In this study, path loss prediction for the key telecommunication networks in Nasarawa State, Nigeria was carried out using signal strength info app for 4G networks. Analysis of path loss using empirical models such as Hata, Egli, and COST-231 Hata models were compared with the measured path loss in different terrains including urban, sub-urban, and non-urban environments. The Root Mean Square Error (RMSE) analysis was carried out between empirical and measured path losses. Results shows that, the order of average predicted path loss at 5km was free space model (BN>CN>DN.AN), Hata model (DN>BN>CN>AN), Cos-231 Hata model (CN>AN>BN>DN), and Egli model (AN>BN>DN>CN). Hate model predicted the highest path loss values while Egli model predicted the lowest values. Overall, Egli model is found to be the most reliable and suitable path loss prediction model for entire Nasarawa State with RMSE value 5.99dBm, 2.90dBm and 3.14dBm for Nasarawa, Keffi and Akwanga LGA respectively. However, Cost-231 Hata model with RMSE value of 5.71dBm is suitable for path loss prediction in Karu due to its irregular terrain. The findings underscore the importance of refining existing models to enhance network planning and optimization. An accurate prediction of path loss is useful for predicting coverage areas of base stations, frequency allocation and determination of signal strength for optimal network performance.

Keywords: Path loss, 4G network, propagation models, mobile communication, RMSE analysis.

1. INTRODUCTION

Communication is the actionable transfer of information or message from one person, group, or place to another by writing, speaking, or using a medium that provides a means of understanding [1]. Wireless communication can be defined as the process of transmitting and receiving data wirelessly from a transmitter to a receiver [2]. According to Akanniet al.[3] wireless communication is one of the oldest forms of communication which have been evident in ancient Nigerian societies where traditional rulers uses town criers to relay messages from the palace to their communities and in the way these communities coordinated their armies in battle. Today, wireless communication plays a crucial role in the modern world due to its convenience and flexibility with over 14.2 billion users worldwide and the number of users is expected to grow significantly by 2026 [4]. According to Thomsonet al.[5], wireless communication research has become a rapidly expanding field due to its diverse applications in various sectors. Since the digital revolution in the early 1990s, devices such as Personal Digital Assistants (PDAs) and mobile phones have become widespread across different regions, including remote areas, mountainous terrains, and dense forests [6].

However, mobile phone signals can be obstructed by physical barriers like mountains or large buildings, leading to communication interruptions. To enhance communication in such situations, it is essential to assess the empirical path loss for improve signal quality [7]. According to Mawjoud[8], calculating the path loss during signal transmission using various empirical models is vital for determination of received signal strength.Patrick [9] pointed out that the development of 4G mobile communications was driven by the demand for innovative services like high-speed web browsing, email, instant messaging, video conferencing, digital television, high-definition video streaming, file transfers, and gaming. In 4G environments, improving video and audio quality requires the analysis of path loss using empirical models such as Hata, Egli, and COST-231 Hata models [10].Mawjoud*et al.*[8] further explained that when data is transmitted, the electromagnetic wave experiences a gradual loss in power density, known as path loss, as it travels from the source to the receiver. Path loss occurs due to energy conservation and geometric factors, which are affected by reflection, refraction, diffraction, and scattering. This gradual loss in signal power poses a challenge for network providers. For cellular networks to effectively cover a specific area, accurate prediction of radio frequency signal coverage is crucial [11].

Wave propagation models are essential tools for determining propagation characteristics in a given environment. Path loss prediction is vital for designing GSM networks, and accurate propagation models are estimated at specific locations. Many countries, including the United States, United Kingdom, China, and Japan, have collected their own propagation data for various cities and towns [8]. However, for the case of Nigeria, no much work has been done in this area as there are no documented propagation data for various cities and towns in Nigeria. The current study focuses on measuring empirical path loss at selected locations in Nasarawa State using the Network Signal Info software to assess the performance of four key telecommunication networks. The study aims to identify the most suitable, reliable, and accurate propagation model for predicting path loss in different environments within Nasarawa State. The study also employs Root Mean Square Error (RMSE) to determine path loss with minimal error.

2. MATERIALS AND METHODS

2.1 Materials

The main materials used for this research are mobile cellular phones (Infinix Note 4 and Infinix X693 LTE/5G Compliant), Subscribers Identification Modules (SIMs),HP ProBook 6550b Version Laptop (computer) and network signal info Application.

2.2 Methods

2.2.1 Research Design

The study employed a cross-sectional design method and used cluster and purposive sampling technique to randomly sample the base station antenna for all mobile networks that have network coverage in Nasarwa State. The collected data was analyzed using statistical methods, with a focus to determine the mean signal strength for each network in each LGA.

2.2.2 Description of the Study Area

Nasarawa State is located in the North-Central region of Nigeria and is known for its diverse terrain, including plains, mountains, and forests. The state has a population of over 2 million people and is served by multiple telecommunications operators including Airtel-AN, MTN-BN, Glo-CN, and 9Mobile-DN. Most of the houses in Nasarawa State are below 30 meters and an average road width of about 35 meters. Attenuation is caused by multiple reflections, absorption and multiple diffractions off roof tops, trees, cars etc. The concrete ground and tarred roads have very relative poor electrical conductivity, and therefore, cause attenuation by absorption. Ground reflected waves are blocked by buildings and trees.

2.2.3 In Situ Measurements

Network Signal Info software with embedded google map was installed in an Infinix Note 4 phone and used to obtain the received signal strength (RSS) from fixed base stations (BST) at selected locations. Ensuring that their cell Identifying Digits (CID) codes matched those on the maps. Readings were taken at 1 km intervals chosen because, theoretically, it is the largest radius of a cell in a cellular network. The study was conducted in three propagation environments such as non-urban terrains (Akwanga LGA), sub-urban terrains (Nasarawa LGA), urban terrains (Karu LGA, Lafia LGA and Keffi LGA) across the State.

2.2.4 Determination of Measured Path-Loss

The measured signal strength was converted to path loss following the work of John [12] as follows:

$$PL_{Measured} = \text{EIRP} - P_r \quad (1)$$

where EIRP is the effective isotropic radiated power (dBm) and P_r is the Received Power (dBm). According to Nwaokoro *et al.*[13] the EIRP is given as:

$$\text{EIRP} = P_{Out} - \text{RL} + G_t \quad (2)$$

whereP_{Out} is the transmitter power output in (dBm), RL is the Signal loss in cable (dBm), $G_t$is the Gain of the antenna (dBm).

$$\text{RL} = 20\log_{10}\frac{VSWR\ +1}{VSWR-1}\text{dBm} \quad (3)$$

where VSWR is the voltage standing wave ratio.

2.2.5 Determination of Empirical Path Loss

The empirical path loss was determined using four different path loss models including free space model, Hata model, COST – 231 Hata model, and Egli model.

Path Loss using Free - Space Model: According to Nwankwere[14], the free-space path-loss can be expressed as:

$$P_L(Free - Space) = 32.5 + 20\log_{10}(d) + 20\log_{10}(f) \quad (4)$$

where f is the carrier frequency in MHz and d is the distance between the mobile and base stations in km.

Path Loss using Hata Model: Following the works ofAgim [15], the HataModel is given as:

$$P_L(Hata) = 69.55 + 26.16\log_{10} f - 13.82\log_{10} h_b - a(h_m) + (44.9 - 6.55\log_{10} h_b)\log_{10} d \quad (5)$$

where P_l (Hata) (dB) is the medium value of the path, h_b is height of the base station antenna, $h_m$is height of the Mobile station antenna, f is transmitter frequency (MHz) and d is distance between the base and mobile stations (Km)

Path Loss using Cost 231 Hata Model: According to Ndukwe [16], path-loss using the Cost 231 Hata Model, can be expressed as:

$$P_L(Cost\ 231\ Hata) = 46.3 + 33.9\log_{10} f - 13.82\log_{10} h_b - a(h_m) + [44.9 - 6.55\log_{10} h_b] \times \log_{10} d + C \quad (6)$$

where P_l (Cost 231 Hata) (dB) is the medium value of the path, h_b is height of the base station antenna, $h_m$is height of the Mobile station antenna, f is transmitter frequency Unit Megahertz (MHz), d is distance between the base and mobile stations (Km) and C is the Clutter correction factor.

Path Loss using Egli Model: The Egli model as defined by Muhammed[17]is given as:

$$P_L(Egli) = 40\log_{10}(d) - 20\log_{10}(h_b) - 20\log_{10}(h_m) - 10\log_{10}\beta \quad (7a)$$

$$\beta = \left\{\frac{40}{f}\right\}^2 \quad (7b)$$

where P_l (Egli) (dB) is the medium value of the path, h_b is height of the base station antenna, $h_m$is the height of the Mobile station antenna, f is the transmitter frequency Unit Megahertz (MHz) and d is the distance between the base and mobile stations (Km).

2.2.6 Regression Analysis

The measured path losses were subjected to regression analysis to obtain path loss models for each of the selected terrains and path loss model for the entire study area. According toUshie[18] the line of regression of Y on X is given as:

$$Y = a + a_0X \quad (8)$$

Therefore, the path loss model for each of the selected locations can be analyzed followingthe works of Mawjoud[8] as follows:

$$P_L = a + a_0X_{BM} + C \quad (9)$$

where

$$a_0 = \frac{N\sum X\,Y - \sum XY}{N\sum X^2 - (\sum XY)^2} \quad (10)$$

$$a = \frac{\sum Y}{N} - a_0\sum\frac{X}{N} \quad (11)$$

$Where\ P_L$is the path loss, $X_{BM}$is the distance between the base and mobile stations and C is correction factor for the environment.

2.2.7 Root Mean Square Error(RMSE)

The root mean square error (RMSE) was used to compares the measured data with the data obtained from the propagation models to determine the minimum RMSEused to pick an empirical path loss model suitable for Nasarawa State. According to Alumona andKelvin [19] the minimum value of Root mean square error (RMSE) for good signal propagation is approximately not greater than 6dBm. Therefore, 6dBmis suitable for path loss prediction for the area of consideration. According toSharma [20] the root mean square error is expressed as:

$$RSM = \sqrt{\frac{(P_{lm} - P_{lp})^2}{n}} \quad (12)$$

3. RESULTS

The result of transmitter parameter which includes base station antenna height (h_t) (m), the standard transmit power P_t (dB),frequency (MHz), antenna gain (dBm), VSWR, signal loss in cable (dB), and clutter correction factor (C) (dB) were measured and presented in Table 1. Also, the result of the mean received signal strength measured at distance 1.0Km, 2.0Km, 3.0Km, 4.0Km, and 5.0Km across each terrain are presented in Table 2.

Table 1: Transmitter parameters for Nasarawa State

		Transmitter Parameters				
Network	**Features**	**Nasarawa**	**Karu**	**Lafia**	**Keffi**	**Akwanga**
AN	Transmission Power (dBm)	32.00	52.00	33.00	32.00	32.00
	BTS Height (m)	35.00	40.00	35.00	35.00	40.00
	Frequency (MHz)	957.50	1857.30	900.00	1762.30	900.00
	Antenna Gain (dBm)	17.50	17.50	17.50	17.50	17.50
	VSWR	1.50	1.60	1.50	1.50	2.00
	Signal loss in cable (dB)	5.10	8.08	6.08	6.18	8.08
	Clutter correction factor (C) (dB)	0.00dB	3.00dB	3.00dB	3.00dB	0.00dB
BN	Transmission Power (dBm)	34.00	20.00	34.00	34.00	34.00
	BTS Height (m)	35.00	40.00	35.00	35.00	40.00
	Frequency (MHz)	952.50	1842.50	2347.00	1842.50	2100.00
	Antenna Gain (dBm)	17.50	17.50	17.50	17.50	17.50
	VSWR	1.50	1.60	1.50	1.50	2.00
	Signal loss in cable (dB)	5.00	8.00	6.00	6.90	8.00
	Clutter correction factor (C)	0.00dB	3.00dB	3dB	3dB	0dB
CN	Transmission Power (dBm)	33.00	33.00	33.00	33.00	33.00
	BTS Height (m)	35.00	40.00	35.00	35.00	40.00
	Frequency (MHz)	947.50	1829.90	2327.00	1734.90	1800.00
	Antenna Gain (dBm)	17.50	17.50	17.50	17.50	17.50
	VSWR	1.50	1.60	1.50	1.50	2.00
	Signal loss in cable (dB)	5.04	8.04	6.00	6.55	8.04
	Clutter correction factor (C)	0.00dB	3.00dB	3dB	3dB	0dB
DN	Transmission Power (dBm)	20.00	32.00	25.00	32.00	34.00
	BTS Height (m)	35.00	40.00	35.00	35.00	40.00
	Frequency (MHz)	927.50	1857.30	2100.00	900.00	2300.00
	Antenna Gain (dBm)	17.50	17.50	17.50	17.50	17.50
	VSWR	1.50	1.60	1.50	1.50	2.00
	Signal loss in cable (dB)	5.54	8.00	6.00	6.10	8.00
	Clutter correction factor (C)	0.00dB	3.00dB	3dB	3dB	0dB

Table 2: Mean received signal strength for Nasarawa State

		Mean RSS (dBm)				
Network	**Dist. (Km)**	**Nasarawa**	**Karu**	**Lafia**	**Keffi**	**Akwanga**
AN	1.00	-77.13	-84.50	-78.75	-85.38	-83.00
	2.00	-77.38	-84.00	-81.38	-86.63	-86.29
	3.00	-79.63	-87.67	-87.25	-89.50	-86.57
	4.00	-83.00	-95.00	-88.75	-89.13	-93.57
	5.00	-85.25	-102.50	-95.00	-96.00	-95.57
BN	1.00	-80.63	-76.83	-78.75	-84.13	-84.43

	2.00	-82.50	-84.83	-81.38	-87.00	-86.71
	3.00	-86.75	-88.00	-87.25	-89.38	-86.29
	4.00	-85.75	-88.83	-88.75	-89.38	-92.57
	5.00	-91.38	-94.66	-95.00	-95.63	-95.43
CN	1.00	-80.13	-83.50	-77.50	-81.50	-83.86
	2.00	-84.50	-86.33	-79.00	-85.38	-84.71
	3.00	-87.75	-90.00	-80.63	-88.75	-84.71
	4.00	-93.38	-96.33	-83.00	-89.38	-87.71
	5.00	-98.75	-103.00	-88.00	-93.13	-88.00
DN	1.00	-88.00	-87.16	-88.75	-86.38	-85.14
	2.00	-90.00	-91.33	-88.88	-93.75	-88.43
	3.00	-95.50	-95.16	-100.40	-101.30	-92.71
	4.00	-103.88	-102.80	-103.50	-106.80	-97.42
	5.00	-105.63	-105.50	-108.10	-111.90	-100.00

Table 3: Mean measured path loss for Nasarawa State

		Mean Measured Path Loss (dBm)				
Network	**Dist. (Km)**	**Nasarawa**	**Karu**	**Lafia**	**Keffi**	**Akwanga**
AN	1.00	126	131	118	129	119
	2.00	132	140	125	130	135
	3.00	136	146	128	133	143
	4.00	142	155	136	143	147
	5.00	148	161	144	150	151
BN	1.00	128	126	118	117	125
	2.00	136	130	126	121	136
	3.00	142	138	130	127	142
	4.00	148	142	144	131	147
	5.00	154	144	150	139	153
CN	1.00	125	130	116	114	119
	2.00	128	138	121	117	129
	3.00	146	144	126	124	139
	4.00	154	146	132	132	140
	5.00	158	154	142	141	147
DN	1.00	118	122	126	120	119
	2.00	125	128	132	125	130
	3.00	128	139	136	129	140
	4.00	136	140	142	135	146
	5.00	144	144	148	140	150

Table 4: Meanpredicted path loss values for Nasarawa State

		Mean Predicted Path Loss (dBm)			
Network	**Distance (Km)**	**Free Space**	**Hata**	**Cos-231 Hata**	**Egli**
AN	1.00	148.12	142.91	138.78	115.12
	2.00	154.14	153.62	153.25	127.16
	3.00	157.67	159.50	153.25	134.20
	4.00	160.16	163.85	163.72	139.20

	5.00	162.10	167.22	167.09	143.08
BN	1.00	152.08	142.94	142.75	126.86
	2.00	158.10	153.41	152.22	125.17
	3.00	161.62	159.53	159.35	132.22
	4.00	164.12	163.88	163.70	137.22
	5.00	166.06	167.64	167.04	141.10
CN	1.00	152.03	143.00	142.82	90.00
	2.00	158.03	153.47	153.29	102.33
	3.00	161.07	159.60	159.41	109.37
	4.00	164.07	163.95	163.76	114.37
	5.00	166.01	167.32	167.14	118.25
DN	1.00	151.85	144.91	142.63	90.82
	2.00	157.85	155.38	153.10	102.24
	3.00	161.39	161.50	159.22	109.90
	4.00	165.89	165.86	163.53	114.90
	5.00	165.83	169.23	166.95	120.78

From Table 3, the measured path loss shows some variations across the networks and across the various terrains at 5km. Findings from this study reveals significant information for comparison of the path loss across the terrains. The order of path loss for urban areas is higher in Karu (AN>CN>BN & DN), followed by Lafia (BN>DN>AN>CN) and Keffi (AN>CN>DN>BN), while for sub-urban areas is Nasarawa (CN>BN>AN>DN), and for non-urban areas is Akwanga (BN>AN>DN>CN). This implies that, AN & BN have the highest path loss across the urban terrain, while CN have highest path loss across the sub-urban terrain and BN has the highest path loss across non-urban terrain. In the urban terrain, BN &DN networks have the lowest path loss in Karu, CN in Lafia and BN in Keffi, while in the sub-urban area DN has the lowest path loss, and in the non-urban area CN has the lowest path loss.

From Table 4, the mean predicted values show variation across the models.The order of path loss at 5km was free space model (BN>CN>DN.AN), Hata model (DN>BN>CN>AN), Cos-231 Hata model (CN>AN>BN>DN), and Egli model (AN>BN>DN>CN). Hate model was observed to predict the highest path loss values followed by cos-231 Hata model while Egli model predicted the lowest values.

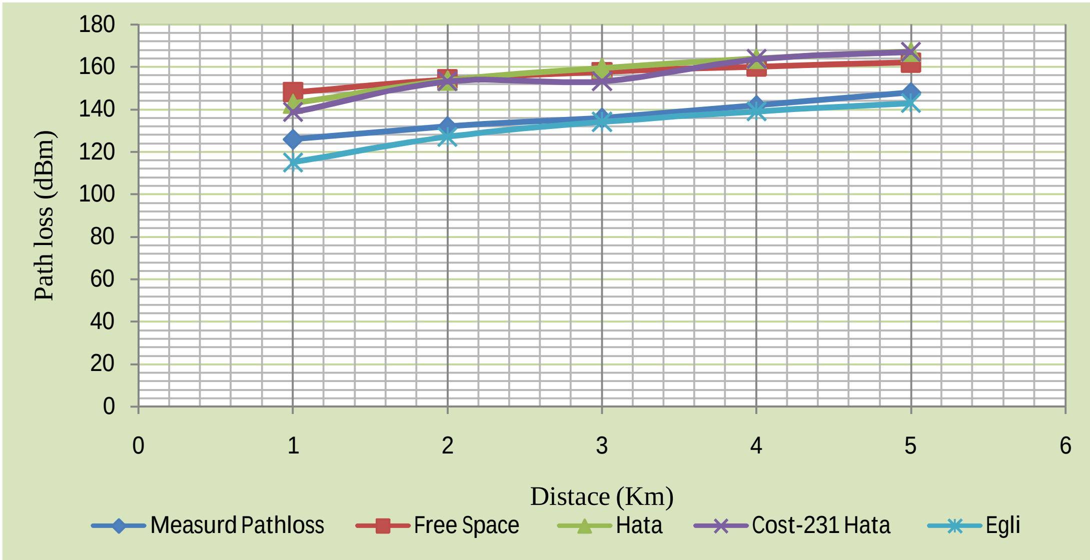

Fig. 1: Comparison of measured and predicted Pathloss along sub-urban terrain of Nasarawa LGA

Figure 1 shows the graph for sub-urban terrain of Nasarawa LGA. The results shows a comparison between measured pathloss and the predicted free space, Hata, Cost 231 and Egli losses with respect to the distance. It was observed that The Egli model value is close to measured pathloss values. This implies that Egli model is highly reliable. Free-space model was shown to be highly unreliable follow by Hata and Cost-231 models because they did not predict any value close to the measured values.

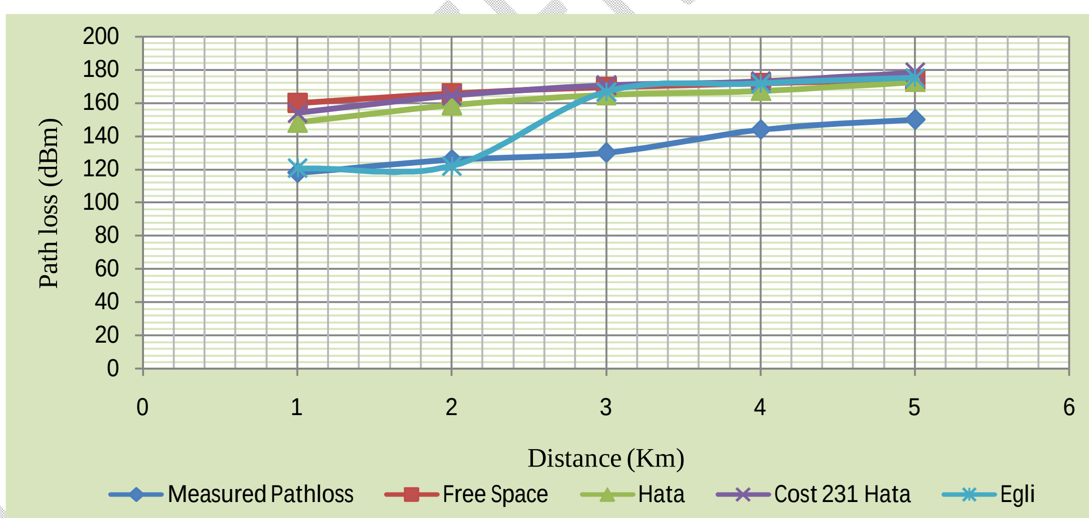

Fig. 2: Comparison of measured and predicted Path loss along urban terrain of Karu LGA

Figure 2 shows the graph forurban terrain of Karu LGA. The results shows a comparison between measured path loss and the predicted free space, Hata, Cost 231 and Egli losses with respect to distance. It was observed that the variation in the measured values (non-straight line graph) can be attributed to the Karu LGA environment having many obstructions in the path, like many high buildings in close proximity, as well as trees in between houses. It was also observed that the measured path loss settles for the same values with Egli model as the distance increases.

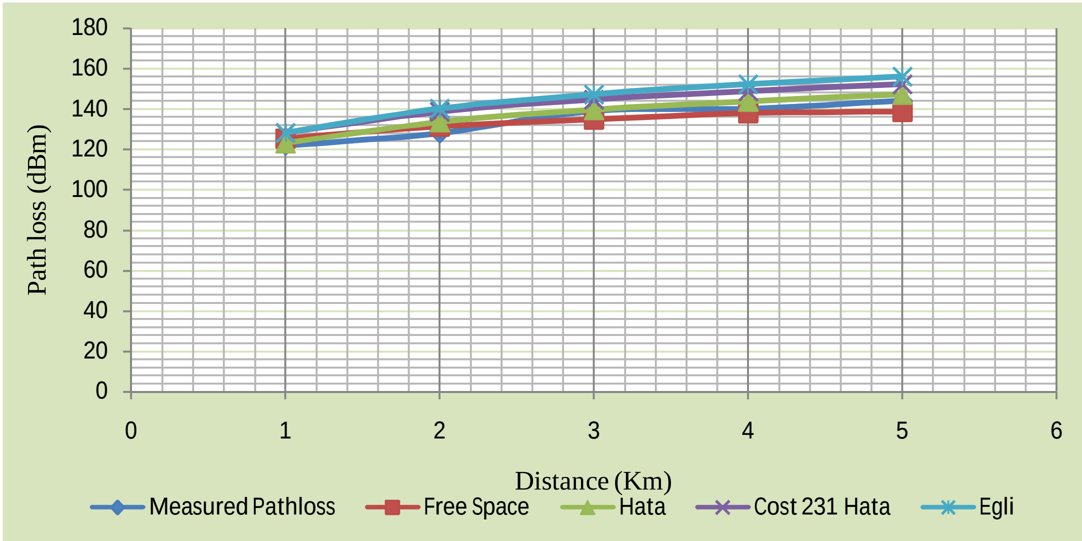

Fig. 3: Comparison of measured and predicted Path loss along urban terrain of Lafia LGA

Figure 3 shows the path loss at urban area of Lafia LGA of Nasarawa State. It was observed that The Free-space, Egli, Hata and Cost-231 models values are close to the measured pathloss values. This indicates that the empirical models are highly reliable along urban terrains of Lafia LGA.This could be attributed to the location of the base stations or height of the transmitting antenna.

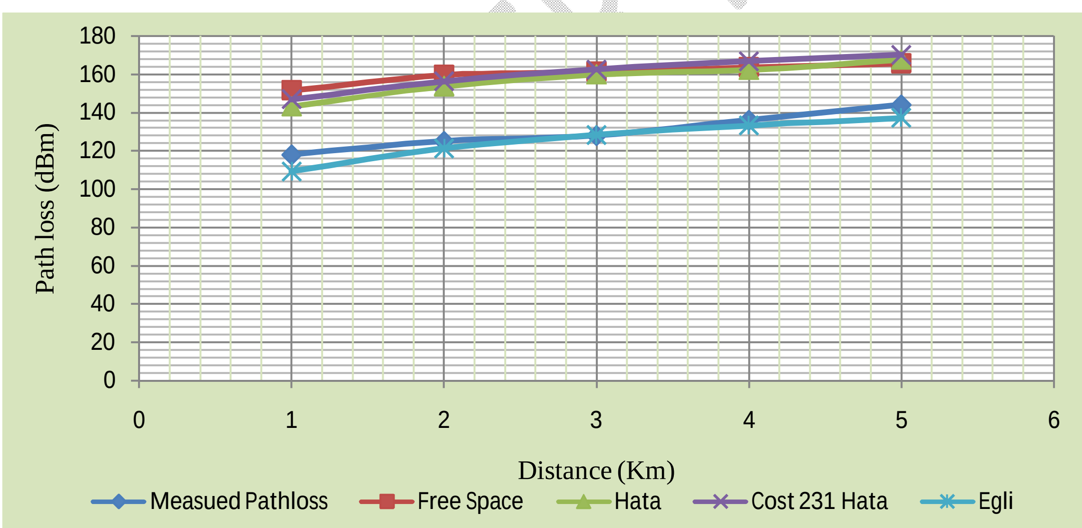

Fig. 4: Comparison of measured and predicted Path loss along urban terrain of Keffi LGA

Figure 4 shows the graph for urban terrain of Keffi LGA. A comparison between measured path loss and the predicted free space, Hata, Cost 231 and Egli losses with respect to distance shows that for a smaller distances the measured path losses are close to Egli model, unlike the free space model, Cost 231 Hata and Hata model, which are largely dispersed. This implies that (Hata and Cost-231 models) did not predict any value close to the measured. This can be attributed to the fact that this models takes into consideration the effective base station antenna height which is highly dependent on the exact topology of the measurement environment.

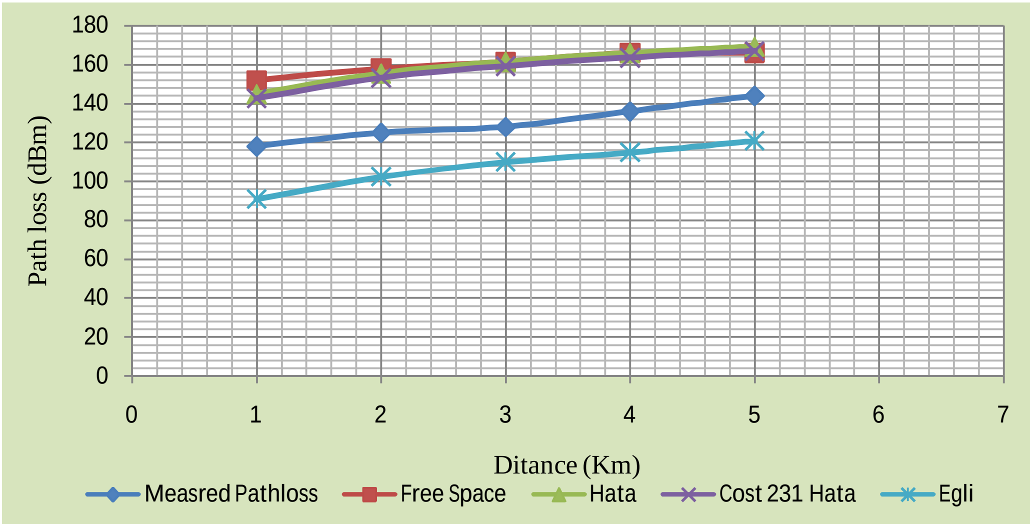

Fig.5: Comparison of measured and predicted Pathloss along non-urban terrain of Akwanga LGA

Figure 5 shows the path loss at non-urban area of Akwanga LGA of Nasarawa State. Comparison between measured pathloss and the predicted free space, Hata, Cost 231 and Egli losses with respect to distance shows that free space shows the highest path loss of 166.15dBm at 5Km distanceand also showed huge fluctuations due to change of receiver antenna height of mobile networks. It was also observed that path losses are decreased when the receiver antenna height is increased.

Table 5 is the root mean square errors analysis resultfor the measured path loss and the predicted path loss for each LGAs, mobile network and the entire State under study.

Table 5: RMSE of Predicted Path loss Models for Nasarawa State

		Path Loss (dBm)			
Location	**Network**	**Free Space**	**Hata**	**Cos-231 Hata**	**Egli**
Nasarawa	AN	43.90	9.21	8.23	2.23
	BN	8.41	7.11	6.89	4.06
	CN	8.05	6.84	6.75	7.69
	DN	13.60	13.10	13.40	10.00
	Mean	**18.50**	**9.10**	**8.81**	**5.99**
Karu	AN	16.10	10.60	5.50	10.80
	BN	30.20	2.10	8.05	8.37
	CN	13.70	3.16	6.75	9.40
	DN	6.75	12.20	2.55	3.18
	Mean	**16.70**	**7.00**	**6.71**	**7.94**
Lafia	AN	10.42	9.08	10.50	4.96
	BN	18.43	15.00	9.02	5.34
	CN	19.05	12.10	12.52	9.08
	DN	13.64	10.50	13.15	10.39
	Mean	**15.38**	**11.86**	**11.41**	**7.44**
Keffi	AN	11.30	6.57	8.81	2.86
	BN	11.40	5.90	8.14	6.40
	CN	13.60	8.45	8.54	1.21
	DN	10.40	9.08	10.50	1.12
	Mean	**11.70**	**7.50**	**9.00**	**2.90**
Akwanga	AN	7.56	7.65	6.98	3.26
	BN	8.85	7.47	8.89	2.77

	CN	13.80	8.63	10.90	1.03
	DN	10.02	9.57	8.54	5.50
	Mean	**10.09**	**8.33**	**8.80**	**3.14**

From Table 5, we examine the minimum values of RMSE for good signal propagation suitable for prediction of path loss and the least RMSE values in the selected location. The RMSE compares the measured data with the data obtained from each of the empirical model to determine the minimum RMSE for each location.From the evaluation, RMSE value obtained for Egli model (5.99dBm, 2.90dBm and 3.14dBm) for Nasarawa LGA, Keffi LGA and Akwanga LGA respectively falls within the acceptable values of RMSE for good signal propagation while for Cost-231 Hata model is (5.71dB) for Karu LGA is the acceptable value. It was also observed that the least RMSE value for Lafia LGA, Cost-231 Hata model (11.41dBm) is above the minimum RMSE value of 6dB for good signal propagation.In these cases the proposed model from (P_L = 106.2 + $7.87X_{BM}$) can be used for Lafia LGA. From this study, Egli model gives a fairer result for path loss prediction for Nasarawa State. However, no generic model is suitable for generalized used since each model differs in their applicability over different terrain. For effective path loss prediction in Nasarawa State, the proposed path loss model (P_L = 110.9 + $8.21X_{BM}$) obtained from the experimental results for the state is reliable, suitable and more accurate.

4. DISCUSSION

The study focuses on predicting path losses for different LGAs in Nasarawa State, Nigeria and comparing measured and predicted values using various models like Egli, Free-space, Hata, and Cost-231 in other to predict the best model, the study yielded several key findings. Firstly, the overall average predicted path losses for different LGAs range from 148.75 dBm to 154.28 dBm, while measured path losses range from 129.9 dBm to 137.95 dBm. The variations between measured and predicted values fall within the acceptable range of 1 ≤ PL ≤ 20 dBm.The study shows that the Egli model provides the best prediction outcomes, with root mean square errors (RMSEs) ranging from 2.90 dBm to 5.99 dBm, which are smaller compared to other models like Free Space, Hata, and Cost-231.The Egli model is considered highly reliable, settling for similar values as the distance increases, unlike the Free-space model, which is shown to be highly unreliable in predicting signal path-loss. The study suggests using the proposed model (P_L = 110.9 + $8.21X_{BM}$) for better prediction accuracy and network coverage performance for all mobile networks in the investigated locations where their values are greater than the minimum RMSE of 6dB. This findings is not in line with Salauet al. [21] who found Okumura–Hata model as the best model for path loss prediction in Akwa Ibom Statewith RMSE values exceeding 6dBm.

5. CONCLUSION

In conclusion, this study determined the path loss prediction for mobile networks in Nasarawa State. The predicted path losses were within an acceptable range, with the Egli model demonstrating the best performance among tested models. This study's approach and findings differ from previous research, highlighting the importance of considering specific geographical and environmental factors in signal strength prediction. Overall, findings of this study provide valuable insights for optimizing network coverage and improving service quality in Nasarawa State.However, it is important to note that further research is needed to focus on enhanced prediction models, advanced estimation techniques, network optimization strategies, 5G deployment, and collaboration.Future research can also contribute to the continued evolution of wireless communication technologies in Nigeria.

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