Analysis of Telecommunication Service Mast Distribution in Minna, Niger State Using Geospatial Technique

Adesina, E.A.[1], Uloko, U. S.[1], Olaniyi, A. M[1], Mobolaji, M. K., Animashaun, A.and Abdulkareem, S.[2]

[1]*Department of Surveying & Geoinformatics, Federal University of Technology, Minna*
[2]*Department of Estate Mgt. and Valuation, Federal University of Technology, Minna*
Email:joefodsolutions@gmail.com, realsolution007@gmail.com

Abstract

Since the embrace of telecommunication in Nigeria, the number of subscribers has tremendously increased and the dependence on telecommunication has grown cutting across all professions to all mans' day-to-day activities. This high rate of growth has led to high pressure on the telecommunication facilities, leading to poor network coverage. The increasing number of subscribers and the high dependence of everyone on telecommunication for man's day to day activities require that research be made into investigating ways to totally eliminate or minimize poor network coverage within the study area. Over the years researchers from different fields have looked into this problem with attempts to help solve this problem, and they most times tend to get stuck with topographic problems. This research tends to look into the analysis of telecommunication mast distribution using geospatial techniques in Minna Metropolis. The aim of this research is to analyze the spatial location (X, Y, and Z) of the telecommunication masts in Minna Metropolis in view of enhancing the performance and efficiency of telecommunication services in the metropolis. The parameters of the masts were acquired from the telecommunication company and a street guide map of the metropolis updated with the masts' locations was used to locate the masts and trigonometric levelling of inaccessible points was used in getting the height of the mast. The geospatial analysis used was view shed analysis incorporating buffer analysis; this was overlaid on the street guide map and a Digital Elevation Model (DEM). The view shed analysis was used to access the effect on topography on the network coverage while the buffer analysis was used to depict the range of network coverage. The result showed that the distribution pattern is based on population density and the concentration is on commercial centers and areas where income per head is high. It also revealed that the masts are well distributed for good 2G coverage, but poor network coverage is still seen due to topographic obstruction. The study also reveals that the facilities were poorly distributed for good 3G coverage at the fringes of the metropolis. It was discovered that topography has effect on the network coverage, as topographic features tends to obstruct the line of sight of signals from the mast. High peak produces better visibility and signal reception than on lowlands in the line of sight and view shed analysis. It was also discovered that in places were masts are well distributed and poor network is still seen, increasing the height of the mast could actually help in solving the problem. The work recommends that masts be placed at high peaks where the line of sight would not be obstructed. Also, LIDAR and UAV generated digital elevation models can also be used for the analysis in order to obtain better accuracy. The research recommends that this can be used for decision making by telecommunication companies for mast installation and it can also serve as forehand information for business men regarding where to establish businesses related to telecommunication and location.

Keywords: *2G and 3G network, mast, topography, and view shed analysis*

1.0 Introduction

Telecommunication mast can be defined as a free-standing structure that supports antenna at a height where they can transmit and receive signals [4]. This structure may be guy or a self-supporting structure. Mast radiator or radiating tower is a mast or tower whose whole body act as a transmitting antenna. At times, mast and towers are interchangeably used, but in structural engineering, mast is said to be a structure held up by stays or guys. They can be ground based or rooftop structures, their main aim is to support antennas at heights that can adequately send or receive radio waves [8].

Ever since Nigerians embraced mobile telecommunication in 2001, the rate of subscribers has increased tremendously [3]. It has found its way into man's day-to-day activities cutting across all subscribers in the various professions. It is used for communication and also accompanying internet facilities give users access to information and communication via the internet. All these have led to a high demand for good network service as it will aid execution of projects, give researchers access to a wider range of information via the internet, and provide a faster means for communication during emergencies and all other advantages accompanying effective telecommunication. Unfortunately, the quality of service delivery is poor, unreliable and unsatisfactory; this has made subscribers to be making use of two or more network providers' services to avoid disappointment due to poor network coverage [7].

According to [3], the provision of good network coverage is hinged on the optimal placement of these masts; of which a key factor to be considered is the topography of the area. Hence, the need for geospatial techniques to study the topographic related issues affecting network coverage is the major concern for the decision makers.

Therefore, this research sets to check for the effect of the mast height on network coverage, the effect of topography on telecommunication mast coverage, and how geospatial techniques can be used to improve the masts' coverage within the study area.

This work is aimed at analyzing the spatial location (x, y, and z) of the telecommunication masts in Minna metropolis in view of enhancing the performance and efficiency of telecommunication services in the metropolis. The objectives of the study are to (1) acquire the parameters of the telecommunication masts such as Identity (ID), Site Status, frequency, range and the coordinates of the mast (2) determine the height of the mast through field observations (trigonometric levelling) (3) acquire the DEM of the study area to be used with the mast parameters for the geospatial analysis (4) carry out the analysis of the telecommunication mast distribution using viewshed analysis (5) Identify the optimal location for the telecommunication masts.

Literature review

Telecommunication literally means communicating from distance. Its transmission can either be in one direction (simplex) or may be receive and transmit signals (half duplex). The signals may be transmitted in guided media like in fiber-optic, coaxial cables, etc. or unguided media using antennas as it is the case with radio transmission, microwave transmission, etc. The Base Station System (BSS) located at the cell site comprise of the Base Transceiver Station (BTS) for managing radio network coverage and the Base System Controller (BSC) for supervising the activities of the BTS(s) [3].

The range of signal coverage is a function of the operating frequency, antenna height, antenna properties, transmission power and the nature of the terrain [1]. The telecom engineers makes use of the frequency used, transmitter power and the antenna height expressed in equation (1).

$$\varepsilon = \frac{120\pi h_t I}{\lambda d} \qquad (1)$$

Where, ε is the field strength in volt/meter at a distance from the transmitting antenna with h_t as the antenna height, I as the antenna current, λ the wavelength of the operating frequency and 120π is the characteristic impedance of free space.

$$f\lambda = c \qquad (2)$$

$$d = \frac{120\pi h_t l f}{c\varepsilon} \qquad (3)$$

Here, c is the speed of light. From this it can be seen that the range of coverage of propagated signal is proportional to the height of the antenna and the frequency of operation, given that the frequency (f) is fixed since it is managed solely by the government agencies as empowered by the constitution. No room for surrounding terrain as a factor, no wonder it is a major problem as stated by [3]. This research tends to use Geographic Information System (GIS) to look into surrounding terrain since the other factors have been tackled. Geographic Information System (GIS) is a computerized information system designed to efficiently capture, store, manipulate, analyze, manage, and present spatial or geographic referenced data. It will be used to carryout viewshed analysis (geospatial analysis) on the telecommunication mast.

Viewshed refers to an area of land that is visible from one or more viewpoints. Two points are said to be inter-visible only if a straight line can be drawn between the points without any intersection with terrain's surface between them. The process of locating visible portion of land is called visibility analysis or viewshed analysis. It makes use of the "the law of rectilinear propagation of waves" that waves will continue to travel on a straight line unless when obstructed by an opaque object. It requires a point layer containing one or more viewshed and a Digital Elevation Model DEM, which is a raster data for viewshed analysis [5]. Thus, the viewshed analysis on the telecommunication mast will provide optimal positions network coverage in the study area.

Study area

Minna is the capital city of Niger state, located at the North-central of Nigeria. Niger State with land mass area of 76,363km^2 is the largest in land mass of all states in Nigeria. Archaeological evidence suggests settlement in the area dates back to about 47,000 to about 37,000 years ago. Its population as at 2007 is 304,113 and majorly comprises of Nupe and Gbagyi as its major ethnic groups. It comprises of high density, medium density and low density (Mandela street area) areas. It has two former Nigeria leaders Gen. Abdulsalami Abubakar and Gen. Ibrahim B. Babangida residing within the city.

Figure 1 shows the map of the study area. Its average elevation above sea level is about 243m. The city is known for extensive yam production. The mobile network services present within the study area are Airtel, Globacom, Mobile Telecommunication Network and Etisalat.

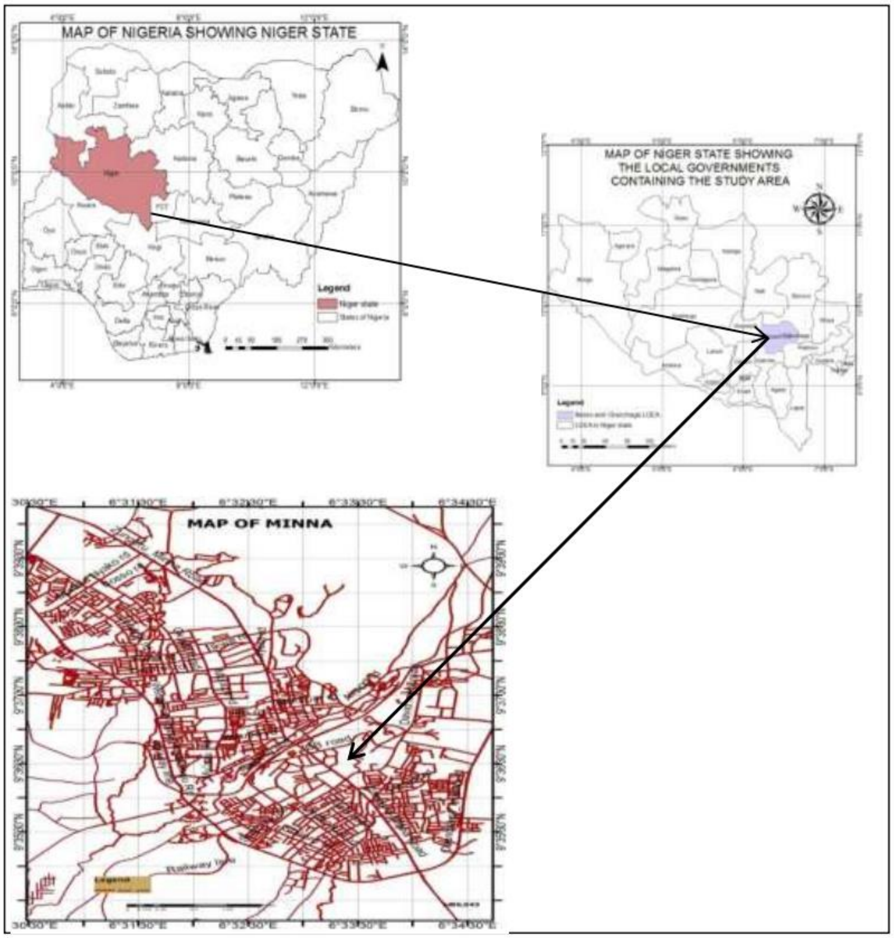

Figure 1: Map of the study area

3.0 Materials and Methodology

Materials

The mobile telecommunication service provider chosen to be used for the research was Airtel. The choice of the mobile telecommunication service provider was just based on availability of data. It was discovered that generally network providers tend to keep information regarding to their telecommunication mast (confidential). They only released surface information regarding the mast, keeping back sensitive information about them. Hence, during the data acquisition stage, field observation was used to capture information not provided by the mobile telecommunication service provider. Figure 2 shows the methodology flow chart used for the research.

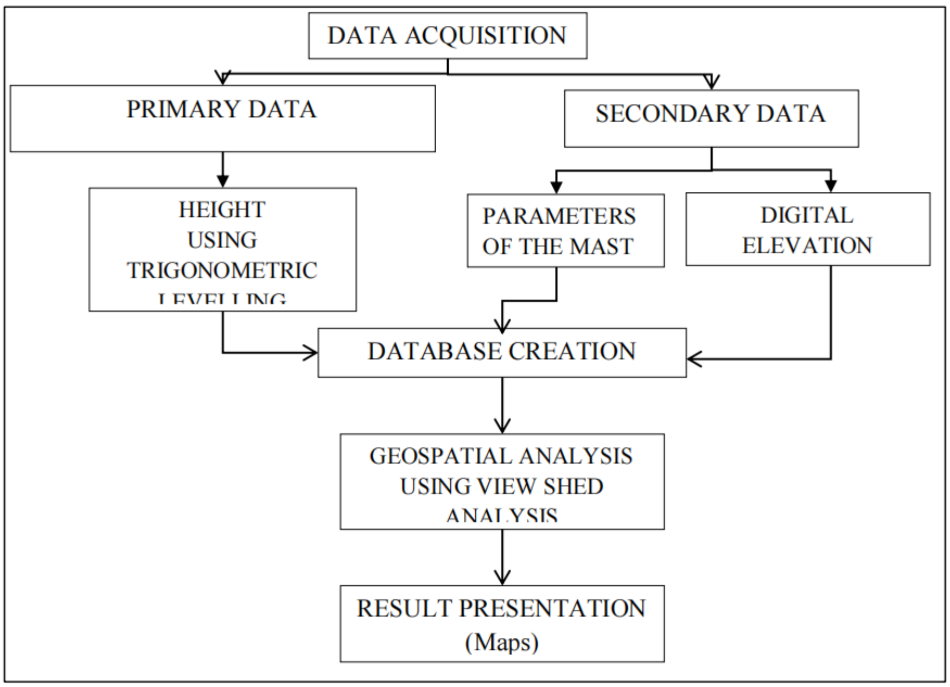

Figure 2: Methodology flow chart depicting work flow

Equipment used/system selection and software

The hardware used includes the Handheld Garmin 78 GPS Map was used for tracking the location of the "masts" within the study area while a Samsung computer with the following configurations, Core(R)Intel® Core™ i3 duo core Windows 7 Ultimate 64-bit (6.1, Build 7600) were used for the research. Also, the software used includes: Google Earth pro to get an aerial view of the study area, ESRI ArcGIS 10.3.3 Desktop (ArcMap 10.3.3) for the Geographic Information System related work and database creation and Microsoft office suite 2010 for report writing and large computations. Finally, other equipment used are the tape for distance measurement, theodolite for angular observation, levelling staff and writing material for recording observations on field

Data type and data source

Type of data

The data collected can be basically grouped into spatial data and attribute data. The spatial data includes: Coordinates of the mast, height of the mast, range of coverage and digital elevation model of the study area. The attribute data includes the Station Identification name (Station ID) and Status (whether it gives 2G, 3G and/or 4G network services).

Data source

The data sources used for this research can be grouped into primary and secondary data. The primary data was acquired through field observations, while the secondary data were obtained from reliable sources. Table 1 shows the secondary data used for the research.

Table 1**:** Secondary data for the study area

S/No	Data	Source	Type
1	Site Status: that is whether 2G, 3G and 4G network	Telecommunication office	Attribute
2	Site Identity (ID)	Telecommunication office	Attribute
3	Range	Telecommunication office	Attribute
4	Frequency	Telecommunication office	Attribute
5	Coordinates	Telecommunication office	Attribute
6	SRTM 30 m resolution Digital Elevation Model (DEM)	srtm.csi.cgiar.org	Spatial

The primary data includes other data acquired by observations necessary for the analysis. This includes all angular and distance measurement obtained on site to determine the height of the mast, as this was not given to the researchers by the Telecommunication Company for security reasons. The primary data comprises of the data acquired on the field for the computation of the masts' height.

Methodology

Since, the coordinates of the mast and their identity (ID) have been obtained. The first task was to track the location of the mast, considering its identification name (ID). This was done during recce and also during the data acquisition to make location of the mast easier. During data acquisition, handheld GPS Garmin 78 was used in tracking the mast. Then, some sets of angular and distance measurements were carried out to be able to compute for the height. The angular measurement carried out on site was done using Electronic Theodolite and all distance measurements were carried out using 50m steel tape. The concept of trigonometric levelling for reduced level of elevated points with inaccessible bases as stated by [2] was used for the data acquisition and data computation for the height.

This method was adopted as an indirect access to the base of the mast, as during reconnaissance survey, it was discovered that some masts were closed up without any security personnel being present and because of the intensity of radiation emission at the base, the base was inaccessible for observations. Thus, these observations were used to compute for the Reduced level of the top of the mast and then for the bottom of the mast. The difference between the reduced level of the top and the reduce level of the bottom gives the height of the mast.

This method assumes that the instrument stations and the elevated object are not in the same plane, hence, it rules out the need for a levelled or near levelled surface to be able to determine the reduced level. Figure 3 gives a pictorial view of the way the observations were carried out for each mast station.

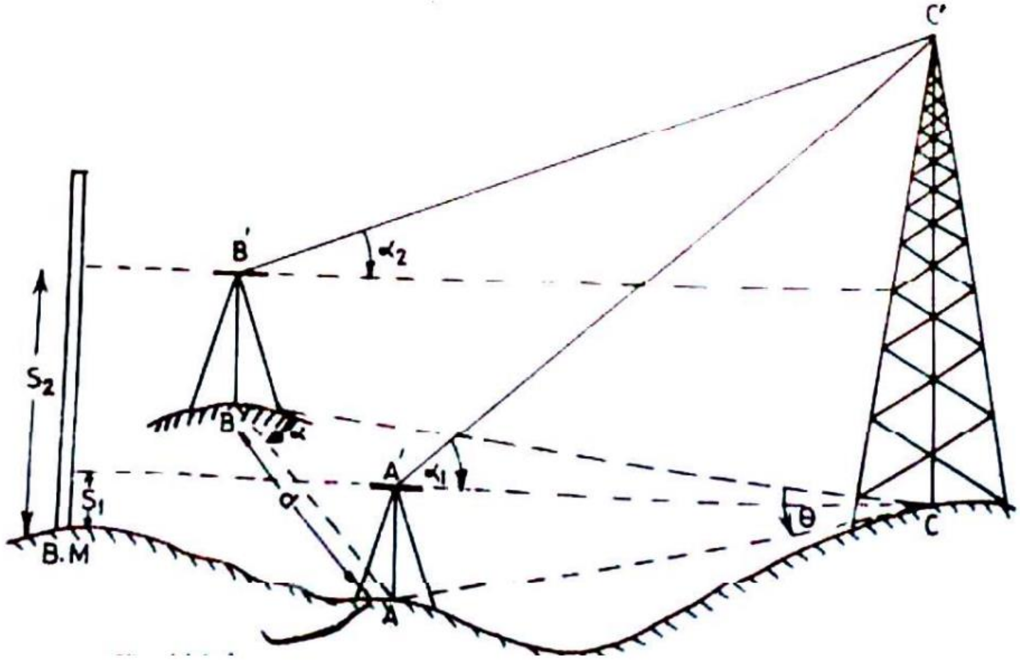

Figure 3: Pictorial view of the observations made for the computation of the height each mast [2]

Observations procedure

The following are the steps used:

i. The theodolite was setup at station A, centered carefully and the horizontal angle BAC was measured which was depicted as β.

ii. The top of the mast (C') was sighted and the angle of elevation $\propto_1$ was observed, ensuring that the altitude bubble is central at its run.

iii. Setting the vertical vernier to zero taking a reading on a staff held vertically on the arbitrary benchmark, the staff reading was recorded as S_1

iv. After setting up the theodolite on station B, with it well centered over the mark observed at A and ensuring the instrument is well levelled, the horizontal angle CBA was taken and recorded, as $\propto$.

v. Sighting C' (the mast top) and the angle of elevation $\propto_2$ observed and recorded ensuring that the altitude bubble is central of its run.

vi. Setting up the vertical vernier to zero by adjusting the telescope, the staff reading at the arbitrary benchmark was taken and recorded as S_2.

vii. The horizontal distance d between A and B was then measured use a 50m steel tape.

All observations made to the peak of the mast were equally repeated for the bottom, so as to be able to calculate for the reduced level of the bottom, which was used in the computation for the height of the mast. The accuracy of this method depends upon the accuracy with which horizontal and vertical angles are measured and also on the accuracy of the horizontal distance between stations A and B.

4.0 Data processing

Coordinates of the mast conversion

The coordinates of the mast were given in longitude and latitude; this was converted to Universal Traverse Mercator (UTM).

Computation of the mast height

Trigonometric method as stated by [2] was used for the computation. Also, excel codes were written to make the computation faster and easier. Elevation of the base and the top of the mast were computed for and the difference was used to get the height of the mast.

The reduced Level was calculated from Station A as

The Reduced level (RL) of the mast top (C') = RL of B.M + $S_1 + \frac{d \sin\propto . \tan\alpha_1}{\sin\theta}$ (4)

Or from B as

RL of the mast top (C') = RL of B.M + $S_2 + \frac{d \sin\beta . \tan\alpha_2}{\sin\theta}$ (5)

For the computation for the Reduced Level (RL) of the bottom of the mast, two conditions are possible,

i. If the mast bottom is lower than the line of sight of the instrument, hence vertical angle would be angle of depression.

For this the equation 6.0 and equation 7.0 was used for the computation of the Reduce Level

The Reduced level (RL) of the mast top (C') = RL of B.M + $S_1 - \frac{d \sin\propto . \tan\alpha_1}{\sin\theta}$ (6)

Or from B as

RL of the mast top (C') = RL of B.M + $S_2 - \frac{d \sin\beta . \tan\alpha_2}{\sin\theta}$ (7)

Were $\propto_1$ and $\propto_2$ are angles of depression to the bottom of the mast

ii. If the mast bottom is higher than the line of sight of the instrument, hence and angle of elevation would be observed for the vertical angle.

For this case equation 8.0 and equation 9.0 was used to calculate for the reduced level of the bottom of the mast

The Reduced level (RL) of the mast top (C') = RL of B.M + $S_1 + \frac{d \sin\propto . \tan\alpha_1}{\sin\theta}$ (8)

Or from B as

RL of the mast top (C') = RL of B.M + $S_2 + \frac{d \sin\beta . \tan\alpha_2}{\sin\theta}$ (9)

where,

$\propto_1$ and $\propto_2$ are angles of elevation to the bottom of the mast

$$Height_{mast} = Reduce\ Level\ of\ the\ top - Reduce\ Level\ of\ top\ Bottom \quad (10)$$

Hence, in cases when the base of the mast were obstructed and could not be observed, observations are made to a point near the base and then the height of that point is measured and added to the computed Height to give the height of the mast.

Database updating

After computing the height of the mast, the relational database containing information about Minna Metropolis was then updated with the information of the mast list below:

i. Site Identity (Site ID)
ii. Status (that is whether 2G, 3G, 4G or combination of any of them)
iii. Approximate coverage
iv. Computed height and
v. Coordinate of the mast location for easy locating.

Geospatial analysis

The geospatial analysis carried out was view shed analysis incorporating buffers; this was done using ArcGIS 10.3.1 (Arc Map). The buffer shows the extent to which the mast can cover and the view shed analysis. The inter-visibility of the line of propagated waves is showing the places obstructed by the terrain as invisible points and the other points as visible points, taking into cognizance the range and the height of the mast. The geospatial analysis shows the areas the mast can cover and the visible parts within the areas.

5.0 Results and discussion of results

Results

Table 2 shows the Longitude and Latitude of the Airtel Telecommunication Company (ATC) Mast observed within the study area. The result of the view shed map of part study is shown in Figure 4, where the area covered by 2G network service (mainly meant for phone calls) is depicted in light green, while the area covered by 3G network services which incorporates calls and fast internet services is depicted in Navy blue. The full result for the study area is shown in the appendices. Figure 5 is the street guide map of the mast in the study area. Figure 6 is the result of the viewshed analysis for 2G and 3G network with the antenna at its' current height. Figure 6 and Figure 7 show the result of the viewshed analysis for the 2G and 3G network respectively, for the current height of the antenna and for the antenna at the mast top. Figure 8 and Figure 9 show the view shed analysis of the existing mast with antenna raised, proposed location of new mast and the mast of which the height is to increase.

Table 2: Mast Parameters

S/No	SITE ID	X (LONGITUDE)	Y (LATITUDE)	ANTENNA HEIGHT (m)	MAST HEIGHT (m)	SITE STATUS	3G Range (m^2)	2G Range (m^2)
1.	NI0039	6.521773	9.667033	26.87684	39.83139	2G & 3G	1500	4000
2.	NI0273	6.51981	9.63955	26.70724	44.41878	2G & 3G	1500	4000
3.	NI0044	6.537831	9.621694	33.20669	47.98771	2G & 3G	1500	4000
4.	NI0372	6.545608	9.646192	22.14978	63.98944	2G & 3G	1500	4000
5.	NI0014	6.546835	9.629557	27.51598	46.82035	2G & 3G	1500	4000
6.	NI0010	6.55539	9.622586	29.85095	43.7705	2G & 3G	1500	4000
7.	NI0015	6.56678	9.625532	36.15008	45.26621	2G & 3G	1500	4000
8.	NI0338	6.56	9.614306	38.14702	66.3856	2G & 3G	1500	4000
9.	NI0038	6.556222	9.608143	27.92547	43.90511	2G & 3G	1500	4000
10.	NI0011	6.558469	9.594477	22.64901	50.10997	2G	0000	4000
11.	NI0370	6.54752	9.59974	30.98976	55.0103	2G & 3G	1500	4000
12.	NI0270	6.57714	9.62428	31.96037	52.92612	2G & 3G	1500	4000
13.	NI0283	6.57189	9.59886	26.47156	38.37614	2G & 3G	1500	4000
14.	NI0040	6.569718	9.576111	31.96953	39.81286	2G & 3G	1500	4000
15.	NI0373	6.55119	9.57917	41.94932	55.93243	2G & 3G	1500	4000
16.	NI0328	6.51076	9.58981	21.74763	34.9064	2G & 3G	1500	4000
17.	NI0316	6.493974	9.56625	28.71748	54.4628	2G & 3G	1500	4000
18.	NI0018	6.460004	9.537137	40.893	40.893	2G & 3G	1500	4000
19.	NI0016	6.53701	9.592723	27.46721	66.43251	2G & 3G	1500	4000
20.	NI0042	6.57445	9.63555	21.61994	43.23987	2G & 3G	1500	4000
21.	NI0004	6.53392	9.60625	18.99603	37.99207	2G	0000	4000
22.	NI0274	6.52391	9.62852	26.30969	52.61938	2G & 3G	1500	4000
23.	NI0041	6.52014	9.65097	25.08272	50.16543	2G & 3G	1500	4000
24.	NI0003	6.53272	9.637137	19.72751	39.45503	2G & 3G	1500	4000

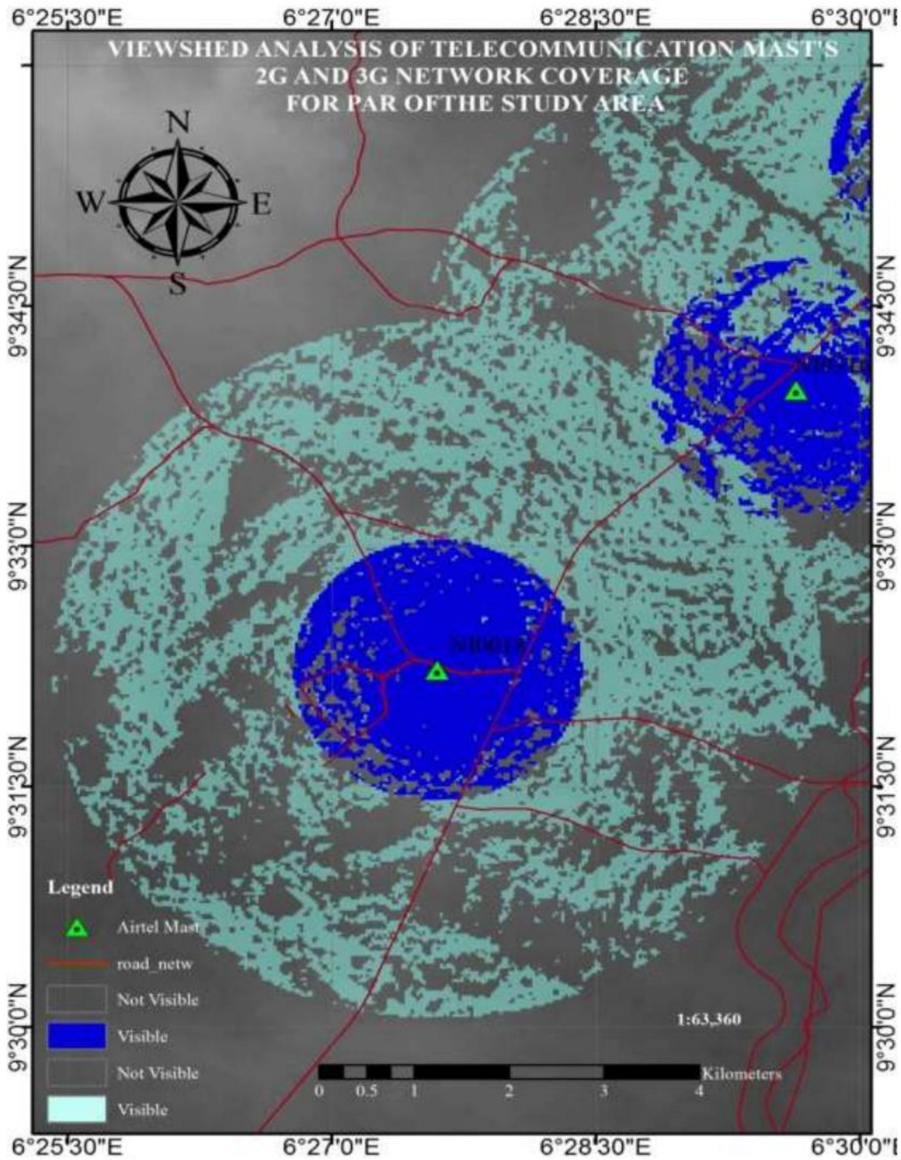

Figure 4**:** Result of viewshed analysis on the Digital Elevation Model (DEM)

Table 3: Parameters of the Proposed Mast and the height to add to some of the mast for good coverage

S/No	Proposed Site ID	X (Longitude)	Y (Latitude)	Antenna Height (m)	2G range (m)	3G range (m)
1	PM1	6.475560665	9.534226418	60	1500	4000
2	PM2	6.489458084	9.548682213	60	1500	4000
3	PM3	6.469909191	9.559662819	60	1500	4000
4	PM4	6.507202625	9.574701309	60	1500	4000
5	PM5	6.483439922	9.580588341	60	1500	4000
6	PM6	6.496221542	9.596957207	60	1500	4000
7	PM7	6.516946793	9.606190681	60	1500	4000
8	PM8	6.513214588	9.631461143	60	1500	4000
9	PM9	6.511501789	9.655640602	60	1500	4000
10	PM10	6.516736031	9.678766251	60	1500	4000
11	PM11	6.538625717	9.655830383	60	1500	4000
12	PM12	6.557190895	9.640218735	60	1500	4000
13	PM13	6.580420494	9.64649868	60	1500	4000
14	PM14	6.581846714	9.611561775	60	1500	4000
15	PM15	6.579169273	9.587006569	60	1500	4000
16	PM16	6.563447475	9.562989235	60	1500	4000
17	PM17	6.540054798	9.573107719	60	1500	4000
18	PM18	6.525701046	9.583409309	60	1500	4000
19	PM19	6.441785812	9.531366348	60	1500	4000
20	NI011	6.558469296	9.5944767	60	1500	4000
21	NI004	6.533919811	9.606249809	60	1500	4000

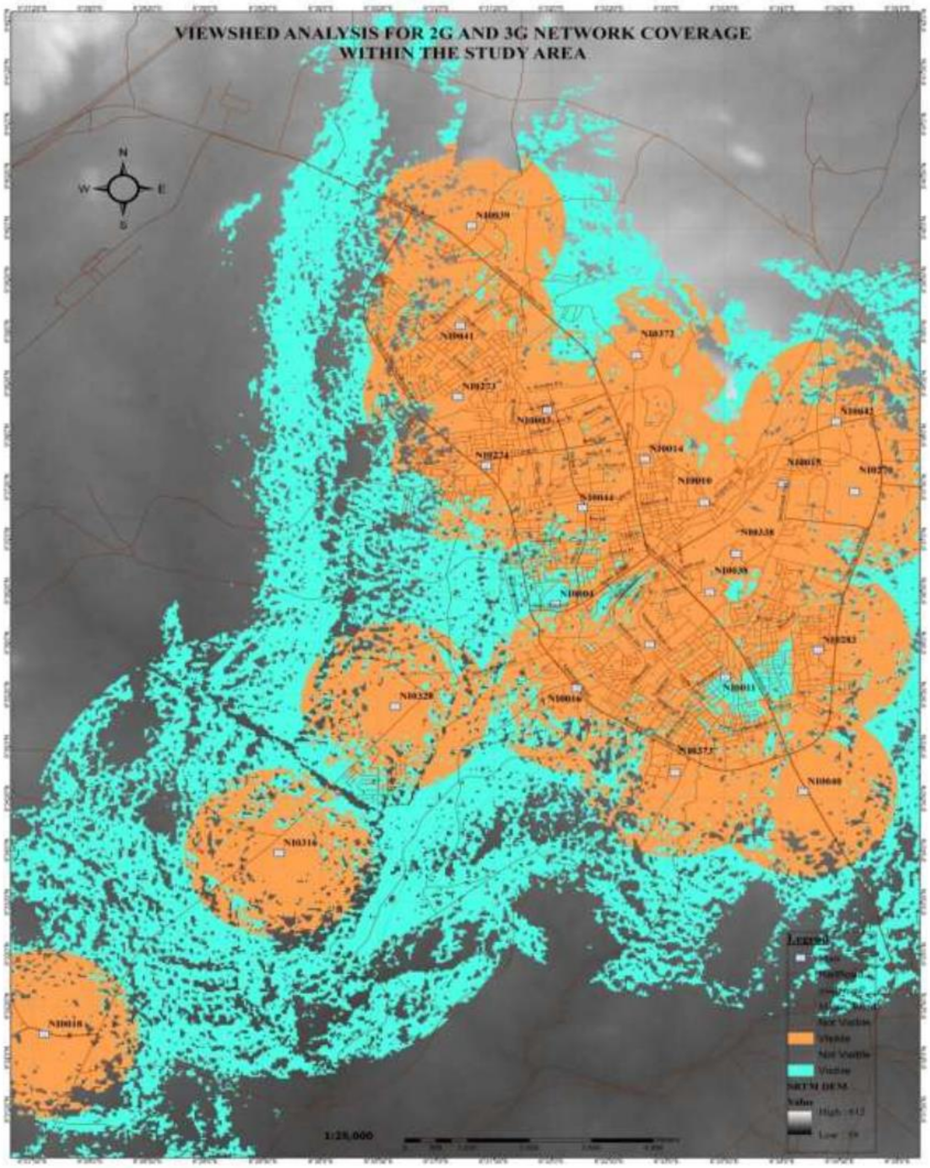

Figure 5: Viewshed analysis for 2G and 3G network coverage within the study area

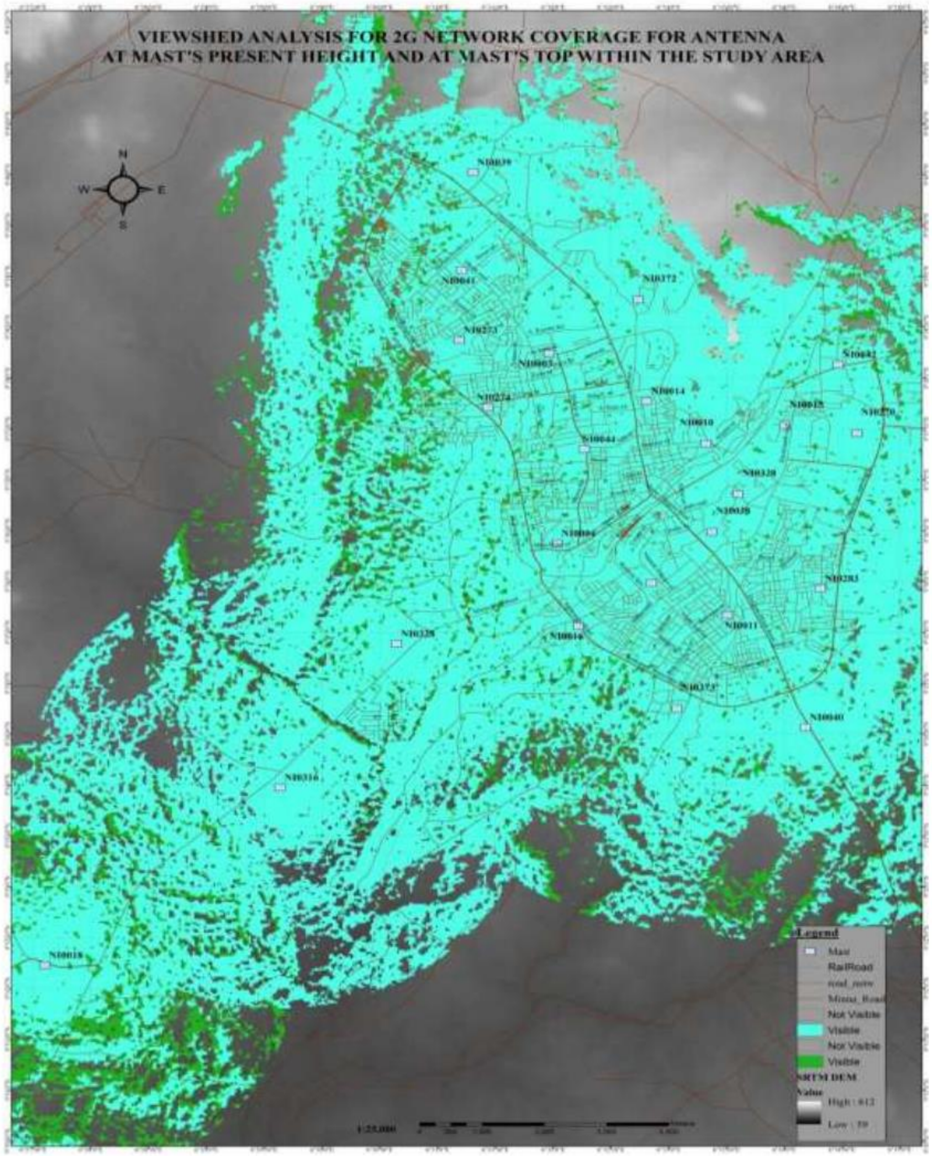

Figure 6: Viewshed analysis for 2G network coverage for antenna at it's present height and at the mast's top within the study area

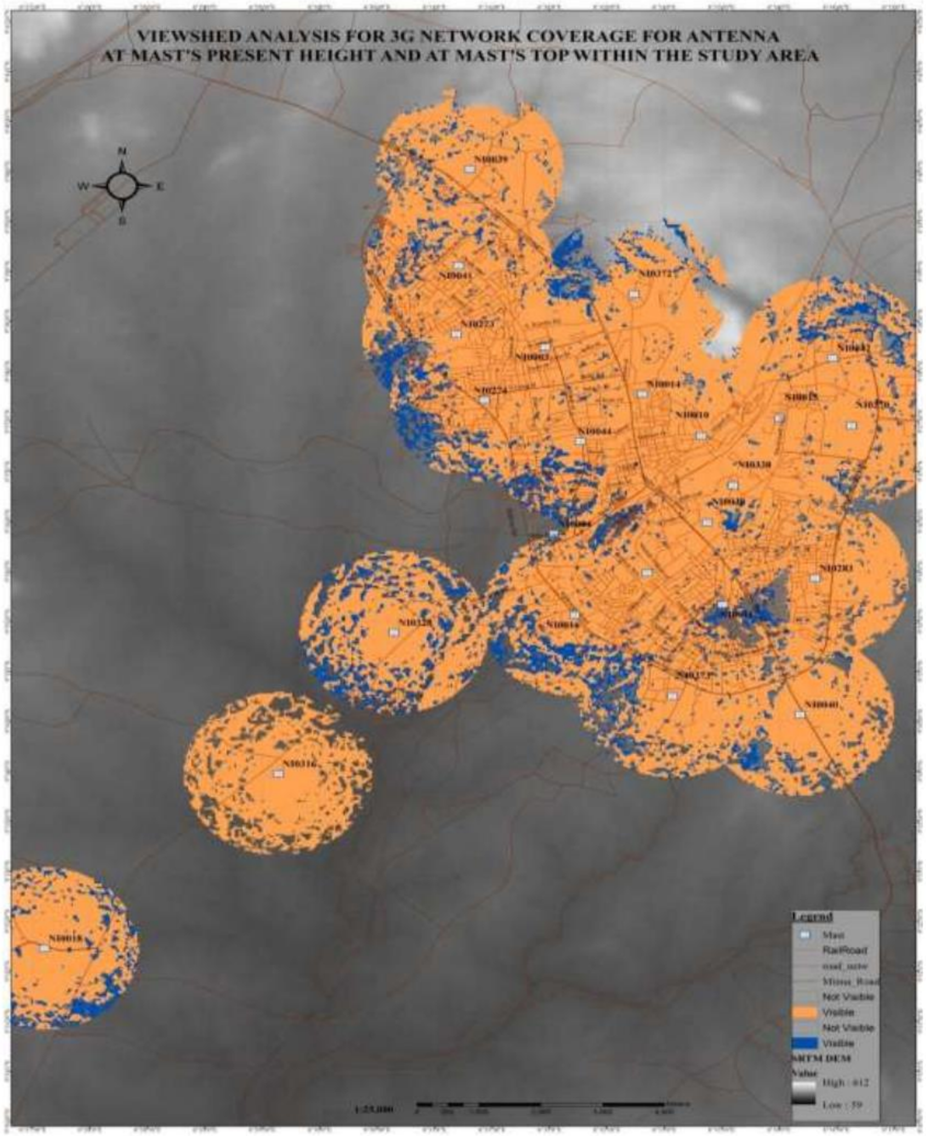

Figure 7: Viewshed analysis for 3G network coverage for antenna at its present height and at the mast's top within the study area

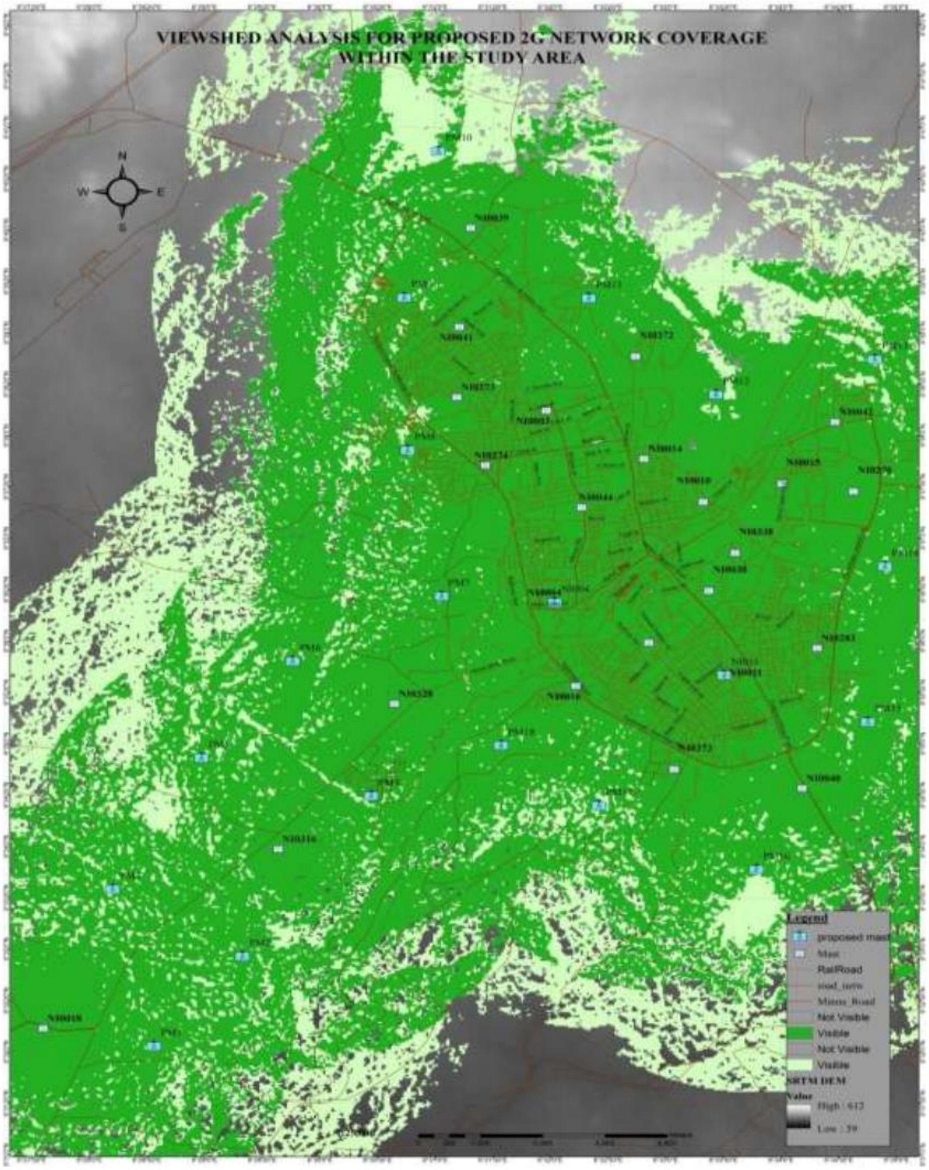

Figure 8: Viewshed analysis for proposed 2G network coverage within the study area

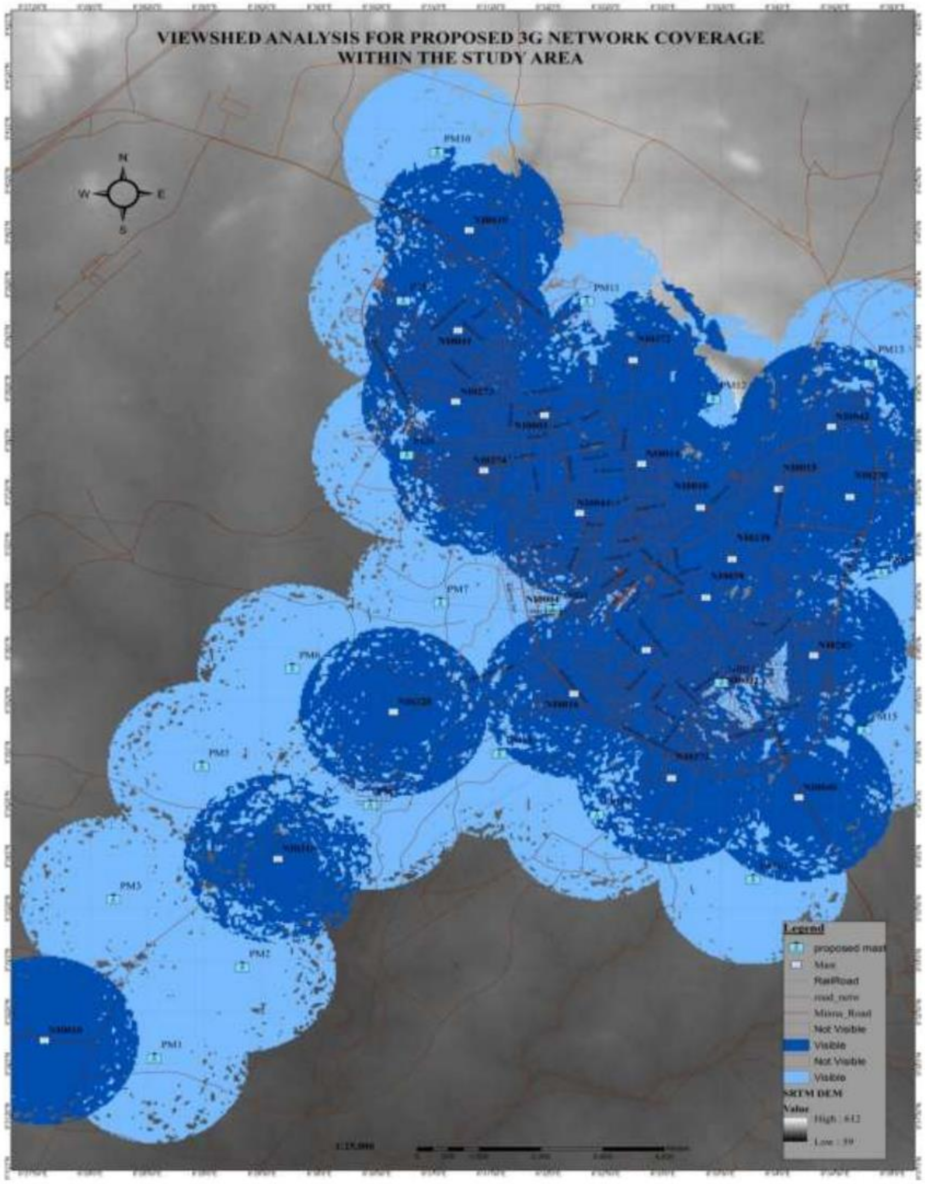

Figure 9: Viewshed analysis for proposed 3G network coverage within the study area

5.0 Discussion of results

The distribution pattern of all the masts in the study area was shown in Figure 4.2; the telecommunication service provider is more interested in the area where population density is high and commercial centers of the city. This can be seen in the large number of mast fixed along Minna - Zungeru road, Mobil area, Tunga area, down to Federal University of Technology, Bosso Campus in the study area.

The viewshed maps produced represents both visible and invisible points of the study area from the masts. The visible points are areas that accesses good network services as offered by the telecommunication company (ATC). View shed analysis also help to show areas within the range of coverage not having good network coverage as it maps out the places visible to the antenna and the places the antenna cannot reach due to obstruction of line of sight.

Figure 6 shows that there is a good distribution of the telecommunication mast for good 2G network coverage within the study area, but traces of invisibility can still be seen around the study area. Also, from Figure 6, it can be seen that the mast distribution is insufficient at the fringes of the city for good 3G network coverage; hence, the need to fixed new mast for good 3G coverage is required. The lack of signals within areas of network coverage as shown in Figure 5; can be traced to the obstruction of signals by topographic features such as surrounding valleys, or hills obstructing the lines of sight at that point. Hence, this is in agreement with [3], that the major problem faced by experts of Telecommunication and Electrical Engineering regarding network coverage is topographic in nature. This is responsible for lack of visibility in points of depression in the study area, as the features on the top of the hills and on slopes seems to obstruct the line of sight.

As shown in Figure 6, where poor 3G network coverage was observed due to the poor distribution, it might be said that the topographic nature of the study area might not be the only cause of poor 3G network coverage within the study area, therefore, there is needs to establish more masts in the area covered by the 3G network for better output. Also, a careful observation of these two masts NI0018 and NI0316, (two adjacent masts) in Figure 6 reveals that the areas between the two mast not covered by NI0018 due to topographic issues was covered by NI0316 vice versa. Hence, installation of new masts will be a lasting solution to this problem.

Figure 7 shows the overlap of the viewshed analysis carried out for 2G network coverage with the antenna at its' present location and when the antenna is at the highest point of the mast. The result showed that an increase in height could take care of the problem of invisibility when the mast are well distributed and poor visibility is still the case, due to obstructions from topographic features as is the case of Tunga, Mobil and Bosso area in the study area. However, this answers the long standing problem being faced by telecommunication companies, Telecommunication and Electrical Engineering experts regarding topography with respect to network coverage. This could serve as a cost effective solution instead of siting a new mast in such areas to cater for this problem.

This implies that with the height of the antenna increased as shown in Figure 7 and Figure 8; and some other mast fixed at areas where the masts were not well distributed as shown in Figure 9; good network coverage can be achieved within the study area. Figure 9 gives additional 19 optimal positions for good 2G and 3G network coverage.

Summary of findings

1. Only 24 Airtel Masts are within the study area

2. The distribution pattern is with interest on population density and the concentration is on commercial centers and areas where income per head is high.

3. Lowlands have less coverage than high land

4. Poor network coverage especially for 2G within the study area is mainly caused by topographic features such as hills, mountains, etc.

In places where the telecommunication mast are well sited and poor network coverage is still the problem an increase in the height of the view part antenna towards the nonvisible area could actually help make some non-visible areas visible and this can serve as a cost effective method for solving network problems.

6.0 Conclusion and recommendations

Conclusion

The result reviewed that the mast were properly distributed for good 2G network coverage but poorly distributed for good 3G network coverage. It also showed that despite the distribution of the masts, network problems still persist within the study area due to obstruction of line of sight by topographic features. This research shows that geospatial techniques could be used to look into the topographic effect on network coverage. From the research, it was discovered that the height of the antenna has effect on the visibility (network coverage). It was also discovered that in areas where good distribution of this mast are and all telecommunication factors such as range of coverage, strength of signals and all other telecommunication factors have being put in place, geospatial techniques could be used as a way to provide cost effective solutions. This can help telecommunication companies and telecommunication experts in decision making. Thus, the research was able to provide pictorial representation (maps) of information regarding the mast to support network planning and management through spatial representation of the available masts and proposed location of mast on a digital elevation model. This maps can also be used for decision making as it gives comprehensive knowledge about the network coverage within the study area with respect to the topography, this can also help the general public in decision making in business (such as internet related businesses, network service business, administration or even day-to-day activities related to network services.

Recommendations

Based on this research, the following recommendations were made:

1. Geospatial techniques may be used as a tool to look into topographic issues regarding network coverage for other networks such as Mobile Telecommunication Network (MTN), Globalcom Telecommunication Network (GLO), Television and radio stations.

2. Mast should be fixed at areas not having obstruction to line of sight.

3. The telecommunication experts should work on increasing the range of 3G network coverage to help solve this problem.

4. Generally, the antennas' height should be increase to ensure good network coverage especially those that are very low.

5. This same work should be repeated with LIDAR/Unmanned Aerial Vehicle (UAV) image so as to be able to give more precise information regarding the terrain about network coverage.

6. Geospatial techniques may be used to get a better view in graphical form of areas not covered by network coverage, this can go a long way in decision making on where to fix the masts.

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