Vulnerability Mapping and Assessment of Global System for Mobile Communications (GSM) Masts in Akure South Local Government Area

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Abstract - **Global System for Mobile Communications (GSM) was introduced in Nigeria in May, 2001. Since then, GSM subscriber base has grown astronomically leading to the indiscriminate installation of Masts and Base Transceiver Stations (BTS) across the country. Meanwhile; The Nigerian communications commission (NCC) and the National Environmental Standards and Regulations Enforcement Agency (NESREA) established environmental standards in 2009 and 2011 respectively to regulate the installation of these stations. In this study attempt was made to scrutinize the compliance or otherwise of GSM service providers with the established guidelines for the mounting of BTSs and Masts, hence; revealing the level of Vulnerability of the residence within the study area using ground survey techniques, to acquire both primary and secondary data alongside their attributes for the existing Mast. Using the instrumentality of ArcGIS 10.3.1 software, the survey data with attributes were imported, processed and analyzed respectively. The result obtained reveals that, a total of 61 locations were attended over the data collection period with Fifty-six (91.80%) of these facilities categorized as being compliant with the WHO standard which ruled for the 10m buffer. With the exception of five (8.2%) indiscriminately installed masts. Therefore this study is hereby recommended for adoption by (NCC) and (NESREA) in Ondo state for effective sanctioning of guilty network providers and for the monitoring of upcoming stations.**

Keywords: Spatial, Pattern, Vulnerability, Standards, Residential.

I. INTRODUCTION

Today, GSM has become a global, regional and local system for communications. The system uses a time division multiple accesses which enables more people to communicate simultaneously with a station. (Borkiewikz et.al, 2004).The wireless technology relies upon an intensive network of fixed antennas (base stations) of towers, and associated structures which include hill tops because they enable signals to be picked up from and transmitted to a large area. A telecommunication mast tower however, consists of a body structure of steel beams and materials with a concrete base of an approximate height of between 25 and 55meters, whereas antennae, transmitters and receivers are mounted on the body of the structures. These antennae receive high frequency radio waves from cell phones. The ranges of these antennas vary from distances as short as 1.5km to 2.4km to distance as long as 48km to 56km. A power source is provided with other accessories, all fenced either by block wall or steel poles and wire depending on the preference of the service providers. The land area covered by each mast location is approximately 144m2 (12m x 12m) (Akin, 2014). It was estimated that, over 1.4 million base stations exist worldwide, and this number is increasing significantly with the introduction of third generation technology (Nakwawessi, 2010). GSM communication system was introduced in Nigeria in August 2001. This changed the face of Information and Communication Technology (ICT) in the country. At its launch, there were only two operators in Nigeria, these are: MTN and Econet which metamorphous to Vmobile, Zain and now Airtel. Today, there are several operators across the nation, among the existing ones in Akure South include: 9mobile, Globacom, Airtel and MTN. The coming of the GSM in Nigeria brought about economic growth and reduction in unemployment. It also made access to communications easier. The new technology introduces new elements into the built environment of Nigerian cities. There hardly exists a city which does not have erected masts in the country (punch, 2009). It was estimated that, more than 120 masts are built monthly on the average by the Service providers (punch, 2009). The service providers as at 2009 have about 3,000 masts each across the country, most concentrating on urban areas (punch, 2009). As at the year, each provider has more than 14,000 live masts in Nigeria. Today, the number of live masts can only be imagined. If 120 masts per month is anything to go by, then each operator would have added about 4, 800 masts (Nwokoro.S., 2000).

Telecommunications systems are generally run by telecommunications service providers, also known as communications service providers. These providers historically offered telephone and related services and now offer a variety of internet and WAN services, as well as metropolitan area network and global services. Nigeria, there are claims that the masts used by telecom providers radiate electromagnetic field (ETF) rays which are injurious to health. The National Radiological Protection Board had said that there is radioactive exposure from mast which may be microwave radiation, electromagnetic radiation and radio frequency radiation. The electromagnetic radiation emitted from masts depends on the height and type of mast but the wave ranges from 50w/m2 and 200w/m2. Some waves emitted by some masts are not hazardous but most masts emit more than 100w/m2 which is said to be hazardous if human being stays around the mast for a long time (Abdel, R. et, al. 2007). The Nigerian Communications Commission (NCC) in collaboration with the National Environmental Standard Regulatory Enforcement Agency (NESREA) was obliged to adopt the World Health Organization(–WHO, 2007) regulations for locating a GSM Base Station in Nigeria, that Mast should be erected 10m from the perimeter wall (fence) of residential, where there is no perimeter wall (fence), a Based Station must be at a minimum of twelve (12) meters and above from the wall of residential, educational, hospital, child care centres and nursing homes. The best opportunities for the sighting of masts are: Railway land, Recycling Areas, Waste water treatment works, Industrial/General Business Areas, and so on(Wang, 2007).In the telecommunication world, GIS is used for network planning and development. The ability to layer information onto the earth's surface, complete with attribute data, allows engineers the unique ability to model and assess a network from the office. This saves valuable time and reduces the number of trips Wang (2007).

Furthermore, the powerful automation capabilities offered by a GIS increase the speed and accuracy of the network design process and can help reduce, and even eliminate, the downstream impacts of design-phase errors on cost and schedule during the network deployment phase. The skill level and design time involved in hand-producing comparable designs would be significantly higher. Using a GIS allows the engineer to add existing and competitive coverage to the map to improve the context of the data provided (Demers, 1997); (Galati, 2006);(N.V, 2005).

a) Significance of Study

Feasibility study of the area reveals that human population and the number of residential buildings are high in the study area. Eventually, the geographic spread of telecommunication

masts particularly GSM in Akure South Local government has painted a very noticeable aerial picture of the city, as indiscriminate installation of the base stations and the claims that the masts radiate electromagnetic field (EMF) rays which are injurious to health, could be the result of poor regulation and failure to adapt standards such as those set by the WHO while locating these base Stations. Therefore, it is justifiable that this study set out a framework for the government and stakeholders to serve as a guide for future planning , designs and implementation.

b) Study Area

The study area is Akure south local government in Ondo state of Nigeria as shown in figure 1. it is located between latitude 7° 5'23.62''N to 7º21'12.972''N and longitude 5°20'46.975E to 5°10'9.953 with an altitude of 353metres above the sea level. It has an area of 331sq.km and a population of 353,211 at the 2006 census, which is projected to 618,570 at 2016.
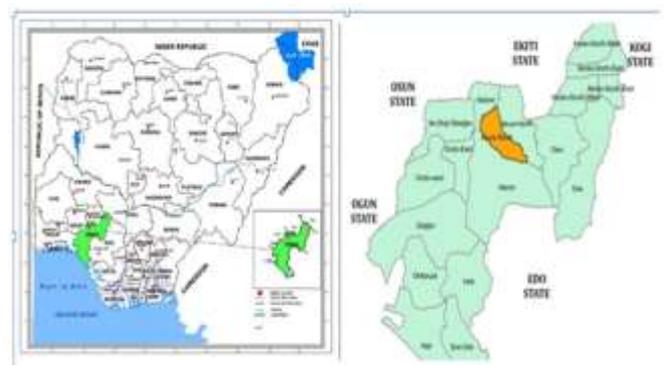

Figure 1: Map of Nigeria showing Ondo state and the study area respectively

II. MATERIALS AND METHODS

One of the main tasks that should be looked at carefully during the building of any GIS application is regarding requiring the appropriate spatial and attribute data and then integrating these data within the GIS environment. For this application, the required data was sourced and built upon the following.

a) Types of Data Used

i. Spatial coordinates of the GSM base stations' locations: The Global Positioning System (GPS) was used to collect the coordinates.

ii. Attribute data of these Base Stations were collected from the telecommunication service providers. The data included the following: (a) Identification numbers of the various GSM

Base Stations.(b) The addresses and locations of the Base Stations.

b) Data Acquisition

For this study, a preliminary field survey was first conducted to identify the locations of the telecommunication masts, in the study area, by documenting their geographic coordinates using the GPS instrument as follow:

 i.   Switch on the GPS and stroll down to set up.
 ii. Then, press ok button, the instrument prompt out another page.
 iii. On the new page, strolling to units and the distance and the speed unit was set to metric with elevations also in meters.
 iv. Then, strolling to position format UTM and the datum was set to WGS 84
 v.   The time format was also set to 24 hours in automatic time zone.
 vi. Then, the instrument was taken back to menu page.

After the necessary parameter settings completed, the GPS was strolled to satellite mode on the menu page and the "enter button" was pressed. The GPS then display satellite acquisition and the co-ordinate. The GPS was allowed to acquire enough satellite after putting it directly on the point with the face up, the co-ordinate acquired for the point was then saved against a point id chosen for the point.

c) Data Processing

The following steps were employed: (i). Image Geo-referencing: The high resolution image of the area (0.5m) was geo-referenced with the aid of Ground control points;

Figure 2: The geo-referenced image of project area with the green cross symbol depicts the point used

By creating a geographical coordinate system using zone 31 North of Minna datum to facilitate geo-spatial processing and analysis. ArcGIS 10.3.1 software was used for the geo-referencing and digitizing exercise. The following procedures were followed in the geo-referencing exercise;

 I.   The arc map software was launched from the desktop
 II. On the arc map desktop, the arc catalogue was launch, and the folder where the image was stored was connected to the arc catalogue
 III. On the arc map desktop, the add map button was clicked, which redirected me to the folder where the image was stored the image had three bands
 IV. After the image was added to the arc map, spatial reference was added to the image (projected coordinate-world-UTM-zone 31)

 i.   The image geo-referencing was done proper by clicking on the geo-referencing tab, followed by clicking the add control tab (where four evenly distributed coordinate was added to the image).

 ii. **Vector Data Creation/Digitizing:** The image covering the study area was utilized after vectorization was performed through ArcGIS version 10.3.1 windows operating environment. The purpose is to transform the raster image into vector Shape files, where the image was digitized under the following themes: the Road networks, Railways and water bodies as Lines. Residential areas, as polygon data (i.e. lines, and polygon features) contained separate attribute tables. The data was converted to shape file and used to perform all the analysis. Different symbolizations were used to map out the filling stations. Further, tables and charts created in Microsoft Excel were used to present the inventoried data. This helped in achieving the first objective of the work, which is to identify and map out the locations of the telecommunication masts.

 iii. **Geo-spatial Database:** A Geo-Spatial database of all the facilities was created for relevant Query Statements and subsequent analysis. Thus, all the necessary information for each facility was entered into its layer's attribute table and stored. This was achieved by adding required number of fields (columns) to the table and entering the data for all the facilities in their corresponding records (rows) in Microsoft Excel and imported into the ArcGIS 10.3.1 software environment. The GSM Base Stations were labeled with their Names, X and Y location, Number of the Facilities, Addresses, Types, Area, and Ownership of the facilities in the study Area.
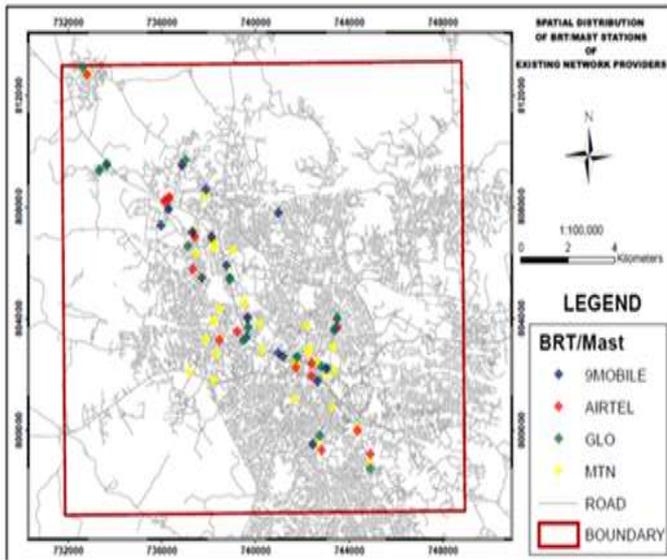
Figure 3: Showing the Spatial Distribution of all telecommunication the masts within the study area
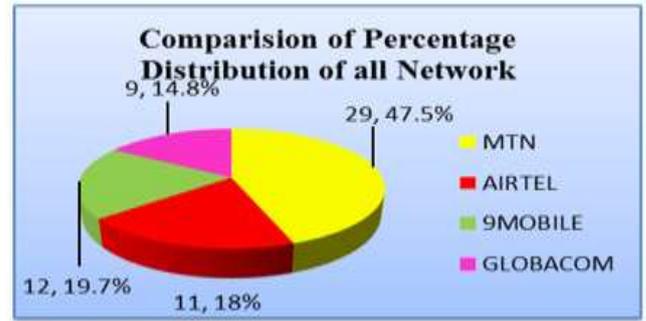

Figure 4: Network Percentage Distribution of all GSM Masts within the study area

From the figure above, it implies that the dominant erected facilities in the area of study belong to MTN masts with 29 land masts (47.5%); 11 Airtel base stations representing 18.0% of the total number of facilities in the area. While 9 erected base stations is owned by Globacom, which represents 14.8%. Meanwhile; 12 base stations covering 19.7% are owned by 9Mobile service providers.

d) Buffer / Average nearest Neighbor Analysis

AVERAGE NEAREST NEIGHBOR SUMMARY FOR ALL NETWORKS

Nearest Neighbor Ratio:	214.947646	
z-score:	4427.222261	
p-value:	0.000000	
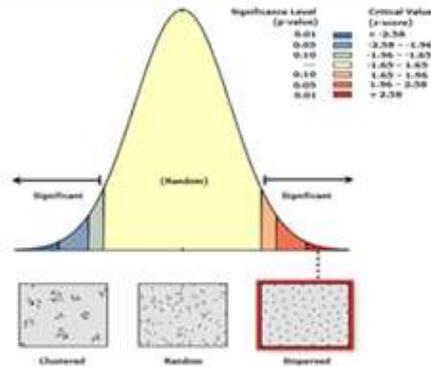
Given the z-score of 4427.22, there is less than 1% likelihood that this dispersed pattern could be the result of random chance.

Observed Mean Distance:	164.8166 Meters
Expected Mean Distance:	0.7668 Meters
Nearest Neighbor Ratio:	214.947646
z-score:	4427.222261
p-value:	0.000000

Average Nearest Neighbor Summary for all Network

| STATISTICAL PARAMETERS	NETWORK PROVIDERS				
	Average Nearest Neighbor Summary				
	ALL Network	Airtel	GLO	9Mobile	MTN
Observed Mean Distance:	164.8166 Meters	779.8318 Meters	852.3007 Meters	645.9832 Meters	471.8376 Meters
Expected Mean Distance:	0.7668 Meters	1.7294 Meters	1.9028 Meters	1.7294 Meters	1.1502 Meters
Nearest Neighbor Ratio:	214.947646	450.924363	447.928294	373.528731	410.235329
z-score:	4427.222261	4127.948886	3726.881064	3417.862394	5645.542405
p-value:	0.000000	0.000000	0.000000	0.000000	0.000000
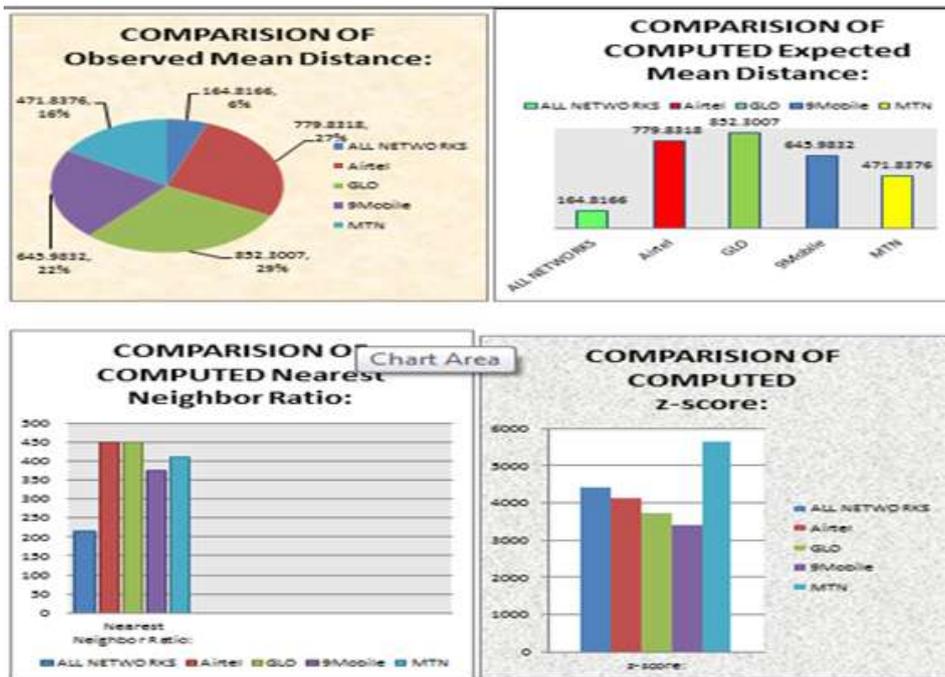
Figure 5: Buffer / Average nearest Neighbor Analysis

IV. CONCLUSION

This study involved the attendance of the telecommunication masts located in Akure South to specifically identify and draw the map location of each facility by using a hand held GPS, it also involved the use of GIS techniques (Buffering, Proximity, Querying) analysis in mapping and analyzing the spatial distribution of GSM Base Stations in Akure South Local Government Area, Ondo State, Nigeria. Field work was carried out to get coordinates of these telecommunication masts, buffer analysis was performed and included all residential areas occurring within the 10m perimeter around the telecommunication masts. A total of 61 locations were recruited over the data collection period. Fifty-six of these facilities were categorized as being compliant with the WHO standard which ruled for the 10m buffer. The buffer analysis showed that most of the telecommunication masts occurred at least 10m from residential areas with five non-compliant locations. These non-compliant areas include; Oke Ijebu area, near RCCG Vine Parish, Okuta Elerinla area, Ajibulu street, Igboyegun area, and Ijapo estate area, Groovy hotel.

In conclusion, this study has successfully achieved its objectives within the study area and one can deduce that most of the study area is free from indiscriminate installation of masts as 91.8% of these erected land masts throughout the study area, happen to comply with the WHO standard which rules that telecommunication masts must not be located less than 10m from residential buildings. This further agrees that a great percentage of the masts passed the 10m, 12m and 20m

buffer tests which keeps the health of the inhabitants around the GSM base stations of the study area at minimal risk.

V. RECOMMENDATIONS

I hereby recommend the findings of this study to the Ondo State government, the Federal Government and the town planning authorities with a view to assisting them with enforcing the relevant provisions for collocation and infrastructure sharing by GSM service providers within Akure South Local Government, along the value chain in order to remedy problems with installations of GSM Land Masts which posed health hazards, and prosecute all the defaulters. And also in reviewing approved development rights for the erection of Base Stations located within a radius of 10meters in the study area.

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