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ANALYSIS OF SPATIAL DISTRIBUTION AND PATTERN OF GSM MASTLOCATION IN JALINGO TOWN, TARABA STATE NIGERIA

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ABSTRACT

The need for communication and connection between humans has necessitated the proliferation of GSM masts across Nigeria. This study analyses the spatial distribution and pattern of GSM masts location in Jalingo town, Nigeria. The specific objectives of the study include identifying the location of GSM masts, mapping out the location and analyzing the spatial distribution and pattern of GSM mast location in the study area. A geo-database was created using ArcGIS 10.1 software to show the spatial location and distribution of base stations across the study area. The Nearest Neighbor Analysis (NNA) of the spatial statistical tool in ArcGIS 10.1 was also computed to reveal the spatial pattern. The vector shapefiles in the database were imported into the ArcGIS environment to create a visual map of points and polygon feature classes. The existing base stations (masts) in the study area were identified and mapped out. A geo-database was created using ArcGIS 10.1 software to show the spatial location and distribution pattern of GSM mast on the map across the study area. The result of the analysis reveals nearest neighbor ratio (NNR) of 0.816940 with a Z-score (critical value) of -2.689989, which reveals that the masts are randomly distributed across Jalingo town. Based on the findings, the study recommends that service providers should embrace the idea of co-location of telecommunication infrastructures as advised by the regulatory bodies (NCC and NESREA), which will reduce operational cost due to duplication of facilities and to avoid clustering of mast in the environment. This means several telecommunication providers can use same mast which ultimately reduces the number of masts over space.

KEYWORDS

GSM mast, Nearest Neigbour analysis, Pattern, Spatial analysis and Spatial distribution.

INTRODUCTION

The increasing need for functional telecommunication networks to service the desires and need of the growing subscribers for effective communication and the use of mobile phones have increased dramatically over the last decade. The introduction of Global System for Mobile (GSM) Communications in Nigeria in 2001 heralded a dawn of relief to the teeming Nigeria population. According to Bello (2010), services like mobile TV, electronic payments, mobile tracking services, cheaper international calls, internet banking, and mobile banking etc. occasioned by mobile telecommunication are common place in the country today. Bello further asserted that GSM has become a significant and an indispensable tool of transmitting or exchanging information for the modern man.

The world and particularly Nigeria is becoming a global village due to high degree of advancement in telecommunication (Akintonwa, Busari, Awodele and Olayemi, 2009). According to Olarenwaju (2016), communication is quintessential to human life and thus its importance cannot be overemphasized as well as communicating with the people in distant places with their instant responses. Olarenwaju (2016) further stated that this ability to communicate with people from far distance with instant response is one of the pleasures of telecommunication. Wireless digital telecommunications, the internet and information communication technology have revolutionized the world and the impact of information technology (IT) has been felt in all economic and social activities in every conceivable manner (Olukolajo, Ezeokoli and Ogungbenro, 2013). Olukolajo *et al* (2013) further stated that the convergence of all forms of communications on the digital playfield is opening up immense new possibilities of achieving speed, versatility and space-time independence.

The evident continuous use and deployment of cellular phones and other wireless communication devices and facilities around the world is phenomenal and has not only reduced the world into a global village, but more importantly, into a global household. There is no doubt that what was once solely a business tool; wireless phones, are now a large market consumer device contributing positively to the Gross Domestic Products (GDP) of various nations thereby creating job opportunities to millions of youths, professionals and even petty traders, which better the lots of the citizenry (Otubu, 2012).

Base Transceiver Stations (BTSs) and Masts form part of the basic infrastructure required for an effective telecommunication system. In order to have optimal network coverage, BTSs are often located in close proximity to the target users. This is the reason why telecom operators oftentimes site their masts in residential neighborhoods (Michael Nnaemeka & Matthew, 2013). A mast is a freestanding structure which supports antennas at a height where they can transmit and receive radio waves (Bello, 2010). Telephony masts are of different types, and range in height from 30 to 300 meters or more. When a call is made, the GSM phone transmits signal to the nearest base station. The signals are received by the antenna of a base station and passed from one cell to another through an underground fibre optic cable or via a "point-to-point" fixed microwave beam, which require a direct line of sight. A base station is a wireless telephone exchange, designed to provide local connections with wider links to other national and international networks (Ogbonna *et al*, 2016).

Every effective base station provides coverage over a limited geographical area, or cell, around its location. The cell covered by a base station depends on the call usage and the physical terrain of the

area (Bello, 2010). To provide comprehensive network coverage, the cells must overlap each other like a patchwork frame, so that users can move from one cell to another without breaking connection. Because each cell can only handle a limited number of calls, there is need for high density of base stations in areas of heavy usage.

The Nigerian Communications Commission (NCC) is the sector-specific regulator in the Nigerian Telecommunications Industry while the National Environmental Standards and Regulations Enforcement Agency (NESREA) is charged with the responsibility of protecting and developing the environment. It can, therefore, be argued that there can never be effective and quality telecommunications service, especially in the area of mobile telephony, without installation of telecommunications equipment such as masts and towers. It can equally be argued that lack of adherence to regulatory standards contributes to unhealthy environment. The need to adhere to regulatory framework for the installation of telecommunications equipment and facilities is therefore a necessity for a suitable and healthy environment and sustainable development. Adherence to NESREA guidelines will help in protecting the aesthetic value of the environment without any major negative effect (Ariyoosu, 2014).

Global System for Mobile Communications (GSM) phones are sophisticated two-way radios that use ultra-high frequency (UHF) radio waves to communicate information (Ogbonna, Okoye & Eleazu, 2016). The introduction of GSM phones and the subsequent rapid increase in the population of users of cellular phones, laptop computers, and tablets in the last decade has increased the need for greater telecommunications coverage across Nigeria and beyond. This demand has increasingly led to the indiscriminate erection of telecommunication masts and Base Transceiver Stations across the country (Nigeria Communication Commission, 2014). This situation is common among urban settlements in Nigeria of which Jalingo is no exception. This trend is a characteristic of developing countries, especially sub-Saharan Africa, where rules are not adhered to.

The need for communication and social connection between individuals via functional telecommunication services with the use of mobile phones has significantly increased in recent times. The optimal socioeconomic functioning of a country is dependent to a great extent on the communication that corresponds to its development scale. Thus, the world is rapidly moving towards an economic system that heavily depends on continuous and widespread availability and dissemination of information, as such, Nigeria as a nation is not left out (Akwule, cited in Isiaka, 2017). The increasingly growing population in urban and semi-urban areas and serious transportation problems justify the necessity for effective communication systems. The rapid increase in the use of GSM in Nigeria and Taraba state in particular, has necessitated the installation of BTS in different locations within Jalingo. Many studies have been carried out in different parts of the country to assess the distribution and pattern of GSM mast location in different part of the country, but not much has been done in Jalingo town. This study therefore examined the spatial distribution and pattern of GSM masts location in Jalingo town, Taraba State, Nigeria. The specific objectives include identifying the location of GSMBase Transceiver Stations (BTS) masts and analysing the spatial distribution pattern in Jalingo town, Taraba state, Nigeria.

CONCEPTUAL CLARIFICATION

Concept of GSM

According to Fendelman (2018), GSM (pronounced gee-ess-em) is the most popular cell phone standard, and is used internationally, so you probably have heard about it in the context of GSM phones and GSM networks, especially when compared to Code Division Multiple Access (CDMA). Fendelman (2018) further stated that GSM originally stood for Groupe Special Mobile but now means Global System for Mobile communications. According to the GSM Association (GSMA), this represents the interests of the worldwide mobile communications industry. It is estimated that 80% of the world uses GSM technology when placing wireless calls. GSM is the most widely accepted standard in telecommunications and it is implemented globally. GSM is a circuit-switched system that divides each 200 kHz channel into eight 25 kHz time-slots. GSM operates on the mobile communication bands 900 MHz and 1800 MHz in most parts of the world. In the US, GSM operates in the bands 850 MHz and 1900 MHz. GSM owns a market share of more than 70 percent of the world's digital cellular subscribers (Fendelman, 2018).

The concept of cellular service is the use of low power transmitters where frequencies can be reused within a geographical area. The idea of the first cellular network was brainstorm in 1947. It was intended to be used for military purposes as a way of supplying troops with more advanced forms of communications from 1947 till about 1979. Several forms of broadcasting technology emerged. The United States began to develop the advanced mobile phone services (AMPS) network, while European countries were developing their own forms of communications (Umar, 2009).

DESCRIPTION OF STUDY AREA

Jalingo, the capital of Taraba State lies roughly between latitude 8° 47′ to 9° 01′N of the equator and longitude 11°09′ to 11°30′E of the Greenwich Meridian (Oruonye and Abbas, 2011)(Fig. 1). It is bounded to the north by Lau LGA, to the east by Yorro LGA, to the South and west by Ardo-Kola LGA. Jalingo has a total land area of about 195.071km^2. It has ten (10) wards comprising of Barade, Kachalla Sembe, Kona, Maji Dadi, Sarkin Dawaki, Sintali A, Sintali B, Turaki A, and Turaki B wards (Orounye and Abbas, 2011). Presently, Jalingo Local Government Area has a projected population (2018) of 176,068 people at 2.83% annual growth rate.

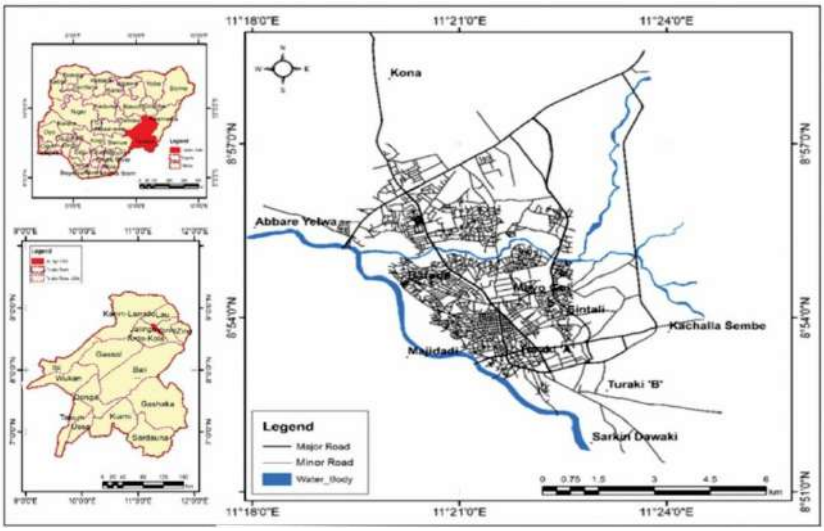

Figure 1: Map of the Study Area

Jalingo LGA is drained by the Lamurde River. The river flow from the highlands in the eastern and southern part through the depressions between the mountain ranges to the valley of river Benue in the west and northwestern part of the region. Jalingo LGA has an undulating topography. The relief consists of chain of mountain ranges. Jalingo local government area has diverse ethnic groups. The indigenous people of Jalingo are mainly Fulani, Mumuye and Kona. Others include Jenju, Bandawa, Wurkun, Hausa and Shomo. In terms of economic activities, Jalingo local government area are mainly farmers, fishers and traders. However, there is increasing numbers of civil servants as a result of increasing presence of Federal Government establishments, growth of commercial activities. Jalingo town has witness increasing rate of urbanization in recent times as a result of the relative peace in the area. Postal and communication services are provided almost exclusively by the NIPOST and GSM companies such as MTN, Airtel, Globacom and 9mobile. The Nigerian Television Authority (NTA), the State Radio Corporation (TSBS) and Television media (TTV) provide means of information dissemination especially to the residents of the state capital and major towns in the region (Oruonye, 2014).

MATERIALS AND METHODS

The study adopted survey research design involving the use of direct observation and measurements. The primary data was sourced via Ground Truth Observations (GTOs) in the field. This includes identification of the locations and collection of the coordinates of GSM Base Transceiver Stations using Global Position System (GPS). Secondary data used in the study included Digital Globe satellite image of the area obtained from Google Earth image online. The image was used to identify and extract the relevant features. Other secondary data used include journals, government policy documents, online articles and newspaper publications.

Instrument of Data Collection

The instruments or tools refer to the means through which the data was collected. Data for the study was collected with the help of Global Positioning System (GPS), measuring tape, and digital globe satellite image. Types of data used include:

i. Digital Globe Satellite image.

ii. Coordinates of the GSM base stations' locations. The geographic positioning system (GPS) was used to collect the coordinates.

iii. Data on the GSM base stations was obtained from various service providers and Nigeria Communication Commission (NCC). The data include the following:

   a) Name of the various GSM Base Station.

   b) The address and location of the base station.

   c) Number of the base stations in the study area.

Population of the Study

The population of the study comprised all GSM base stations of mobile telecommunications companies operational in Jalingo town. Based on reconnaissance survey, 59 BTS stations was identified in Jalingo town.

METHODS OF DATA ANALYSIS

Data Processing: This involved the processing, extraction and analysis of relevant spatial and attribute information about the study area from the satellite image. The following steps were employed:

Image Geo-Referencing: The Digital Global satellite image of the area was geo-referenced with the aid of ground control points using GPS. The image was geo-registered with the geographic coordinate system WGS 1984 using the Geo-referencing tool bar of the ArcGIS 10.1 software. The image was later projected to projection coordinate system Minna Datum zone 32 using the projection/transformation tool in the ArcToolBox of the ArcGIS software.

Vector Data Creation: The satellite image was vectorized using the ArcGIS 10.1 software. The purpose is to transform the raster image into vector shapefiles, where the image was digitized under the following themes: the road networks and water bodies as polylines. Residential areas as polygon with each feature type having separate attribute.

Geo-spatial Database: A geo-database was created using the ArcGIS 10.1 software, this enabled subsequent analysis, and querying and sorting was done. First the GSM base stations in Microsoft excel command delimited format with fields (column); X and Y locations, number of facilities, address, area, and corresponding records (row) was imported into the ArcGIS 10.1 software environment and exported into the Geo-database. Secondly digitized road networks, water bodies and residential areas from the satellite image were also exported into the Geo-database.

Data Analysis: The vector shapefiles in the database was imported into the ArcGIS environment to create a visual map of points and polygon feature classes. This shows the spatial location and distribution of base stations on the map across the study area.

The Nearest Neighbor Analysis (NNA) of the spatial statistical tool in ArcGIS 10.1 was used to compute and establish spatial pattern that exist between BTS in the study area. Nearest Neighbor Analysis is the method of exploring patterns in the location data by comparing mean distance (Do) of the phenomena in question to the same expected mean distance (De) usually under a random distribution. Analysis produces a Nearest Neighbor Ratio (Rn) result between 0-2.15. If the Rn value result fall between a range of 0-0.49 the pattern is said to be significantly clustered, while a range of 0.5 – 1.5 indicates a significant random distribution, if the Rn value falls within 1.56 – 2.15 the pattern is said to be significantly dispersed or regular depending upon the number of points per pattern. A Negative Z score indicates clustering, while a positive Z score means dispersion or evenness (Getis and Ord, 1998).

RESULTS OF THE FINDINGS

Spatial Distribution of GSM Masts in Jalingo Town

The map of Jalingo town was interpolated to show the spatial location of the masts as shown in Fig. 2. Masts in the study area are located within buildup areas, most of which are residential areas. Jalingo town is majorly a low land as observed by Oruonye (2014). Thus, the BTS are located within the lowland area of Jalingo town.

Only one BTS was observed to be located in an isolated area with no buildup areas in Wuro Sembe, Kachalla Sembe ward. The BTS were also observed to be located more within the densely populated areas of the town as shown in Fig. 3 and Fig. 4.

Location of GSM Base Station in Jalingo

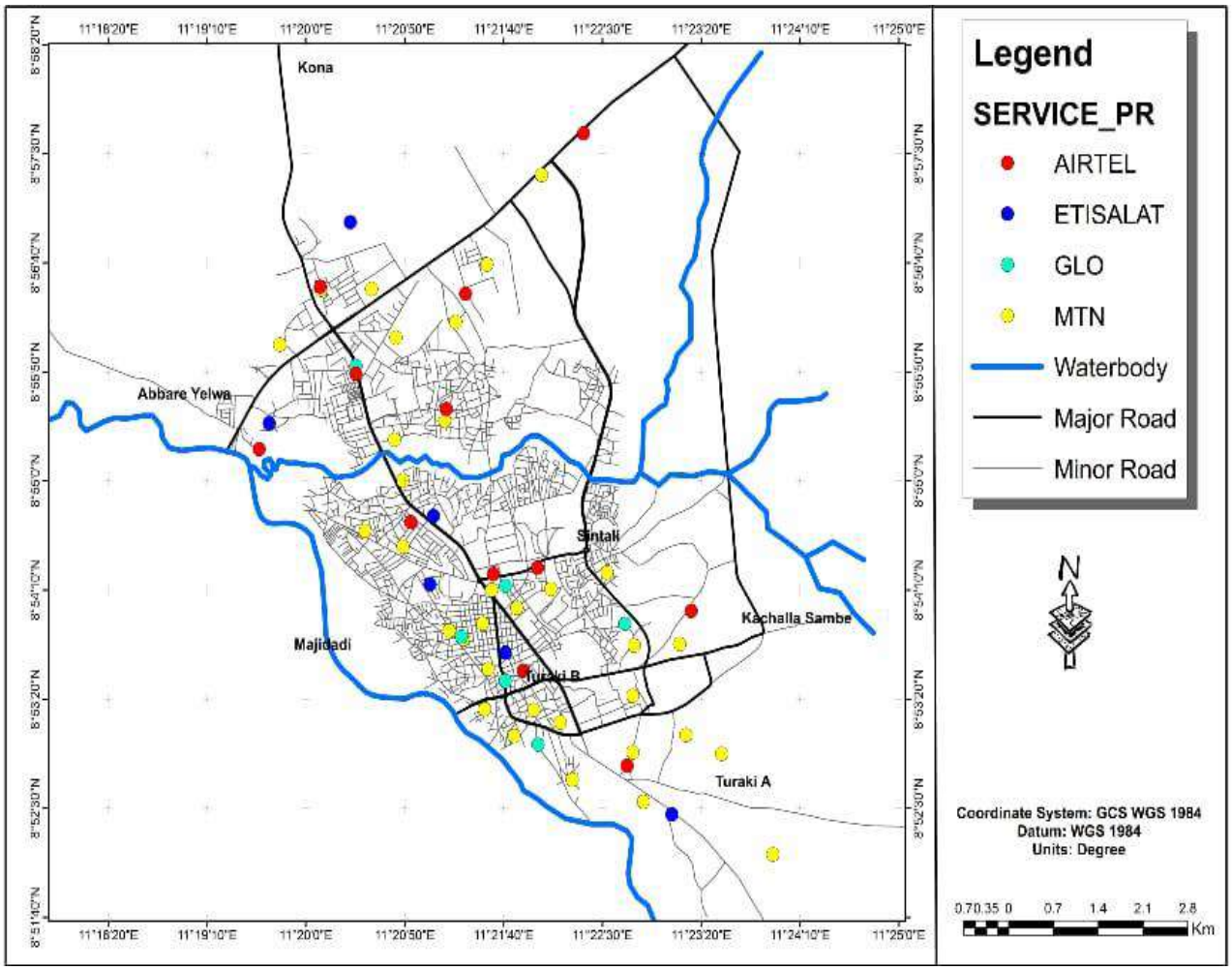

Figure 2: The Spatial Distribution of Masts

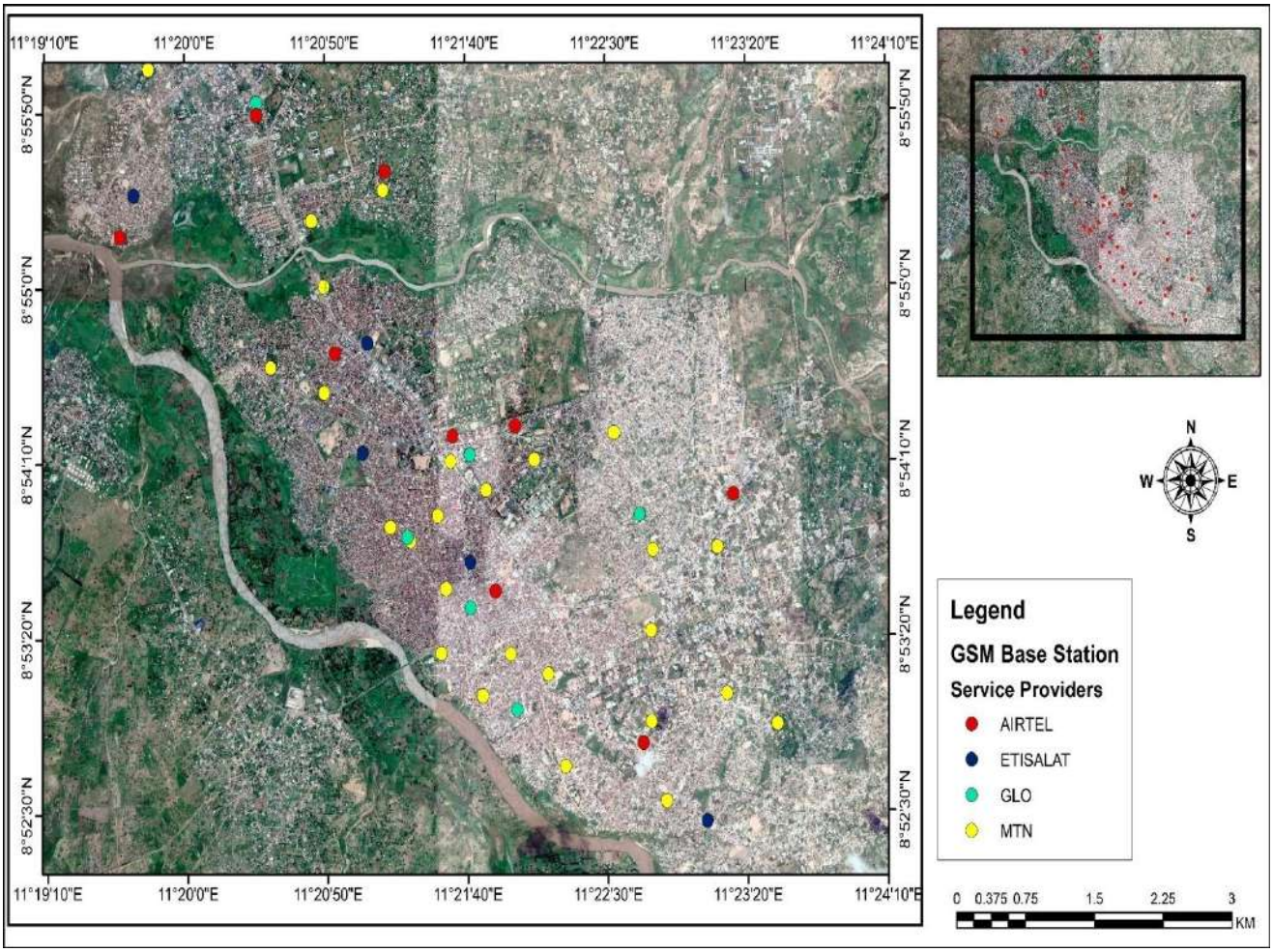

Figure 3: The Spatial Distribution of Masts

Table1: Distribution of Masts in Jalingo Town

Service Providers	Number of Masts	Percentage
MTN	34	58
Etisalat	6	10
Glo	7	12
Airtel	12	20
Total	**59**	**100**

Source: Field survey, 2019

Figure 4.shows the spatial location and distribution of masts in the study area. Figure 4 shows that there is concentration of masts within the center of the town. This could be attributed to ease of securing these installations against theft and vandalisation if located outside the town and the need to service the population within the centre of the town as well as the number of prospective subscribers. Table 1 shows that out of the 59 Masts captured, 34 are owned by MTN, 6 are owned by Etisalat, 7 are owned by GLO while 12 are owned by Airtel.

Distribution Pattern of GSM Masts in Jalingo Town

The analysis of the distribution pattern of GSM telecommunication masts in Jalingo town was carried out with the aid of the average nearest neighborhood analysis. Results generated are shown in Figure 3 and Figure 4.

The result as shown in fig. 3 and Table 2 indicates that the BTS in Jalingo town are randomly distributed. The result shows that the nearest neighbor ratio is 0.816940 (observed mean distance divided by the expected mean distance), with a critical value of <-2.58 and a test of significant: P value of 0.0071445 as shown in fig.3. The result of the breakdown shows that the spatial pattern of distribution of telecommunication masts in Jalingo town was random (Table 2) and there is less than 1% likelihood that this random pattern could be the result of random chance.

The random pattern shows that the masts are not evenly distributed over space. This implies that the BTS are randomly distributed to cover space in Jalingo Town. This observed pattern further confirms the absence of adherence to definite spatial planning and technical standard guide for the location of masts. The result of this study is in line with the finding of Eyankware, Iyi, Okwu and Ulakpa (2016) in a study of impact of telecommunication masts on environmental planning in Enugu urban area of Enugu State, which revealed the random distribution of BTS within eighteen layouts in Enugu with an observed mean distance between masts located is less than 1km. Thus the spatial distribution is neither clustered nor dispersed but random in nature while the mean distance for medium ranges from 0.7km to 1km and low density layout is above 1km. The results are in contrast with the findings of Adamu *et al* (2016) on the spatial distribution pattern of telecommunication masts in Zaria, Kaduna State where it was observed to be clustered. Similarly, the findings of this study are contrary to the result of Isiaka (2017) in which it was reported that the spatial pattern of distribution of GSM masts in Ile-Ife was observed to be clustered. All these reports shows that as at present the spatial distribution patterns are clustered in major places, but as population continues to grow so will the number of subscribers and more masts are going to be required to meet their demand for reliable coverage. This simply indicates that the installation of masts does not follow a particular pattern across the country. This could be attributed to difference in land forms and/or availability of land.

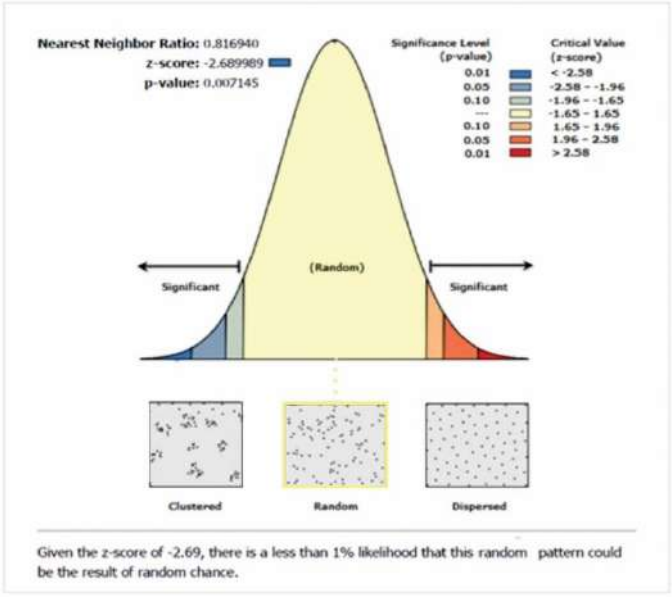

Figure 4: Average Nearest Neighbour Analysis

Table 2: Average Nearest Neighbour Summary and Dataset Information of GSM Mast inJalingo Town

Observed Mean Distance	895.786090 Meters
Expected Mean Distance	1096.514063
Nearest Neighbor Ratio	0.816940
Z – Score	-2.689989
P – score	0.007145
Input Feature Class	Masks Points
Distance Method	Euclidean
Study Area	283752969.277664
Selected Set	False

CONCLUSION

This study has analyse the spatial distribution and pattern of GSM masts location in Jalingo town, Nigeria. The result of the findings shows that out of the 59 GSM masts identified, 34 are owned by MTN, 6 are owned by Etisalat, 7 are owned by GLO while 12 are owned by Airtel. The findings of the study show that there is concentration of masts within the center of the town. This could be attributed to ease of securing these installations against theft and vandalisation if located outside the town and the need to service the population and prospective subscribers within the centre of the town. The result of the findings reveals that the BTS in Jalingo town are randomly distributed. The result shows that the nearest neighbor ratio is 0.816940 (observed mean distance divided by the expected mean distance), with a critical value of <-2.58 and a test of significant: P value of 0.0071445. The result reveals that the spatial pattern of distribution of telecommunication masts in Jalingo town was random. These observed pattern reveals the absence of adherence to definite spatial planning and technical standard guide for the location of GSM masts in the study area.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations are made:

i. Service providers should embrace the idea of co-location of telecommunication infrastructures as advised by the regulatory bodies (NCC and NESREA) which reduce operational cost due to duplication of same facilities and to avoid clustering of mast in the environment. This means several telecommunication providers can use same mast which ultimately reduces the number of masts over space.

ii. There is need for awareness and sensitization to the general public by relevant regulatory bodies (NCC and NESREA) through the land owner's union or community based associations on the risk involved with residing in close proximity to a telecommunication mast. These programs should be carried out through land owner's union or community based association to improve the knowledge of the general public about hazards involved with these practices and to curb future lease of land properties to telecommunication companies without investigating the purpose the land is intended for.

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