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Spatial Distribution of Base Transceiver Stations in Ile Ife, Nigeria

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Abstract
This paper assesses the spatial distribution of base transceiver stations (BTS) in Ile-Ife, Nigeria. The multi stage sampling technique was employed in the study. The first stage involved the identification of BTS, 50 were identified across the study area, and these were used to obtain information about the physical and locational characteristics of the BTS. Twenty three (23) of the BTS with buildings in their immediate environment were purposively selected. In establishing the location and pattern of distribution of the BTS in Ile-Ife, the nearest neighbor analysis was used. The study revealed a high concentration of BTS erection in area with high concentration of people especially where we have higher institutions and n few residential areas of Ile-Ife. The study further revealed that the distribution of BTS in Ile-Ife are in random form with Rn value of 0.21 and negative z-score (-69.46) which indicates that the BTS are clustered rather than being random or dispersed. The study therefore concludes that telecommunication operators or service providers should be encouraged to adopt the method of collocation which enables different service providers to connect to a mast at a particular place in time. This is done in order to reduce clustering of masts in the study area.
Keywords: Base transceiver stations, Location, NCC, Spatial distribution, Telecommunication mast
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1. Introduction

The need for functional telecommunication networks to service the desires of users for effective communication, and the use of mobile phones have increased dramatically over the decades (Adebayo, 2012). This has given birth to the development of Global System for Mobile Communication (GSM) in 1982. GSM is one of the widest expanding and most demanding telecommunication applications in the world today (Shalangwa, 2010) and according to Bello (2010) GSM has become a significant and an indispensable tool of transmitting or exchanging information for the modern man.

According to NBS (2015), there are four major GSM providers in Nigeria. These are MTN, Airtel, Globacom and 9mobile. MTN has the highest subscribers with 61.21 million (42.8%), followed by Globacom with 21.0%, Airtel with 20.5% and 9mobile with 22.3 million (15.7%) subscribers. The subsequent growth in the number of users of cell phones in the last decades has led to substantial increase in the need for greater telecommunication coverage across the States in Nigeria. The operation of the GSM in the country has brought about growth in the economy and reduction in unemployment (Adamu, 2016). It also encouraged easier access to communication. The new technology introduces new elements into the built environment of Nigerian cities such as the Base Transceiver Station (BTS). Base Transceiver Stations and Masts form part of the basic infrastructure required for an effective telecommunication system (Oruonye *et al,* 2021). There hardly exists a city in the country today where BTS are not erected. BTS are located very close to the target users in order to have optimal access and network coverage in places where they are mostly needed (Bond *et al*, 2003) The importance of telecommunication cannot be over-emphasized. This is because telecommunication has been the main source of communication in terms of dissemination of information globally. Telecommunication companies are faced with the problem of Base Station capacity as the number of subscribers increase. This brought about the introduction of more Base Stations in order to meet the demand for good and reliable coverage (Musa *et al*, 2016). This demand has brought about haphazard and unsystematic erection of Base Transceiver Stations (BTS) across the States of Nigeria (NCC, 2014). Therefore, indiscriminate location of BTS can affect both the environmental and aesthetic value of a particular area. Environmental impact such as fire and explosion from the mast, accidental collapse of mast, falls and injuries arising from maintenance of masts, even obstruction to flight navigation among others are caused as a result of indiscriminate erection of BTS in some area and without recourse to the environment (Umar, 2009).

Studies of Christchurch (2007); Onifade *et al* (2014); Odunola *et al*, (2015) established that residents' living closer to telecommunication mast are affected in various ways which have resulted into several negative impacts

on the people of the immediate environment; some of these impacts include partial deafness, effects on television/radio reception, pollution of the underground water around the mast location resulting from diesel from generating set which can lead to typhoid, dysentery and diarrhea, among others. Abdel-Rassoul *et al* (2006) also reported that people living close or near telephone mast in Egypt are living with the occurrence of dizziness, several cancer cases such as cancer of the breast, cancer of the lung, lymphoma, leukaemia and haematopoietic cancer. Kulkarni and Grandhare (2012); Boniface and Udochukwu (2012) also established the adverse effect of living close to the BTS to include migraine, insomnia (lack of sleep) and sudden movement of body parts. Although all these studies were concentrated on the environmental impact of telecommunication Base Transceiver Stations but the physical and locational characteristics of the BTS were not considered in which this study intends to examined.

2. Literature Review

2.1 Nigerian Communications Commission (NCC)

The telecommunication industry was deregulated in 1992 and was spitted into two forms; these include NITEL which was commercialized and the establishment of the Nigerian Communications Commission (NCC) which serves as the telecommunication industry regulator in the country (Sadiq *et al*, 2011). The authority regulating the operation of the telecommunication industry in Nigeria is the Nigerian Communications Commission. NCC emerged from the deregulation of the telecommunication sector by the Federal Government in 1999. Due to the liberalization and reformation of the sector which opens room for GSM licenses in 2001 with two telecommunication giants namely Econet Wireless communications (now Airtel) and MTN communications later the entrants of Globacom, Multilinks, Zoom, Visafone, Etisalat, Starcom (Ogboru, 2013). The Commission is governed by the Nigerian Communications Commission Act No. 19, 2003. The Commission was established with the responsibility for creating an enabling environment for competition among operators in the industry as well as ensuring the provision of qualitative and efficient telecommunication and services throughout the country (Sadiq *et al*, 2011). It also helps in publication and specifying of technical code and specifications in respect of communications equipment and facilities in use in Nigeria.

NCC developed guidelines on installation of telecommunication masts and towers in 2004 according to Section 136 (3) of the NCC Act, 2003 which was later amended in 2009, aimed at ensuring environmental safety and sound practice in the sector especially to protect the safety of persons and property (Ogboru, 2013). The guidelines provides standards to be adhered to by telecom operators, designers, fabricators and installers of telecom towers towards ensuring environmental safety and sound engineering practice in the sector (NCC, 2009). The NCC Guidelines 2009 also state that five meters should be a setback for towers away from the existing property apart from the fence. The location of the generating set within the base station must be five meters from the properties excluding the fence (NCC, 2009). The conformity of setback for all towers in their location especially within the residential areas is important in order to reduce the effect of heat, smoke and noise pollution from the generators (NCC, 2009). According to the National Environmental Standards for Telecommunications and Broadcast Facilities Regulations (2011) GSM BTS are expected to be located 10 metres away from an existing perimeter wall (fence) of residential/business premises, schools and hospitals. In cases where there is no perimeter fence, the BTS should be erected within the distance of 12 meters and above away from external wall of existing building. This is done in order to ensure that the installation and operation of telecommunications and broadcast base stations and masts do not constitute public nuisance or negative impacts on the public health and safety.

2.2 Base Transceiver Station

Zunia (2011) referred to BTS as a site where antennas and electronic communications equipment are placed to create a cell in a mobile phone network (cellular network). A Base Station can cover a straight distance of 4km in each direction depending on the topography of the location. Radio frequency electromagnetic fields are used to transfer signals between mobile phones and a network for mobile or normal telephony. In order for a base station to cover 360 degrees, it requires three transmitters to operate. Base Transceiver Stations (BTS) are found ubiquitously especially near or in homes, hospitals, shops, day care centres, offices. Base stations are mostly located in residential areas for reasons which include; a closer location to the users in order to have good communication quality (Adamu, 2016; Adeyinka *et al,* 2018).

2.3 Factors that influences the erection of telecommunication masts

Several factors are considered in locating a site for base transceiver stations. All these factors are considered by the service provider in order for the base stations to serve the required population and also maximize their economic profit in their various locations. A site that is meant for erection of mast should double the height of the tower (if the height of a tower is 50 metres, the site should be 100 x 100 square meters)

According to Omole (2006); Alesheikh and Golestani (2011), the factors that influences the location of base

stations include the following;

i. The elevation of the identified place on the earth surface should relates to the surrounding area
ii. Direction of expansion of telecommunication service of the proponent
iii. The need to preserve and conserve places and sites of monumental, architectural and historic importance
iv. Proximity to population centres
v. Distance from neighbouring stations
vi. The ease of using existing utility
vii. The magnitude of environmental pollution parameters

Other factors include weight and disposition of all feeders and cables, wind drag on each element of the array and dependent on wind direction, the available ground area and access to the site, the geological nature of the site, the overall cost of land, foundations and structure, the cost and implications of future maintenance or structural replacement, any special planning considerations imposed by statutory bodies, directions for the various directional antennas and the aesthetic appearance of the structure (Stottrup-Anderson, 2009).

There are factors which are mostly considered in locating base stations based on the order of their importance. Population is considered to be the most importance among others. The fact that population is the most important factor considered in locating base station has posed a problem to their location especially in highly populated area as there will be scarcity of land in such area.

3. Materials and Methods

3.1 The Study Area

The study area is Ile Ife in Osun State. Ile Ife is located in Osun State, South-Western part of Nigeria. It comprises of two Local Government Areas (LGAs) Ife Central and Ife East LGAs and it covers a landmass of about 283 kilometer square (110 square miles). It is located between latitude 7º 28′N and 7º 45′N and longitude 4º 30′E and 4º 34′E of the Greenwich Meridian with an altitude of 286m. The area is bounded in the north by Ede North and Atakumosa West LGAs in the East, in the West by Ife North LGA and Ife South in the South as shown in Figures 1 and 2.

Figure 1: Osun State in the National Context

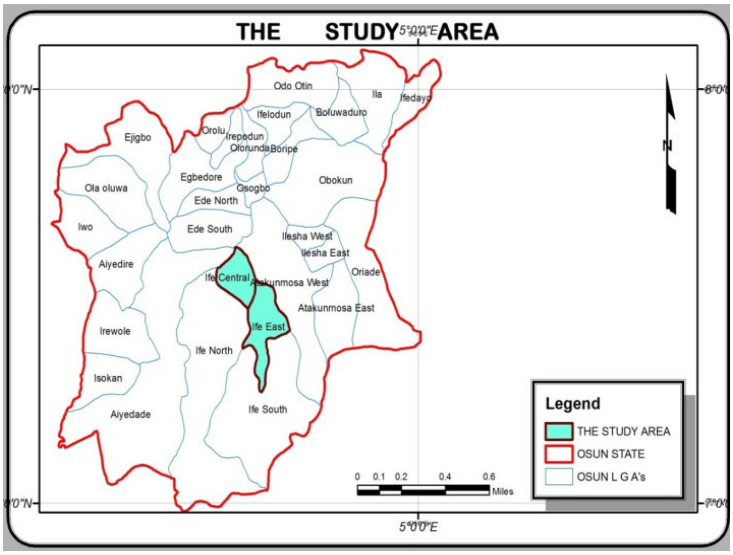


Figure 2: Map of Osun State showing Ife Central & Ife East LGAs

The projected population of Ile Ife for 2021 is 384,863. The population comprises of the Ife indigenes and non-indigenes from other parts of the country. The indigenous economic activity of the people in the city involves administrative works and agriculture such as farming (production of cash crops such as cocoa, Palm Oil, Kolanut, Cotton), fishing and hunting (Olajuyigbe, 2016). The area is covered with good and efficient telecommunication services provided by both public (Federal and state governments) and private organizations. The provision accommodate the use of Global System for Mobile communication (GSM), telephone and other internet facilities which increases the number of GSM phone users in the region.

3.2 Research Method

The multi-stage sampling technique was employed in the study area. The first stage involved the identification and geo-referencing of the Base Transceiver Stations (BTSs) of the four major Global System for Mobile communication (GSM) service providers that are located in Ile-Ife, the service providers includes: MTN, 9Mobile, Airtel and Globacom. Fifty (50) BTS were identified (Table 1) and they were used to obtain information about the physical and locational characteristics of the BTS. The next stage involved the identification of buildings located within 0 - 100meters, 101 - 200meters and 201 - 300 meters to the BTS, twenty three (23) BTS were purposively selected (Table 2), these are BTS with buildings located in their immediate environment. The handheld Global Positioning System (GPS) was used in geo-referencing the location of the identified BTS in the study area. The Nearest Neighbour Analysis was used in establishing the location and pattern of distribution of base transceiver stations in Ile-Ife.

Table 1: Total Number of BTS in Ile-Ife

S/N	Location	Number of BTS
1	Arubidi	1
2	OAUTHC (General)	4
3	Iloro Road	2
4	Oke-Ogbo	2
5	Fajuyi	1
6	Isale Agbara	2
7	Powerline	1
8	Igboya	1
9	Parakin	2
10	Eleyele	2
11	Adesanmi	2
12	Fasina	2
13	Opa	1
14	Mayfair	3
15	Mopol	2
16	Aladanla	1
17	Ilesa Garage	1
18	Palace Area	1
19	Ife City	2

20	Lagere	2
21	OAU	10
22	Modomo	2
23	Ilode	1
24	Ede Road	2
	Total	**50**

Source: Authors' Compilation, 2021

Data that were collected include nature of location (subdivided plots, dedicated plots, roof tops, organized open spaces, incidental open spaces), nature of adjacent land uses (residential, commercial, recreational, others), types of roads adjacent to base stations (expressway road, arterial road, distributor roads and local roads), height of the mast, land size, material used, the floor characteristics. Descriptive statistics such as mean, frequency distribution and percentages was employed in the analysis.

Table 2: Total Number of Buildings in the selected BTS within 300m Radius

BTS Location	0 – 100 meters	101 – 200 meters	201 – 300 Meters	Total Buildings (Sampling Frame)	Sample Size (10%)
Ede Road	33	44	54	131	13
Adesanmi	35	33	24	92	9
Mopol	13	12	29	54	5
Powerline	19	43	66	128	13
Modomo	22	56	42	120	12
Nasfat	6	19	5	30	3
Fasina	4	12	4	20	2
Parakin	30	56	54	140	14
Mayfair	66	85	81	232	23
Igboya	30	85	117	232	23
Eleyele	49	109	66	224	22
Aribidi	25	82	154	261	26
Lagere	29	108	162	299	30
Palace Area	24	57	134	215	22
Iloro Road	57	115	122	294	29
Oke Ogbo	48	84	91	223	22
Ilode	34	51	80	165	17
Opa	13	26	41	80	8
Ife City	21	44	78	143	14
General	28	48	52	128	13
Aladanla	16	33	32	81	8
Ilesa Garage	18	63	77	158	16
Fajuyi	24	49	56	129	13
Total	**644**	**1314**	**1621**	**3579**	**357**

Source: Authors' Compilation, 2021

4. Results and Discussion

4.1 Spatial Distribution of Base Transceiver Stations

It has been established that distance to facilities is an important determinant of accessibility to the use and patronage of any facility (Olugbamila, 2016). The availability or location of a particular facility will determine its patronage. In determining and establishing the spatial distribution pattern of Base Transceiver Station in the study area, the nearest neighbour analysis (NNA) was employed to determine statistically the existing pattern of distribution whether it is random, regular or cluster in the different radius within the location of BTS in Ile-Ife. The model shows the level at which any observed distribution deviates from what may be expected, if the distributions of points are uniform, random or dispersed. The coordinates of the various location of Base Transceiver Stations in the study area were captured through handheld Global Positioning System (GPS) as presented in Table 3 and the spatial analysis were carried out in the GIS platform. The nearest neighbour analysis ranges from 0 (when there is no distribution at all that is clustered pattern) to 1 (randomly dispersed pattern) to 2.15 (regularly dispersed/uniform pattern). The closer the calculated index value is to zero, the more clustered the distribution and conversely, also the closer the calculated index value is to 2.15, the more dispersed the distribution (Omole, 2002 cited in Olugbamila *et al*, 2021). This can be categorically explained as;

Rn = 0; the distribution is clustered

Rn = 1; the distribution is random

Rn = 2.15; the distribution is regular

The data in Table 3 is the geographical location/coordinates of the 50 Base Transceiver Stations spread across Ile-Ife and owned by the four major service providers which include MTN, Airtel, 9mobile and Globacom. The coordinates was used to show the spatial distribution of the BTS in the study area which is presented in Figure 3.

Table 3: Geographical Location of BTS in Ile-Ife.

Location	Latitude	Longitude	Service Providers
Arubidi	7.484483	4.553502	MTN
OAUTHC 1	7.504736	4.573752	AIRTEL
OAUTHC 2	7.505670	4.574440	MTN
OAUTHC 3	7.505670	4.574440	9Mobile
OAUTHC 4	7.503742	4.572825	GLOBACOM
Iloro Road 1	7.489751	4.565054	MTN
Iloro Road 2	7.489120	4.563815	AIRTEL
Oke-Ogbo 1	7.486456	4.573216	MTN
Oke-Ogbo 2	7.485508	4.572158	9Mobile
Fajuyi	7.495533	4.561681	MTN
Isale-Agbala 1	7.481009	4.574667	MTN
Isale-Agbala 2	7.485508	4.572158	GLOBACOM
Powerline	7.494162	4.499616	GLOBACOM
Igboya	7.502962	4.557185	MTN
Parakin 1	7.490414	4.534534	MTN
Parakin 2	7.493482	4.533395	9Mobile
Eleyele 1	7.490587	4.546316	AIRTEL
Eleyele 2	7.492115	4.547799	MTN
Adesanmi 1	7.497808	4.512608	AIRTEL
Adesanmi 2	7.499400	4.513483	MTN
Fasina 1 (NASFAT)	7.493362	4.485969	AIRTEL
Fasina 2	7.479857	4.479857	MTN
Opa	7.516033	4.577785	GLOBACOM
Mayfair 1	7.488779	4.531122	MTN
Mayfair 2	7.490384	4.529073	AIRTEL
Mayfair 3	7.488081	4.532654	GLOBACOM
Mopol 1	7.495317	4.509169	MTN
Mopol 2	7.495005	4.509295	AIRTEL
Aladanla	7.500233	4.569802	GLOBACOM
Ilesa Garage	7.496816	4.567993	AIRTEL
Palace Area	7.483377	4.559797	MTN
Ife City 1	7.509597	4.577555	MTN
Ife City 2	7.509691	4.577912	GLOBACOM
Lagere 1	7.486138	4.565054	MTN
Lagere 2	7.486153	4.544335	AIRTEL
OAU 1	7.504946	4.524312	MTN
OAU 2	7.515571	4.528886	MTN
OAU 3	7.518027	4.511903	MTN
OAU 4	7.515961	4.514001	MTN
OAU 5	7.517431	4.513370	AIRTEL
OAU 6	7.503346	4.523526	AIRTEL
OAU 7	7.506737	4.519934	9Mobile
OAU 8	7.515326	4.529271	9Mobile
OAU 9	7.520472	4.517395	GLOBACOM
OAU 10	7.519367	4.519890	GLOBACOM
Modomo 1	7.493516	4.488707	MTN
Modomo 2	7.501393	4.495792	9Mobile
Ilode	7.481501	4.577125	MTN
Ede Road 1	7.499268	4.515928	MTN
Ede Road 2	7.503770	4.509112	AIRTEL

Source: Authors' Compilation, 2021

The data in Table 3 were used to display the spatial distribution of Base Transceiver Stations in Ile-Ife as

shown in Figure 3. There are high concentration of BTS erection in the area where there are higher institution such as Obafemi Awolowo University (OAU) campus and Obafemi Awolowo University Teaching Hospital Complex (OAUTHC) where we have 10 and 4 BTSs respectively and few ones distributed towards the residential areas of the study area such as Modomo, Parakin, Igboya, Isale-Agbara among others. The spatial distribution indicating different service providers is illustrated in Figure 4.

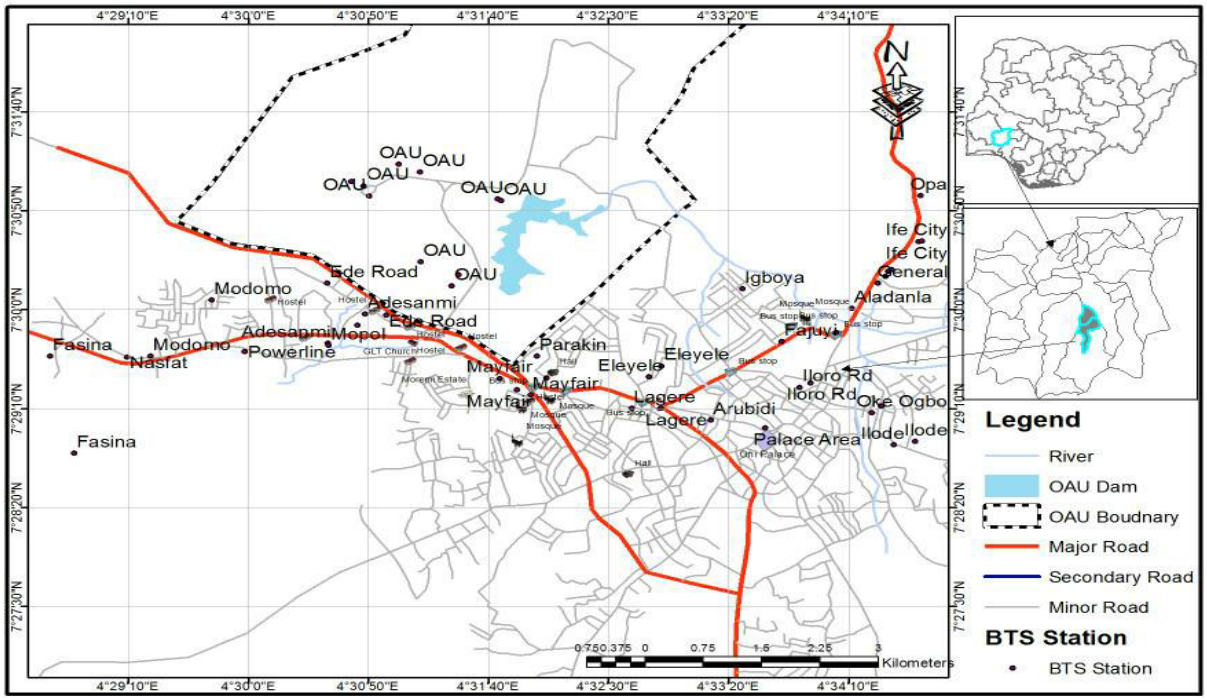


Figure 3: Spatial Distribution of BTS in Ile-Ife
Source: Authors' Compilation, 2021

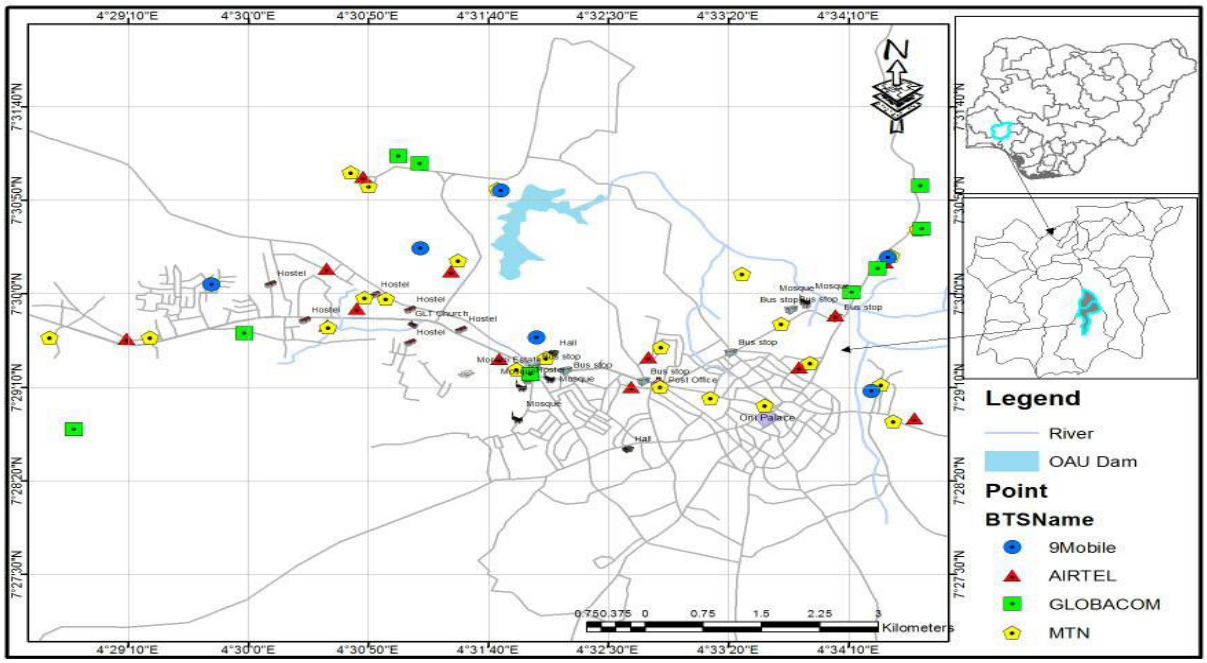
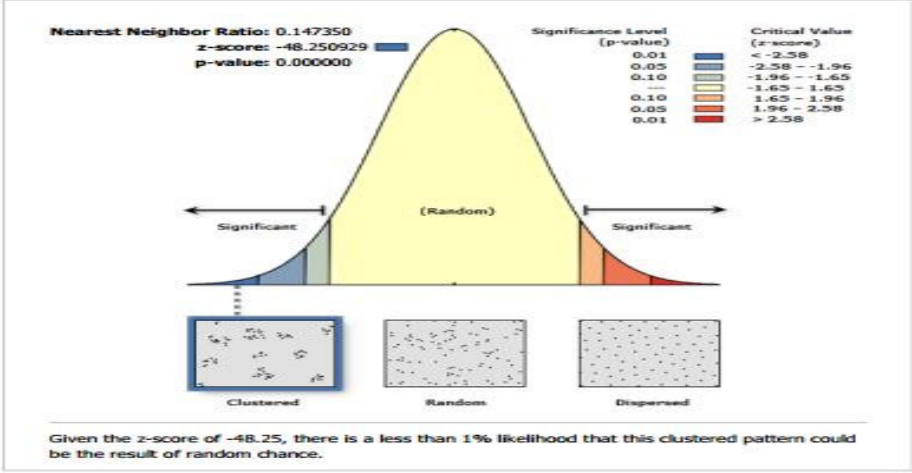


Figure 4: Spatial Distribution of BTS indicating different Service Providers.
Source: Authors' Compilation, 2021

This implies that BTS were erected in areas where there are large population (target consumers) This corroborated the work of Bond *et al* (2003) and Oruonye *et al* (2021) that BTS are located in close proximity to the target users and in the densely populated areas of the town in order to have optimal network coverage in places where they are mostly needed. Among the four service providers MTN, Airtel, 9Mobile and Globacom, MTN masts dominate the study area with the total number of 23(46%) which is almost half of the BTSs present

in the study area, this is followed Airtel 12(24%), Globacom 9(18%) and 9Mobile 6(12%) (See Table 3).

The nearest neighbour analysis for the spatial distribution of BTS in Ile-Ife in the three different categories of distance (0 -100m, 101 – 200m and 201 – 300m) are presented in Figures 5, 6 and 7 respectively. It all revealed a particular spatial pattern of distribution that is clustered. .In analyzing the pattern of distribution of BTS in the first category of distance (0- 100m) as shown in Figure 5, the Nearest Neighbour Index (Rn) of 0.15 indicates that the distribution pattern of buildings around the BTS(s) were clustered though with an emerging signs of a tendency towards an irregular distribution.



Average Nearest Neighbor Summary

Observed Mean Distance:	0.000151 Degrees
Expected Mean Distance:	0.001025 Degrees
Nearest Neighbor Ratio:	0.147350
z-score:	-48.250929
p-value:	0.000000

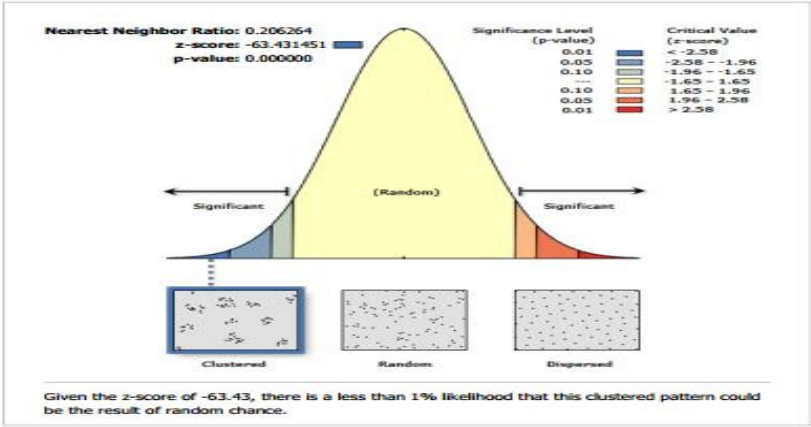
Dataset Information

Input Feature Class:	100m
Distance Method:	EUCLIDEAN
Study Area:	0.003679
Selection Set:	False

Figure 5: Nearest Neighbour Analysis of Distribution of BTS in Ile-Ife within 0 – 100m
Source: Authors' Compilation, 2021

Figure 6 shows the distribution pattern of BTSs in the second category of distance (101 – 200m), the result of the analysis showed a Rn of 0.21 with a Z-score of -63.43 indicating that the distribution of BTSs were clustered than being random or dispersed.

The result of the NNA for the third category of distance (201 – 300m) presented in Figure 7 shows that the pattern of distribution of BTSs were clustered as the other distances are with a Rn of 0.21 which is far lesser than 1 with a Z-score of -69.46.



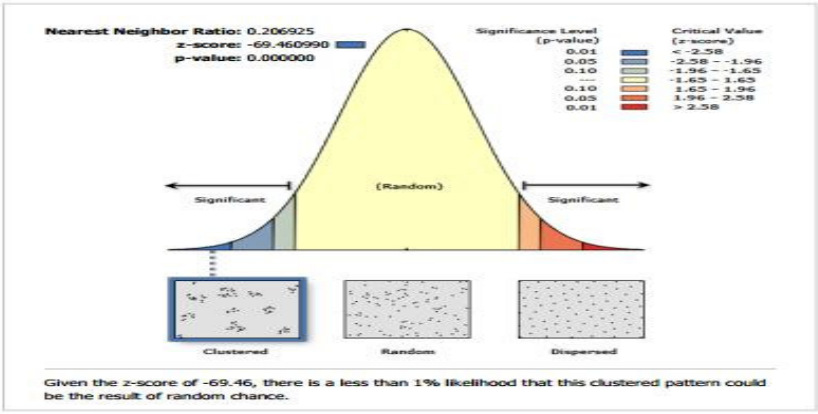
Average Nearest Neighbor Summary

Observed Mean Distance:	0.000156 Degrees
Expected Mean Distance:	0.000755 Degrees
Nearest Neighbor Ratio:	0.206264
z-score:	-63.431451
p-value:	0.000000

Dataset Information

Input Feature Class:	200m
Distance Method:	EUCLIDEAN
Study Area:	0.003976
Selection Set:	False

Figure 6: Nearest Neighbour Analysis of Distribution of BTS in Ile-Ife within 101-200m
Source: Authors' Compilation, 2021



Average Nearest Neighbor Summary

Observed Mean Distance:	0.000146 Degrees
Expected Mean Distance:	0.000707 Degrees
Nearest Neighbor Ratio:	0.206925
z-score:	-69.460990
p-value:	0.000000

Dataset Information

Input Feature Class:	300m
Distance Method:	EUCLIDEAN
Study Area:	0.004195
Selection Set:	False

Figure 7: Nearest Neighbour Analysis of Distribution of BTS in Ile-Ife within 201-300m
Source: Authors' Compilation, 2021

5.0 Conclusion

Telecommunication is very important in any sector of the economy. This ranges from global, regional and local system for communication both in the developed and developing nations. Mobile communication is one of the widest growing and most demanding telecommunication applications in the world today. In this regard, this research work has investigated the spatial distribution of Base Transceiver Stations (BTSs) in Ile-Ife, Osun State.

The spatial distribution is determined by the use of Nearest Neighbour Analysis. It was used to statistically determine the existing pattern of distribution in the study area. The calculated Rn as obtained for the first category of distance (0 – 100m), the second distance (101 – 200m) and the third distance (201 – 300m) were

0.147350, 0.206264 and 0.206925 respectively. This revealed one particular pattern of spatial distribution which is clustered. Based on this, the study established that spatial distributions of available BTSs are unevenly distributed in Ile-Ife, Osun State. On the above premise, it is therefore recommended that telecommunication operators or service providers should be encouraged to adopt the method of collocation which enables different service providers to connect to a mast at a particular place in time. This is done in order to reduce clustering of masts in the study area.

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