ANALYSIS OF THE SPATIAL DISTRIBUTION OF GLOBAL SYSTEM OF MOBILE COMMUNICATION BASE STATIONS IN ZARIA URBAN AREA, KADUNA STATE, NIGERIA

By

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ABSTRACT

The geographic spread of telecommunication masts, particularly Global System for Mobile communication (GSM) in urban Zaria has painted a very noticeable aerial picture of the city, yet worried of indiscriminate installation of the base stations and the claims that the masts radiate electromagnetic field (ETF) rays which are injurious to health, this study analyzed the spatial distribution of GSM base stations (masts) in Zaria Urban area, Kaduna State, Nigeria. The existing base stations (masts) were identified and mapped using World Health Organization (WHO) (2007) regulations for locating a GSM Base Stations; that Mast should be erected ten (10) metres away from the residential areas. Spatial data of the GSM base stations (masts), Quickbird Satellite image of urban Zaria, Record from field survey, Geographic Positioning System (GPS), various service providers and Nigeria Communication Commission (NCC) were used for the study. The criteria for the location and distribution of the base station masts were also tested using the 10m buffer zone tests. The result revealed 116 GSM Base Stations in the study area, out of which only 16 masts complied, while the remaining 100 do not comply with the standard of WHO. Finally the spatial distribution of these facilities within the residential areas also exposes such areas to the effect of electromagnetic radiations. The regulatory agencies should keep checks on service providers that violate the 10m of siting GSM Base stations away from residential areas and remove the wrongly sited masts. Finally there should be proper awareness to the public media and schools on the possible health risk of electromagnetic radiations for people living close to GSM Base stations.

Key words: Distributions, GIS, GSM Base Station, Health Hazard

INTRODUCTION

Mobile telecommunication is one of the most exciting technologies in the world. It is a sign of technological innovation which heads to crucial development; it also increases productivity, income, quality of life and life expectancy. Telecommunication plays an important role on development, contract, exchange of information and trade (Idzi, 2007). Telecommunications are evolving towards personal communication networks, whose objective can be stated as the availability of all communications service anytime, anywhere to any one by a single identity number and pocket-able communication terminal (Oloucha and Ogbale, 2007).

Mobiles are central to information and communication technology (ICT) Information and communication technology can be referred to as the means and method for transmitting information, message ideas from one place to another. It provides a space communication referred to as cyberspace which is often connected. 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 metamorphosed to Vmobile, Zain and now Airtel. Today, there are several operators across the nation, among the existing ones in Urban Zaria include: Etisalat, Globacom, Startcomms, Visafone, 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 effects of mast on city dwellers can be complex. There are silent long term problems that may affect the residents' health. In United States for instance, masts have been associated with cancer and other grave illnesses. Occurrence like fatigue, headache, decreased concentration, dizziness, local irritation, tumour induction, sperm motility, morphology and viability, cancer, especially brain tumour and leukaemia, viral and infectious diseases has been blamed on living within 1-5km distance from masts in Dunganon (Abdel, Batanouny and Salem, 2007). There have also been issues related to the fact that some of the mast that are erected are not very strong and there have been cases of towers that have fallen down to cause fatal accident and other nuisance to the environment. The vibration and noise from the generators in the host neighborhood also impair the residents' peaceful living (Bortkiewitz, Zmyslony and Gadzicka, 2004).

In 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 $50w/m^2$ and $200w/m^2$. Some waves emitted by some masts are not hazardous but most masts emit more than $100w/m^2$ which is said to be hazardous if human being stays around the mast for a long time (Abdel, Batanouny and Salem, 2007).

Both the World Health Organization (WHO) and Federal Ministry of Health (2007) confirmed that, research has been able to provide support for a causal relationship. But given the large number of mobile phone users, it is important to investigate, understand and communicate any potential public health impact from mobile phones and masts, which work by transmitting radio waves through a network of fixed antennas called base stations.

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). 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; Jones, 2005; Galati, 2006).

Although many studies on GSM Base Station have made an appreciable effort, a good example is found in the work of Iortile and Agba (2014), examined the radiofrequency radiation distribution

around mobile base stations in Makurdi, Benue State, Nigeria using electromagnetic field tester (EMF 827, Lutron) to ascertain the radiofrequency field levels of some selected MTN and AIRTEL base station at a distances approximately 10.00 metres to the north, south, west and east for each base station respectively. Their result shows that the average magnetic field level of the base station ranged between 0.09ut to 0.15ut. The mean electric field values for eye, brain and muscles ranged between 18.81 vm-1 to 31.55vm-1 and the specific absorption rate (SAR) ranged between 0.18 Wkg-to 1.03 Wkg-1for the networks. In conclusion, the radio frequency emitted by the GSM base stations are within standards of the regulatory agencies and has no health risk to residence found within the study area.

Likewise Akin and Margaret (2014), studied location adequacy of Telecommunication Masts and residents livability in Osogbo, Nigeria. Their result shows that there were more MTN masts (45.7%) in the area. This is followed by Glo (20%), Airtel (17.14%). Multilinks and Starcommshas 8.57% each has 2.86% of the total masts in the area. The radiations coming from these mastsaccording to radiologist are electromagnetic waves, RF radiation and infrared. These radiations are capable to cause: epilepsy, leukemia and different types of cancer. This implies that residents living very near these masts are at risk.

Danraka (2010) examined the distribution of Zain base stations in Kano metropolis using GIS technique. The pattern was related to the concept of central place theory. His result shows that, the impact of Zain base station is perceived with high response of people using the network and more business own phone rather than private users. 70 percent of the respondent indicates a regular network provide by Zain and only 30 percent experience a network failure and actions were taken from the network providers for proper and stable network. The study recommended the use of cellular radio communication system due to high cost associated to construction of base stations. Also different telecommunication network companies should share a single base station in a particular geographical area.

It could be seen that, many studies as cited before now have contributed correspondingly on the subject matter in Nigeria. Yet it is still not known whether GSM base stations in urban Zaria are distributed in harmony with the recommended standards in anticipation of the claimed effects in Zaria urban area, Kaduna state, Nigeria.

Ultimately, the geographic appearance of telecommunication masts in urban Zaria has painted a very noticeable aerial picture of the city, yet worried of indiscriminate installation of the base stations and the claims that the masts radiate electromagnetic field (ETF) 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 (Emma, 2012). Also, increase in population growth and the easier access of communication between individuals has necessitated the increase in number of the facilities across the city to the extent that residential areas have become signal transmitting stations. It is very common to find erected masts located within residential areas in the study area. Using Remote Sensing and GIS technique, this study is set to analyze the spatial distribution of GSM Base stations in urban Zaria area. To achieve the aim, the specific objectives are set to identify and map GSM Base Stations in the study area and map out areas vulnerable to the health hazards related to electromagnetic radiation from GSM Base Stations in the study area.

THE STUDY AREA

Urban Zaria Area is located on Latitudes 11^0 03´ N - 11^0 12´ N and Longitudes 7^0 35´E - 7^0 45´E and is about 686 m above sea level. In terms of total land area, it covers about 45,567 km^2, with a population of 6,066,562 people as at 2006 (NPC, 2009). The space economy of the town is comprised of industrial, commercial, educational residential agricultural and transportation land uses. It consists of two Local Government Areas; Zaria Local Government and Sabon-Gari Local Government. The area spread from Shika sub-settlement in the North to Dutsen Abba sub-settlement in the south west and from Dambo sub-settlement in the east to Wusasa sub-settlement in the west as seen in (Figure 1).

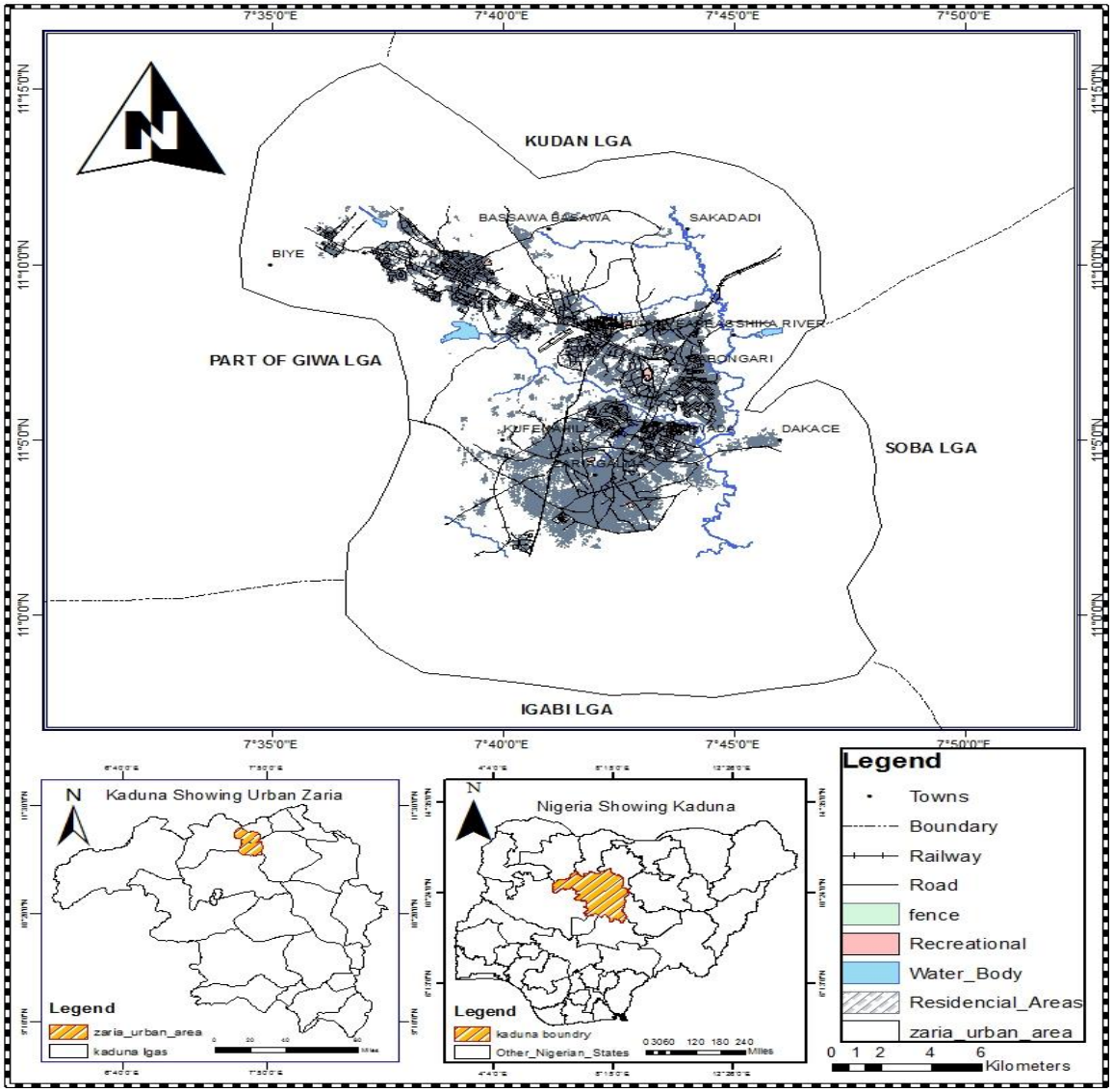

Figure 1: Urban Zaria (Study Area)
Source: Modified From Ministry of Land and Physical Planning (2016).

MATERIALS AND METHODS

A reconnaissance was carried out as the first step in the execution of this paper so as to have an insight into the work to be done and to aid accurate decision making during execution of the paper.

Types and Sources of Data

The data for the study were both primary and secondary data source. The primary source which include, coordinates (longitude and latitude) of the base stations were collected using global positioning system (GPS) and Quick bird Satellite image. While the Secondary source were used to gain background information about the address, location and number of the Base Stations from each service provider and NCC (Nigeria Communication Commission).

Analytical Method

To identify and map GSM Base Stations in the study area, the database was imported into Arc GIS environment and the data containing the relevant vector Shape files were checked in ArcGIS environment to create a visual map of point and polygon features classes. The X and Y coordinate of the facilities has then automatically displayed the locations of all the base stations on the map. This shows the distribution of the facilities across the study location.
To map out areas vulnerable to health hazards related to electromagnetic radiation and health implications from GSM Base Stations in the study area; all the facilities were 10m buffered within the software environment, so that proximity analysis to the Residential areas were done to show the residential areas that fall within 10m radius of the Base Stations.

RESULTS AND DISCUSSION

Identifying and Mapping GSM Base Stations in Zaria Urban Area

The tables below and Figure 2 are the coordinates and the generic map for the study area at a glance. This shows the spatial distribution of GSM Base stations in Zaria urban. The data in Table 1 is the Geographical Location/Coordinates of 23 Airtel land masts which were spread across Zaria Urban area. The Coordinates was used to create the spatial distribution of Airtel base station later in Figure 2.

Table 1: Geographical Location/Coordinates of Airtel GSM Base Stations in Zaria Urban Area

SERVICE PROVIDER	COORDINATES		LOCATION
AIRTEL	EASTING	NORTHING	
A1	358331	1225165	Along Kofar Doka - Dan Magaji Road Behind 7up
A2	358634	1222501	Kaura Rimi Doko
A3	359108	1222653	Amaru behind former magajin Gari house
A4	356809	1222015	Durumi Zaria city
A5	358018	1220651	Kofan Gayan
A6	359291	1222839	Anguwar Liman Zaria city
A7	357918	1222618	Durumi Zaria city
A8	359863	1223544	Banzazzau near child care hospital
A9	359245	1224457	Kofar Doka
A10	357931	1222343	Kan Fage Zaria city
A11	358330	1222639	Babban Dodo Turaki Ismaila Road
A13	360404	1226038	Kongo near Garajin Jaji
A14	357605	1228656	Benz Shop
A15	361578	1224762	WTC
A16	356854	1225459	Dan - Magaji behind Mamuda Garage
A17	362132	1228438	Dogon Bauchi Sabon Gari
A18	360302	1227377	Behind PZ Building
A19	360357	1227695	Total premises PZ area
A20	353277	1233332	ABU main Campus
A21	352783	1233748	Behind Mr. Biggs
A22	385338	124114	Near Energy Research Gate
A23	385462	123987	Zango

The data in Table 2 is the Geographical Location/Coordinates of 38 MTN land masts which were spread across Zaria Urban area. The Coordinates was used to create the spatial distribution of MTN base station later in Figure 2.

Table 2: Geographical Location/Coordinates of MTN GSM Base Stations in Zaria Urban Area

SERVICE PROVIDER	COORDINATES		LOCATION
MTN	EASTING	NORTHING	
M1	356658	1221679	lowcost opposite police station
M2	358543	1222427	Anguwar Liman
M3	359354	1223417	Kwarbai near Nabara house
M4	358841	1223105	Emir's Palace
M5	359655	1223271	Madarkachi near Mai Anguwa house
M6	357587	1222774	Anguwar Juma Zaria city
M7	356929	1221356	Lowcost opposite central Mosque
M8	357035	1221759	Kofar Kuyambana Zaria city
M9	358373	1222663	Babban Dodo Zaria city
M10	358631	1222149	Kaura Kwan Kira
M11	360156	1223886	Ban-Zazzau Zaria City
M12	359424	1225590	Near Albarkawa Estate property agency Tudun Wada
M13	359939	1226611	Agoro, behind Baba trader house
M14	358286	1226347	Emir Road Gaskiya Layout
M15	361589	1226233	Gyallesu
M16	358979	1226357	Gaskiya Cooperation
M17	361426	1224770	WTC
M18	361688	1224327	Jos Road
M19	356851	1225461	Danmagaji Behind Mamadu Garege
M20	361076	1229542	BATC (Tobacco)
M21	360481	1230987	Dogarawa
M23	360544	1231353	Dogarawa
M24	356339	1232396	NITT
M25	355645	1235379	NARICT
M26	361775	1228321	Sabon Gari Jafaru Road
M27	359847	1229896	MTD
M28	362145	1229735	Sapele Road Sabon Gari
M29	358577	1230156	Hanwa highcost
M30	360163	1227831	Behind police Head Quarters
M31	352766	1233789	Opposite North Gate
M32	351504	1234645	DAC Agric
M33	350713	1236516	Bomo Samaru
M34	352752	1234217	Samaru
M35	349816	1235242	Area G
M36	353242	1233395	Main Campus
M37	385014	124286	Agric police station
M38	385431	124063	Zango Filling Station

The data in Table 3 is the Geographical Location/Coordinates of 11 Starcomms land masts which were spread across Zaria Urban area. The Coordinates was used to create the spatial distribution of Airtel base station later in Figure 2.

Table 3: Geographical Location/Coordinates of Starcomms GSM Base Stations in Zaria Urban Area

SERVICE PROVIDER	COORDINATES		LOCATION
STARCOMMS	EASTING	NORTHING	
S1	359943	1221761	Anguwar Liman Zaria City
S2	359805	1224751	New Jos Road near HEBN Publisher PLC
S3	359073	1226401	Gaskiya Cooperation
S4	359188	1228221	Road D, off western way GRA
S5	361315	1226201	Gyellesu
S7	361496	1229322	Kings Road Sabon Gari
S8	357663	1228907	Hanwa by Express, near Maslaha Seed.
S9	358324	1230114	New Extension Opposite NNPC Mega Station
S10	353061	1234219	Samaru
S11	352946	1233900	Samaru

The data in Table 4 is the Geographical Location/Coordinates of 8 Visafone land masts which were spread across Zaria Urban area. The Coordinates was used to create the spatial distribution of MTN base station later in Figure 2.

Table 4: Geographical Location/Coordinates of Visafone GSM Base Stations in Zaria Urban Area

SERVICE PROVIDER	COORDINATES		LOCATION
VISAFONE	EASTING	NORTHING	
V1	356928	1226950	Tukur Tukur
V2	359399	1225787	Layin Pumpo Tudun Wada
V3	355752	1224741	St Luke Wusasa
V4	356903	1224819	Danmagaji Juma'a Mosque
V5	361116	1229572	BATC (Tobacco)
V6	358385	1226286	Gaskiya Layout
V7	362713	1227333	Anguwar Gwado
V8	352421	1233753	Quarter 3

The data in Table 5 is the Geographical Location/Coordinates of 11 Etisalat land masts which were spread across Zaria Urban area. The Coordinates was used to create the spatial distribution of Airtel base station later in Figure 2.

Table 5: Geographical Location/Coordinates of Etisalat GSM Base Stations in Zaria Urban Area

SERVICE PROVIDER	COORDINATES		LOCATION
ETISALAT	EASTING	NORTHING	
E1	361484	1226206	Gyellesu
E2	361712	1230804	Sabon Gari
E3	360141	1231381	Dogarawa Anguwan Barau
E4	362661	1226691	Anguwar Gwado Kan Tsauni
E5	360455	1227792	Near Unity Bank PZ area
E6	361198	1230309	Sabon Gari
E7	352882	1234047	samaru
E8	385406	124010	Zango

The data in Table 6 is the Geographical Location/Coordinates of 28 Globacom land masts which were spread across Zaria Urban area. The Coordinates was used to create the spatial distribution of Globacom base station in Figure 2

Table 6: Geographical Location/Coordinates of Globacom GSM Base Stations in Zaria Urban Area

SERVICE PROVIDER	COORDINATES		LOCATION
GLO	EASTING	NORTHING	
G1	360211	1225622	Fanfon Gwaiba
G2	358498	1226141	Gaskiya Layout Haruna Soba Street
G4	359059	1227077	Tudun Jukun
G5	357787	1226473	Gonan Ganye
G6	360217	1226009	Layin Wawa Tudun Wada
G7	359973	1226354	Agoro opposite filling Station
G8	355115	1223409	Madachi (wusasa)
G9	356307	1225364	Anguwar Dankali
G11	361056	1227767	Dogon Bauchi Sabon Gari
G12	358585	1225977	NBPZ Annex Campus
G13	362688	1226105	Jushin Waje
G14	360559	1227685	Sabon Gari Cresent Street
G15	362779	1226967	Anguwar Gwado Tsauni
G16	360359	1230369	Chikaji Industrial Layout
G17	362282	1228342	Sabon Gari
G18	361325	1229313	Kings Road Sabon Gari
G19	361798	1228121	Nupe Street Sabon Gari
G20	361417	1227763	Cemetery Road Sabon Gari
G21	355171	1220131	NBPZ Main Campus
G22	356806	1221416	Low-cost Opposite Police Station
G23	358829	1230213	Yan Goro
G24	358595	1230149	New Extension Hanwa
G25	355030	1231828	Zango near Yan Shanu
G26	352931	1234713	Samaru
G27	351697	1234306	Behind all Saint Church
G28	84894	124367	Area G

Culminating from the tables above is Table 7 which implies that the dominant erected facilities in the area of study belong to MTN masts with 38 land masts while Visafone and Etisalat have the least land masts with 8 each.

Table 7: Percentage of the GSM Base Stations in Zaria Urban Area

SERVICE PROVIDER	NUMBER OF BASE STATION	PERCENTAGE
AIRTEL	23	19.8%
MTN	38	32.8%
STARCOMMS	11	9.5%
VISAFONE	8	6.9%
ETISALAT	8	6.9%
GLOBACOM	28	24.1%
TOTAL	116	100%

The data in table 7 is the percentage of the GSM base station in the study area, this implies that the dominant erected facilities in the area of study belong to MTN masts with 38 land masts While Visafone and Etisalat with the least facilities in the study area with 8 land masts each.

Figure 2 below is the generic map for the study area at a glance showing the spatial distribution of all GSM Base stations in Zaria urban. They are distributed almost everywhere in the study area, which helps to provide network services in the area

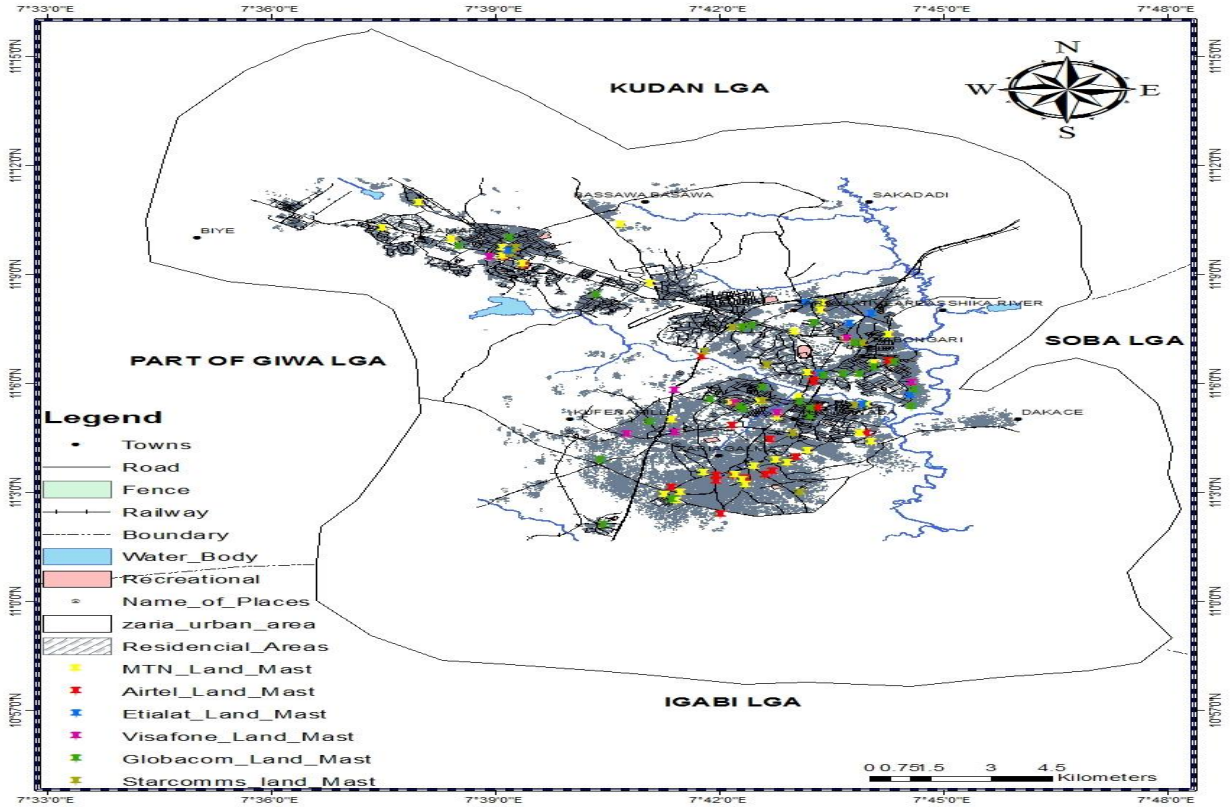

Figure 2: Spatial Distribution of All GSM Base Stations in Zaria Urban Area
Source: Author's GIS analysis, 2016.

Figure 2 shows clearly that there are more masts situated in the southern and north east part of the study area.

Areas Vulnerable to the Health Hazards Related to Electromagnetic Radiation from GSM Base Stations

A buffer of 10 meters was conducted as stated by the World Health Organization (WHO 2007). It is clearly shown that the residence that fall within the distances of 10m are vulnerable to electromagnetic radiation emitting from the GSM Base Stations in the entire district going by the WHO regulations. Figures 3, 4 and 5 below are simply showing settlements at risk with respect to radiation and early grave diseases from GSM Base Stations using the WHO standards of 10m. It has been deduced from the geospatial analysis that most service providers violate the standards issues by WHO which makes the inhabitants around GSM Base Stations at high health risk. This agrees with the observation made by Aderoju et al. (2014), whose result within three Abuja districts (Utako, Garki and Wuse) shows that, all the 119 Base Transceiver Stations (BTS) sampled in his study area failed the 10m and 12m buffer zone tests, which makes the inhabitants around GSM Base Station at high health risk.

Due to the large nature of the study area, Figure 2 is divided into three parts in order to display fully as shown in Figures 3, 4 and 5.

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Risk map of A.B.U main Campus to Kwangila

Figure 3, shows several locations of GSM base station from A.B.U main Campus to Hanwa G.R.A.

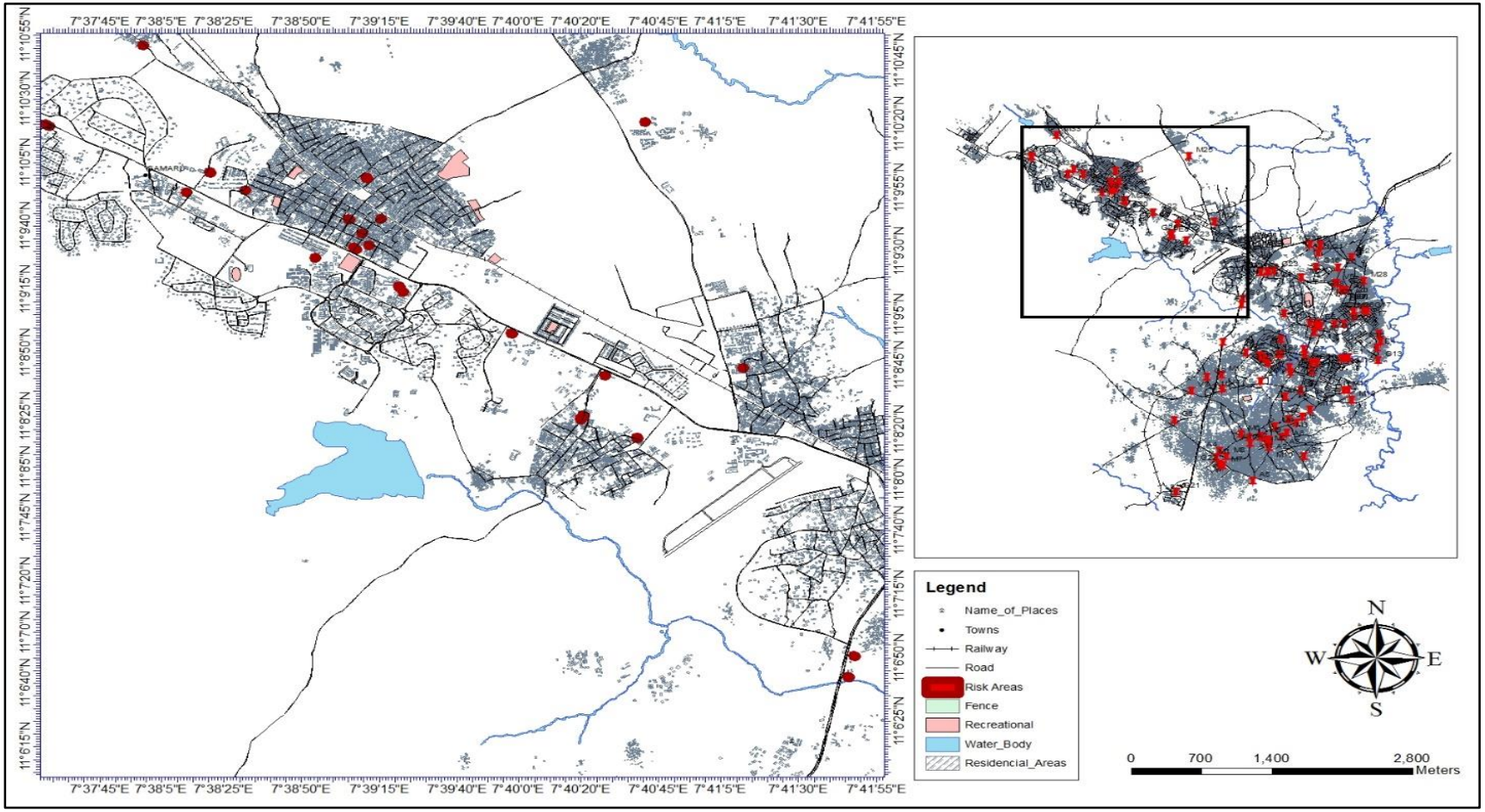

Fig 3: GSM Base Station Settlement Risk Map (A.B.U main Campus to Kwangila)

Source: Author's GIS analysis, 2016.

Risk map of Kwangila to Zaria City

Figure 4, shows several locations of GSM base station from Kwangila to Zaria City

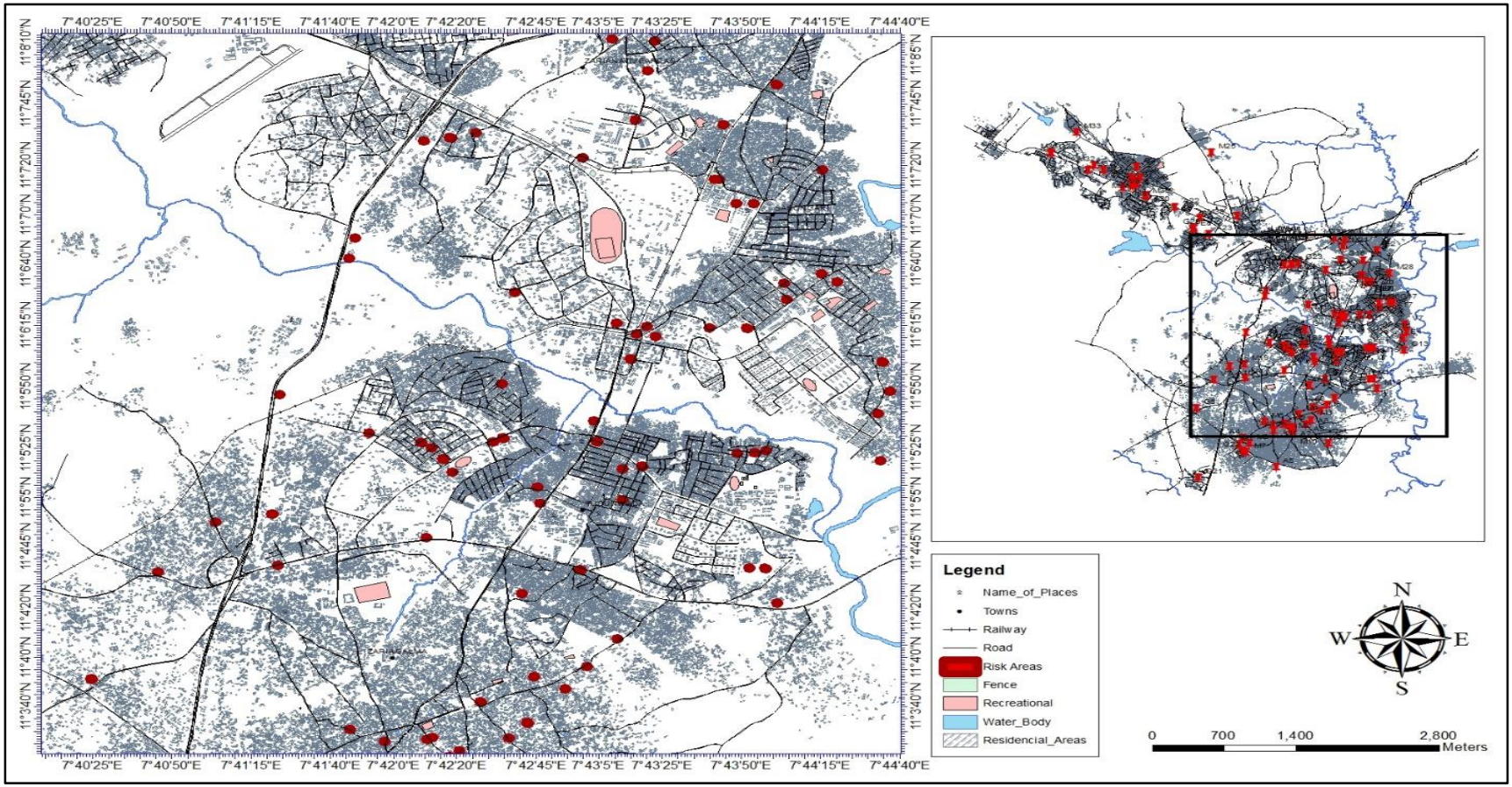

Fig 4: GSM Base Station Settlement Risk Map (Kwangila to Zaria City)

Source: Author's GIS analysis, 2016.

Risk map of Zaria City to Nuhu Bamalli Polytechnic Zaria

Figure 5, shows several locations of GSM base station from Nuhu Bamalli Polytechnic Zaria.

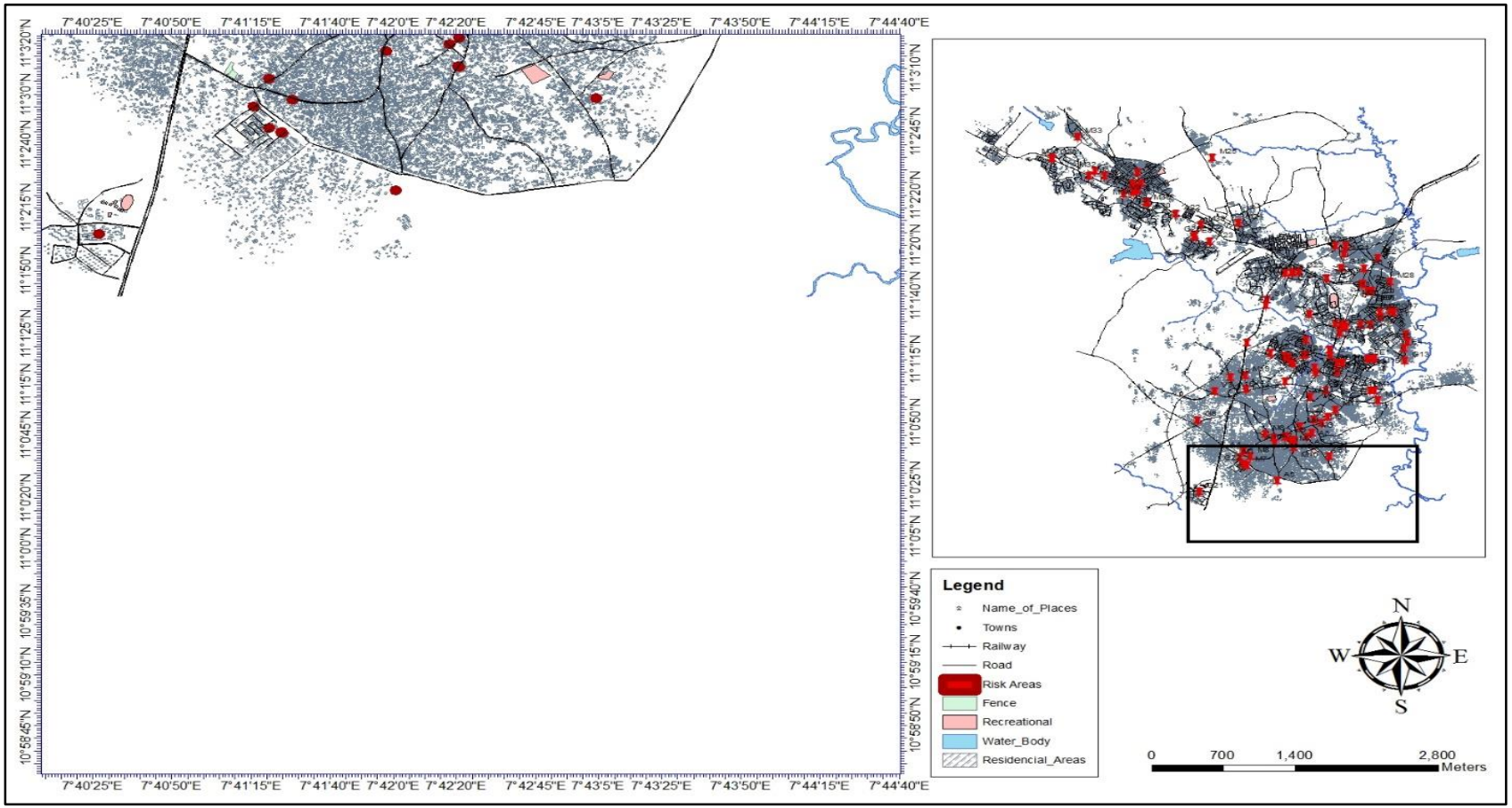

Fig 5: **GSM Base Station Settlement Risk Map (Zaria City to Nuhu Bamalli Polytechnic Zaria).**

Source: Author's GIS analysis, 2016.

The analysis in the figures above shows that 100 masts are closer to homes signifying non-adherence to the minimum standard of mast which is 10m as stated by the WHO. Their distribution and level of compliance are summarized in Table 8.

Table 8: Figure 3, 4 and 5 Comply and Not Comply GSM Base Stations in Zaria Urban Area.

LOCATIONS	NUMBER OF BASE STATION THAT COMPLY	NUMBER OF BASE STATION THAT DO NOT COMPLY	PERCENTAGE
Figure 3 (Abu – Kwangila)	9	18	23.28
Figure 4 (From Kwangila - Zaria City)	6	71	66.38
Figure 5 (Zaria City – Nuhu Bamalli Polytechnic Zaria)	1	11	10.34
TOTAL	16	100	100%

The data in Table 8 shows that 23.28% of the base stations were located within ABU Zaria and Kwangila, showing 9 compliance and 18 non adherence to WHO standard, while 66.38% of the land masts were located between Kwangila and Zaria city showing 6 compliance and 71 non adherence to the 10m standard. Finally, 10% of the base stations were located between Zaria city and Nuhu Bamalli Polytechnic Zaria showing only 1 compliance and 11 non adherence to the standard. It has been deduced from the geospatial analysis that comply base station were mostly located within educational and military environments. These include those located at ABU main campus, ABU Kongo campus, Polytechnic Zaria, FCE Zaria and Sabon Gari Barrack.

However, several locations of GSM base stations (100 masts) fall within a buffer zone of 10m, these locations as shown by the figures are situated within so many residential places ranging from Samaru to Zaria City. Having fallen within such distance from residential buildings, the areas are considered risk locations in terms of the effect of electromagnetic radiation. it could be seen that, the spatial distribution of these facilities within the residential areas are not only incompatible with the established standards as shown by the proximity analysis, but also exposed such areas to the effect of electromagnetic radiation emitting from the Base Stations and subsequently leading to early grave diseases, fatigue, decreased concentration, dizziness, local irritation, tumor induction, sperm motility, morphology and viability, cancer, leukemia, viral and infectious diseases.

Also, Emma (2012), discovered that fumes from the generator in GSM base stations emit carbon monoxide which could be harmful to respiratory organs when inhaled in large quantity and this may result to health implications or death. The noise causes pollution to the environment and this causes partial deafening of ear if it persists. The vibration from the mast may cause headache, sleeplessness and risk of brain tumor for people living around the area.

CONCLUSION

Going by the findings of this study, it can be concluded that most of the telecommunication companies do not adhere to the required standard or regulation for siting GSM base stations. Also, since most of the land masts were found within residential areas, areas that falls within the buffer

zones 10 metres of Zaria are therefore at risk of health issues related to the emission of electromagnetic radiation, carbon monoxide and vibration of the generators used. It is recommendations that:

i. The regulatory agencies should keep check on service providers that violate the 10m of siting GSM Base stations away from residential areas and remove the wrong sited masts.
ii. Telecom operators can come together to have one base station (mast) and each operator can connect with this base station.
iii. There should be proper awareness to the public through the media, schools and other agencies on the possible health risk of electromagnetic radiations for people living close to GSM Base stations.

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