Original Research Article

Space Based Assessment of Base Transceiver Stations in Kwamba, Niger State, Nigeria

ABSTRACT

Global System for Mobile Communications (GSM) started operations in Nigeria on the 16th of May, 2001. An important feature of the communication system is the Base Transceiver Stations (BTS). However, their installations have brought about public concerns and fears, specifically to issues relating to environmental risk, public health and sometimes construction problems that might result to mast collapse. This study is aimed at identifying the spatial distribution of BTS in Kwamba, analysing the terrain of the study area and examining their level of compliance to NESREA standards for siting a BTS. The data for the Kwamba study was collected from two sources; Primary and Secondary sources. The primary data include the use of GPS to obtain coordinates of the GSM base stations and their respective elevations. The Secondary and geographic data includes Google Earth imagery obtained from Google Earth, Landsat images, SRTM data from USGS Earth Explorer and shape files (roads etc) from OSM data. ArcMap was used to plot a map showing the distribution and slope extraction of the study area to provide information on the terrain. Also, using NESREA stated standard, 10metre buffer test on all existing BTS in Kwamba was carried out using ArcMap. Findings from the research revealed that there are 24 BTS distributed randomly in Kwamba. 7 out of the 24 failed the 10metre buffer test, meaning they were not in compliance with 10m setback distance as stated by NESREA for locating a BTS close to residential homes. The study recommends that stakeholder(s) imbibe the use of GIS techniques in the siting of BTS as it will assist in monitoring of non-compliance to the regulated standard of NESREA by the service providers. The adaptation of use of GIS techniques will also assist the regulatory bodies in effectively carrying out constant supervision of the service providers.

Keywords: Base Transceiver Stations (BTS); Global System for Mobile Communication; (GSM); Radiation, Telecommunication.

1. INTRODUCTION

One of the significant breakthroughs of technology is in the telecommunication sector. The world has become a global village because of the ease of information dissemination especially through mobile calls and internet which has helped to revolutionize socioeconomic development around the world. It is one of the fastest growing technological development in the world today [1]) The wireless telephone system especially Global System for Mobile Communication (GSM) which uses low intensity and microwave radiation is a major breakthrough in modern telecommunication [2]. Modern telecommunication is of great importance to modern society, contributing to its growth and economic development [3]. All modes of communication are coming together on the digital playing field, creating a wealth of new opportunities for speed, adaptability, and space-time independence [4,5,6] According to [7], the role and distribution of mobile phones and supplementary wireless communication services round the world is cogent, it has not merely eased the world into a universal group but beyond highly into a global home. In addition, to experience economic growth, digital mobile telecommunication network is necessary in order to attract foreign investment [6]

In Nigeria, with the return of democracy in 1999 brough about total independency in the telecommunication sector, which introduced the procurement of Global system for mobile (GSM) communication licenses in May, 2001 [8,9] during President Olusegun Obasanjo administration. According to National Communications Commission (NCC), the introduction of GSM in Nigeria changed the face of_Information and Communication Technology in the country spanning from two known service providers MTN and ECONET (the later which metamorphose to Vmobile, ZAIN and now AIRTEL), to four active service providers which are MTN, GLOBACOM, 9MOBILE and AIRTEL.. The National Bureau of Statistics (NBS) report [10], stated that the sector recorded a growth of 27 million network subscribers in 2002; while the mobile permit raised the total number of subscribers to over 143.05 million in 2015. One of the important components of GSM is the Base Transceiver Station (BTS). This consists of antennae mounted on structures such as masts or mounted on buildings connected by cables to transmission and receiving apparatus. This wireless technology is based on an extensive network of fixed antennae of towers and associated structures that allow signals to be transmitted to a large area. He further elaborated that these antennae picks up high-frequency radio waves emitted by cell phones and transmit from as close as 1.5 km to 2.4 km to as far as 48 km to 56 km [10]. Construction of telecommunication base stations has introduced new elements into the build up environment as there is hardly any settlement without one. As at 2009, each service provider has about 3000 telecommunication base stations across the country [12].

A Base Transciever Station (BTS) as defined as a piece of installed equipment that is used in facilitating the wireless communication between a User Equipment (UE) and its network [13]. Many BTS are being deployed periodically for an improved quality of telecommunication services by the network providers to meet increasing customer demands. The economic gain and drop calls have been the driving force for BTS siting, rather than the standard regulations, reiterating that siting of BTS is a function of population of such localities [14]. However, these installations have brought about public concerns and fears, specifically to issues concerning environmental risk, public health and sometimes construction failures that might result to mast collapse and danger from the radiation from antennas mounted on telecommunication masts.

There are speculations of adverse health concerns due to the exposure of electromagnetic radiation which are attributed to the location of BTS and its impact on the populace living in close proximity to it [15,16,17,18]. The electromagnetic radiated from the BTS masts largely is dependent on the height and type of the mast which ranges between 50w/m2 and 200w/m2. this is most of the emitted waves by some of the BTS might not be hazardous but could emit over 100w/m2 which is attributed to be harmful if the populace have stayed within close proximity for a long period of time [19]. Adverse effects such as loss of memory, sleep disturbance, burning sensations or warmth around the ear, headaches, effects on the immune functions and stimulating hormones are some of the effects that have been discovered resulting from those living within close proximity of the Base Transceiver Station (BTS) [20,21,22] In addition, the BTS is powered with a 24 hour diesel generator plant that that serves as a contributing factor to noise pollution and greenhouse gas emissions which are injurious to human health.

Various studies have embarked upon the impacts of BTS on residents in close proximity. According to [23], who used a 1.5 km radius surrounding the BTS, there is a higher prevalence of partial deafness, underground water contamination that causes typhoid and dysentery among those who live nearbPerceived psychological impacts (such as memory loss, fatigue and dizziness) were found to be significant among residents around a BTS sitting [24,25]. It is due to these perceptions that agencies around the world including Nigeria have enacted regulations for siting of BTS in the environment to mitigate the trend of health hazards related to BTS siting. The link between radiation emitted by GSM base station/cellular phones and its health effect on human health remains subject of continuing debate in research following the uncertainty over the health and safety caused by non-ionizing radiation emitted by GSM base stations [26].

GIS techniques were used to assess the spatial distribution of MTN base station masts and their impact on health in Kaduna North LGA, Nigeria. Her findings show that there are 40 MTN base station masts located and distributed in the study area, and that the majority of the inhabitants living where the base stations are located were experiencing some sickness as a result of the mast's installation, and that the most common environmental problems discovered associated with the mast's location include the emission of gas pollutants and noise from generators [27]. Aside from radition emissions, the population must contend with heat from transmitters, as well as smoke and noise from generator sets [28,29,30].

There has been a reported disagreement in Nigeria on which government agency or level is in charge of controlling the placement of telecommunications masts and enforcing environmental standards in the telecommunication industry. In united Kingdom, it was also reported that a mobile phone company was asked to remove its BTS from a block of flats after seven clusters of cancer and other serious illnesses were discovered [22]. The Nigerian Communication Commission (NCC) and National Environmental Standards and Regulations Enforcement Agency (NESREA), established regulations guarding the construction of base stations by telecommunication service providers in 2009 and 2011 respectively [31,32]. NCC had a 5m setback while NESREA had a 10m setback from a fence building and 12m from an unfenced building. In addition, in order to reduce visual pollution and foster fair competition in the telecommunications business, the Nigeria Communication Commission (NCC) encourages and promotes infrastructure sharing among its licensees. Other guidelines on BTS location as stated by NCC include; telecommunication towers taller than 25 meters will not be permitted in residential areas, without prior approval and a permit from the National Airspace Management Agency, no masts (regardless of height) may be positioned within 15Km of any airport, in non-residential areas, mounting alternative structures taller than 30m is permitted and there shall be no towers or masts built close to high a voltage electrical power transmission lines [33].

This study further identifies the spatial distributions of GSM base stations in the study area, analysing the terrain of the study area, and ultimately examines the distance of each base station from residential homes using NESREA standards. This study tends to employ geospatial techniques to manage the risk of base stations in close proximity to residential areas. Hence, it will help identify the vulnerable residences being exposed to EMR from BTS. In addition, this will ensure for planning and managing BTS deployments in the Kwamba environment and will further monitor and check the level of compliance by network service providers to the existing global and local BTS location standards. The aims of the current study is to assess the spatial distribution of BTS and the level of compliance to regulatory standards.This study has been carried out in in Kwamba area in Suleja, Niger State, Nigeria in 2022 using a geospatial analytical approach.

2. MATERIALS AND METHODS

2. 1 Study Area

Kwamba is a settlement of Suleja local government in Niger State, Nigeria. It lies between longitude 7°9'0"E to 7°12'0"E and Latitude 9°10'0"N to 9°13'30"N. It has an area of 136.33 km^2 [34]. Kwamba experiences high temperatures during the summer months and lower temperatures during the harmattan months of November to March. It has an average temperature of 26.3°C yearly and average rainfall is 1328mm (see fig.1)

Data Used and Data Sources

The data used for this research were sourced from both primary and secondary sources. The primary data used for this study were collected through field work, using the Global Positioning System (GPS) to obtain the geographical coordinates of the base transceiver station masts.The earth observation data used for this study were Google earth, open street map (OSM) and remotely sensed imagery, (30m resolution) acquired from USGS. The imagery of Kwamba was geo-referenced with the aid of acquired Ground control points using GPS while on the field.

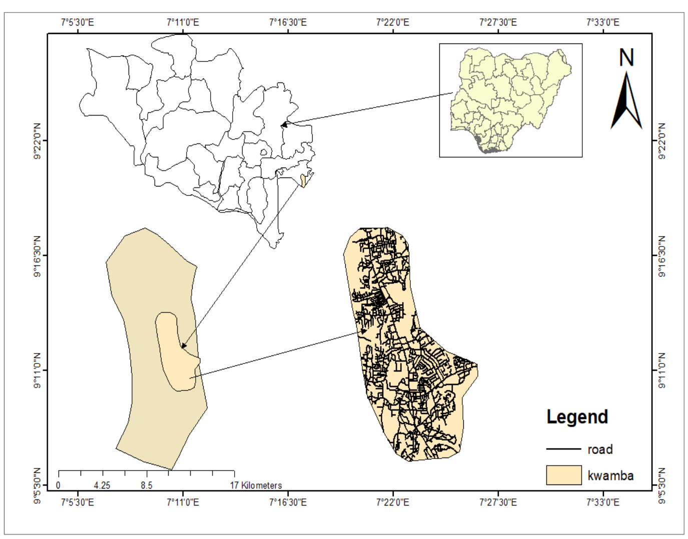


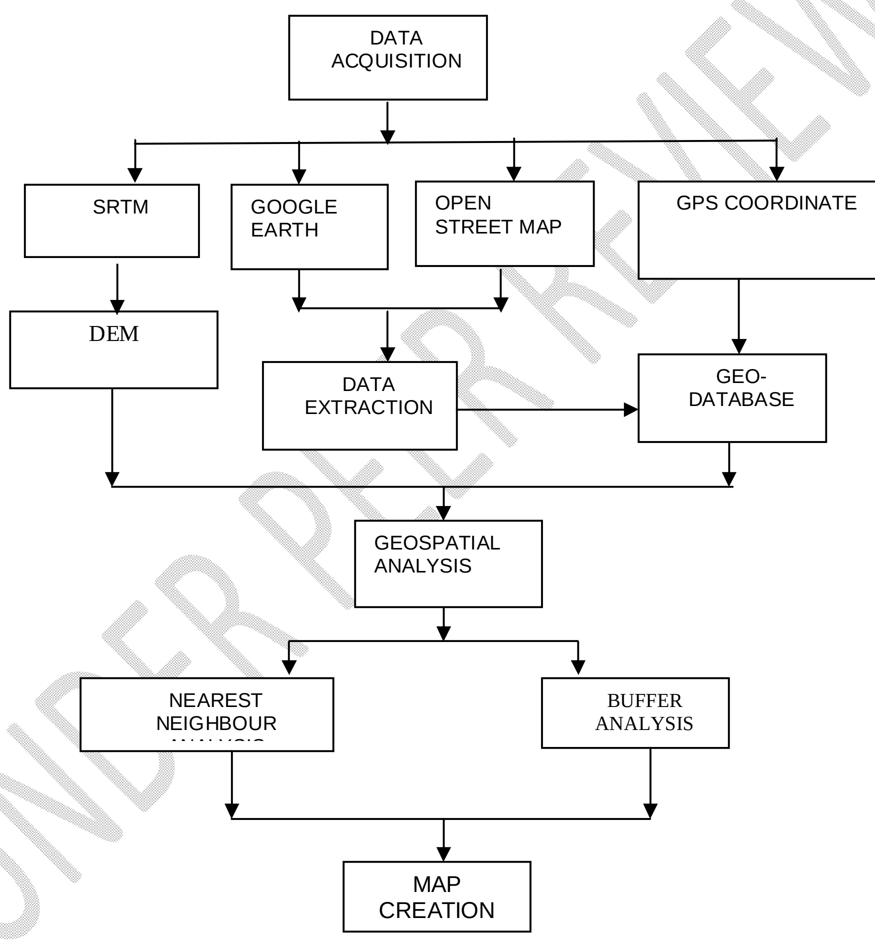
Fig. 1: Map showing Kwamba town, Suleja Niger state.
Source: GIS Achievers (2020)

2.3 Methodology

In identifying the spatial distribution of BTS, a field work was carried out and a handheld GPS was used to collect the coordinates of existing stations in the study area. This was collected alongside other attribute data such as addresses, service providers as well as functionality. A Geo-database was created to integrate data collected on the field for geospatial analysis in the ArcMap environment. SRTM (Shuttle radar topography mission) is a Digital Elevation Model (DEM) that displays contours of an area. The DEM data was used to generate the slope of the study area. Nearest Neighborhood Analysis was carried out to investigate the pattern of base transceiver stations distribution. This analysis would provide if the locations of the base transceivers were either of a clustered or dispersed nature in a particular location. Buffering analysis was carried out to examine the distance of each BTS from residential homes. However, NESREA gazette stated that; BTS are to be located 10m from fenced residential buildings and 12m or more from unfenced residential buildings, hospitals, educational centers and nursing homes. Buffer zones of 10m, 20m, 50m and 100m were created. Summary of data used and its workflow are displayed (Table 1; figure 2).

Table 1: Summary of dataset.

DATA	DATA TYPE	DATA SOURCE	YEAR	RESOLUTION	USAGE
GPS data(longitude and latitude)	Primary data	Field work	2021		Identify the location of each base transceiver station.
SRTM DEM data	Secondary data	Earthexplorer.usgs.gov	2021	30m	Used to analyse terrain (slope) of the study area.
Shapefile (buildings, roads)	Secondary data	Open street map	2021		Use for buffer analysis.
Satellite image	Secondary data	Google Earth Engine	2021	5m-15m	Geo-reference study area map



DATA ACQUISITION
SRTM
GOOGLE EARTH
OPEN STREET MAP
GPS COORDINATE
DEM
DATA EXTRACTION
GEO-DATABASE
GEOSPATIAL ANALYSIS
NEAREST NEIGHBOUR
BUFFER ANALYSIS
MAP CREATION

Fig. 2: Methodology framework

3. RESULTS AND DISCUSSION

The first phase was dedicated towards the collection of the exisiting BTS in order to identify their exact position as installed within the proximity of Kwamba area in Suleja, Niger State, Nigeria.

Table 2: Inventory of BTS in Kwamba.

S/No	Latitude	Longitude	Elevation (M)	Functional	Non-Functional	Address Of BTS
1	9.18124	7.18628	456	•		Bangmama, off Suleja-BakinIku Rd
2	9.18172	7.185627	460	•		Suleja-BakinIku Rd
3	9.18263	7.1857	458	•		Suleja-BakinIku Rd
4	9.18282	7.18645	459	•		Bagmam
5	9.19372	7.185351	452	•		AlhassanBako Dr Rd
6	9.19624	7.18146	467	•		off Suleiman Barau Rd
7	9.19931	7.18042	465	•		KurminSarki área
8	9.20176	7.180894	476		•	KurminSarki área
9	9.19856	7.175478	454	•		Off Bida-Suleja Rd
10	9.20691	7.171349	434	•		Kwamba área
11	9.20618	7.17014	430	•		Kwamba área
12	9.20452	7.16637	440	•		Kwamba área
13	9.21095	7.16913	424	•		Off Bida-Suleja Rd
14	9.21601	7.17077	440	•		Kwamba área
15	9.21602	7.175489	445	•		Kwamba área
16	9.22104	7.173263	447	•		Kwamba área
17	9.19705	7.172774	414	•		back of suleja township stadium
18	9.19621	7.176983	424	•		Suleja LGA Secreteriat
19	9.19117	7.179127	467	•		Back of Chicken Republic
20	9.1871	7.178668	427		•	Bida-Abuja Rd
21	9.1854	7.176481	426	•		Kwamba área
22	9.18017	7.174522	428	•		Awwalibrahim primary school
23	9.17914	7.17438	435	•		Awwalibrahim primary school
24	9.17801	7.181456	409	•		off Suleja-BakinIku Rd

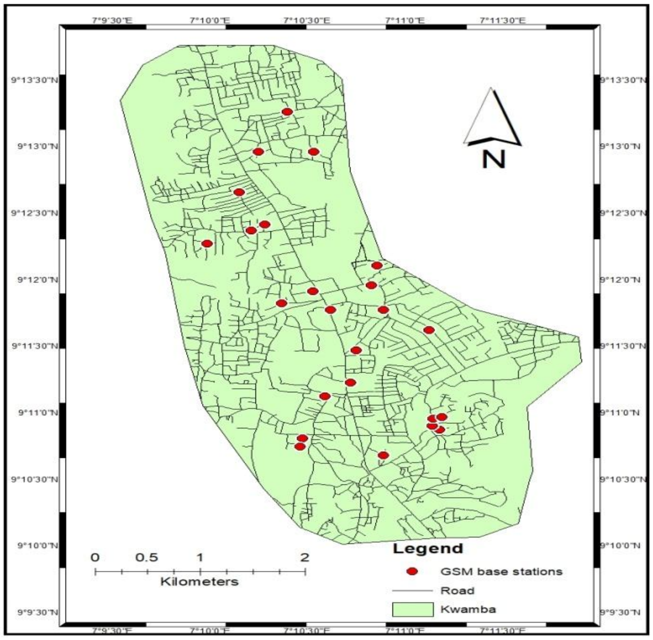


Fig. 3: Map of Kwamba showing existing BTS.

Source: Authors

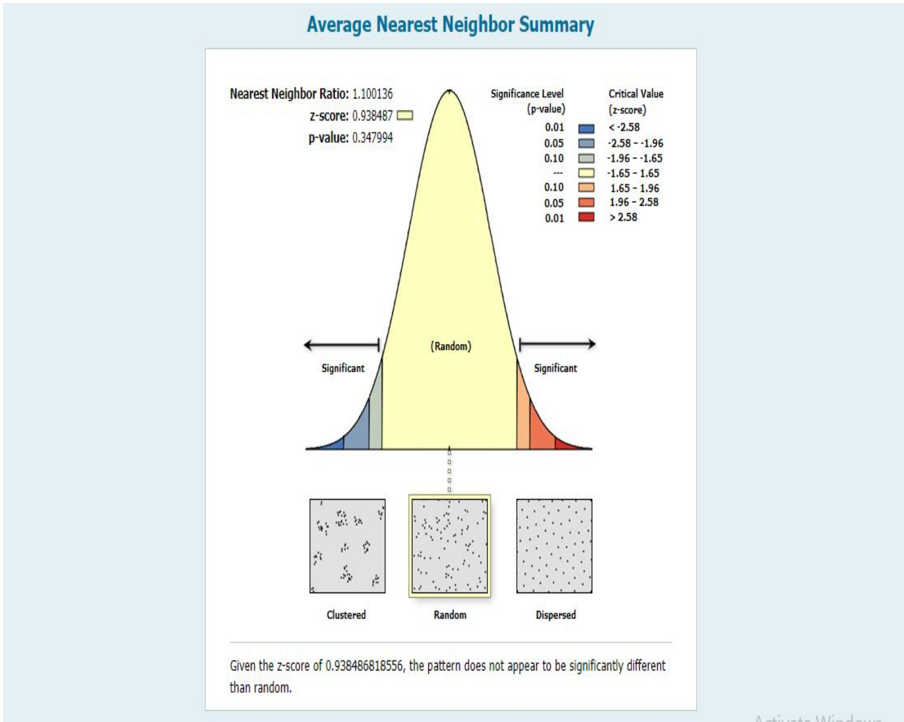


Fig. 4: BTS distribution pattern in Kwamba

Source: Authors

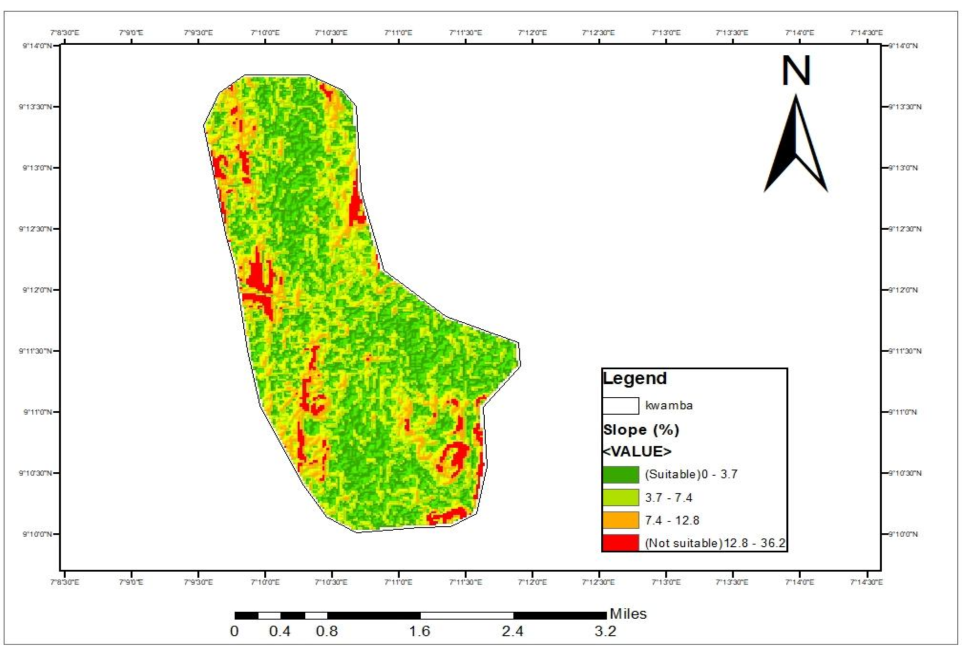


Fig. 5: Slope of Kwamba

Source:Authors

The pattern of distribution of BTS inventory in Kwamba is shown (Table 2 and Figure 3). The table has information on longitude, latitude, elevation, address of BTS and service providers with their functionality**.** The identified BTS were plotted on ArcMap to identify their geographic position on the study area map (figure 3). The positions of the BTS were point data represented by latitude and longitude as captured during the field observation. Nearest neighbourhood analysis was performed to investigate the nature of the distribution of BTS in Kwamba. Nearest Neighbour Ratio is 1.100136 (Observed mean distance/expected mean distance), a critical value of <2.58 and a test significant P value of 0.347994. The analysis reveals that the BTS were randomly distributed across the study area (figure 4). Shuttle Radar Topography Mission (SRTM) is a Digital Elevation Model (DEM) that displays contours of an area. Using ArcMap, the DEM data was used to analyse the slope of the study area to identify the suitability in % of whether or not a BTS can be installed. The result of the analysis shows the most suitable areas with relatively flat topography with slope range of 0–3.7% (figure 5).

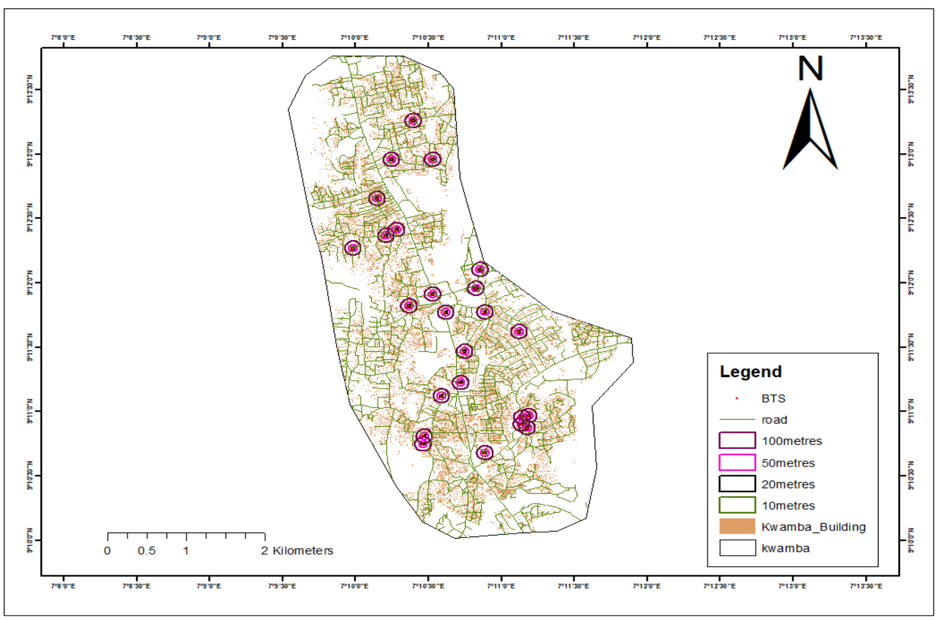


Fig. 6: Map of Kwamba showing buffer zones of 10m, 20m, 50m, and 100m around BTS

Source:Authors

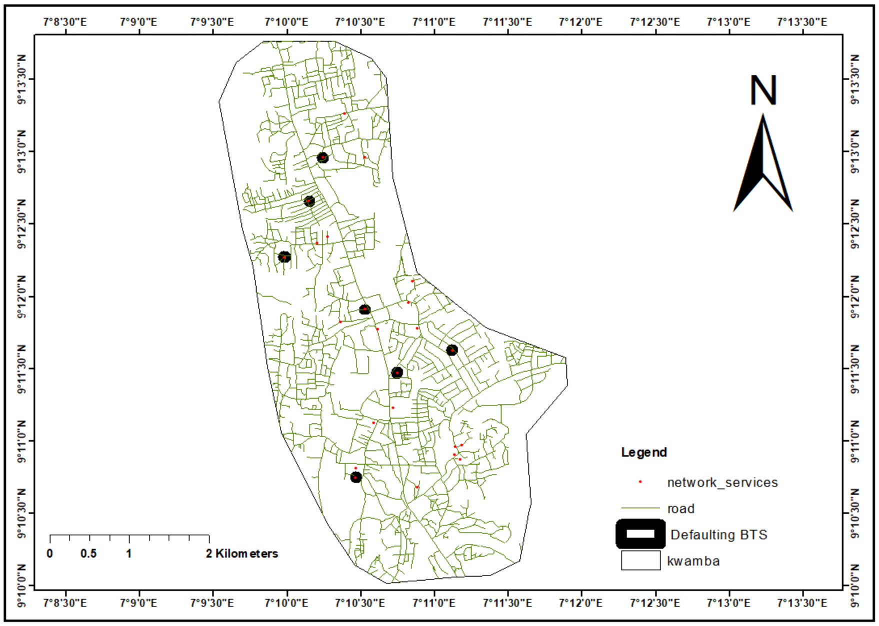


Fig. 7: Map of Kwamba showing BTS defaulting 10m Setback

Source:Authors

The buffering of 10metres, 20metres, 50metres and 100metres was done around identified BTS to enable proximity analysis to buildings in Kwamba town (fig. 6). A minimum regulatory setback distance of 10metres as stated by NESREA was used in the research. The buffer analysis was carried out to determine if the regulatory setback distance of GSM base stations residents in Kwamba was duly considered by service providers. 7 out of the 24 (30%) BTS violated NESREA 10m minimum setback distance for citing a GSM base station (fig. 7). There are also situations where two or more base stations have been sited close to each other. This also means that there was 70% compliance by service providers in Kwamba when siting a GSM base station. Though, reasons are not known but it cannot be far fetched from negligence by administrations.

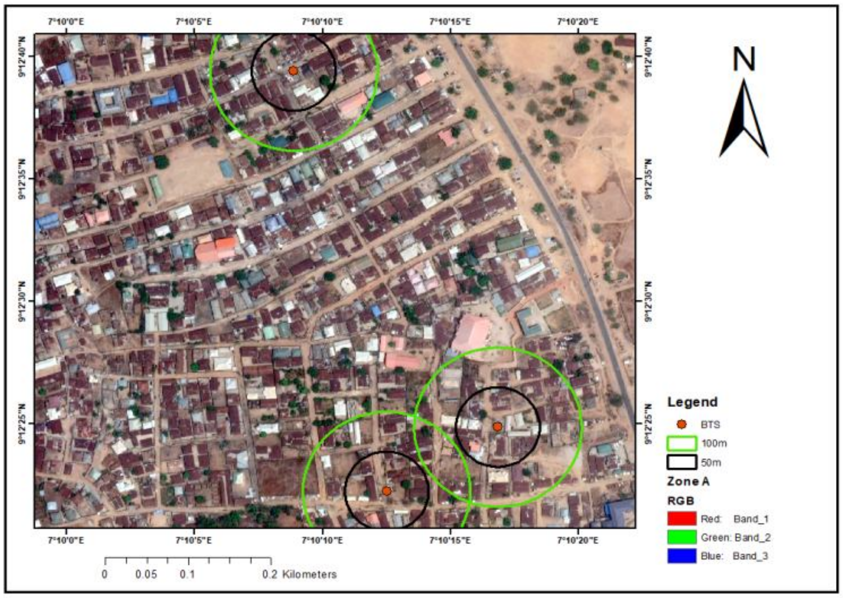


Fig. 8: Kwamba Zone A
Source:Authors

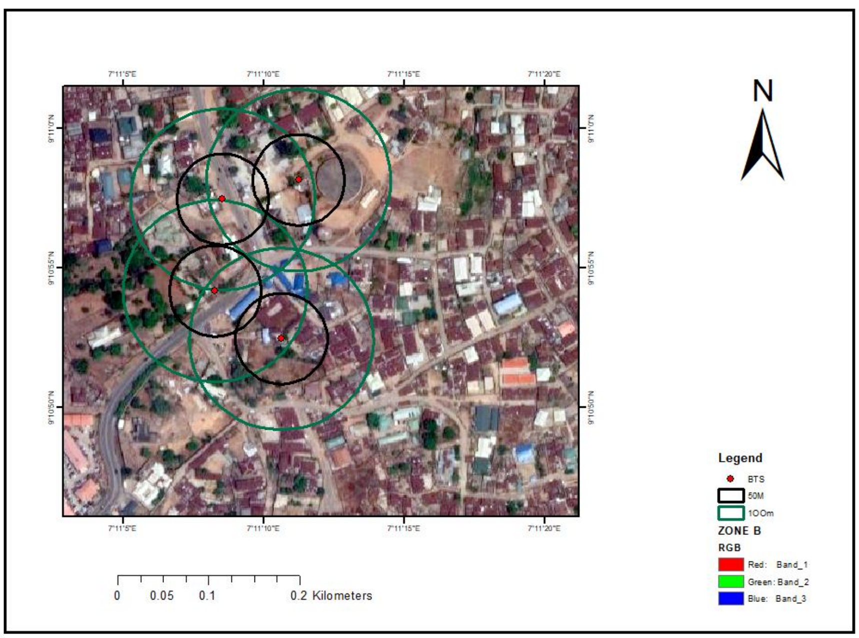


Fig. 9: Kwamba Zone B.
Source:Authors

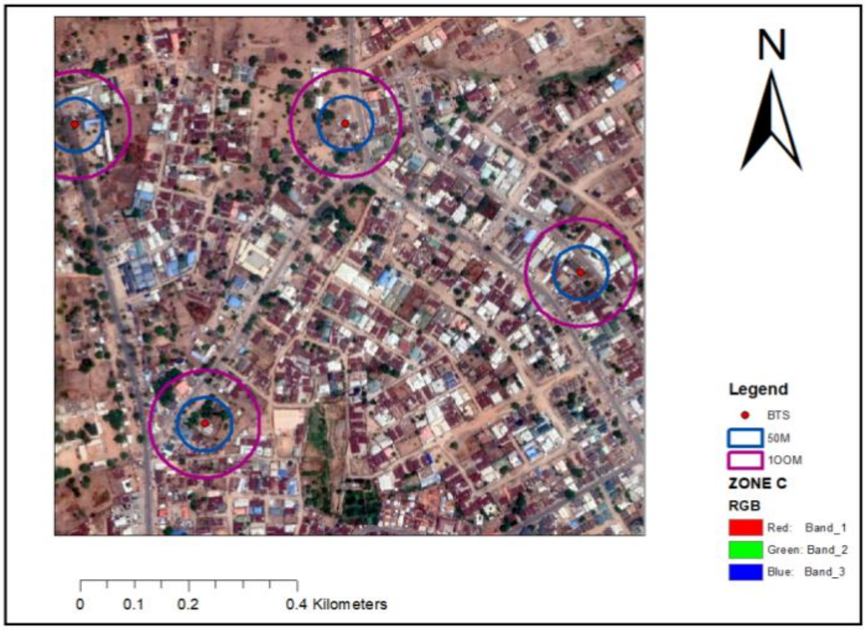


Fig. 10: Kwamba Zone C
Source:Authors

With various researches across the globe recommending a 100m to 400m safe zone, the study area was zoned into A, B and C to show settlements at risk of health hazards caused by radiation from BTS within a 100m radius. It has been deduced that there are still areas that fall within 100m radius of a BTS (Figure 8, 9 and 10). Some of these settlements existed before the siting of a BTS and therefore are at risk of potential health threat from radiations emanating from BTS. This means that the 100m radius is also not enough with consideration to human health as well as other environmental hazards.

CONCLUSION

The study employed geospatial techniques to map and analyse BTS in the study area and its risks to settlement around it. The BTS distribution pattern was revealed to have critical value of <2.58 and a test significant P value of 0.347994, which reveals that the BTS were randomly distributed across the study area. In addition, 7 out of the 24 base stations were found to not comply with existing 10m setback standards established NESREA for siting GSM base stations in Nigeria. This study did not have a paramedical approach to know if there exists long term health issues connected to living population around BTS in Kwamba. Through the findings of this research on the 24 GSM base stations locations idenified and investigated in Kwamba, the following recommendations are necessary; all regulating agencies should constantly supervise service providers that do not comply with the 10m standards for citing BTS away from residential homes as established by NESREA and equally sanction them. Furthermore, advocacy needs to be strengthened on the utilization of GIS technique in citing BTS to help reduce non-compliance of service providers to existing standards.

ACKNOWLEDGEMENTS

Authors will want to acknowledge Mr Salihu Saidu of the department of Geography Federal University of Technology Minna for supervising this research from proposal to completion.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

1. Kerimoglu, G.; Mercantepe, T.; Erol, H. S.; Turgut, A.; Kaya, H.; Çolakoglu, S. & Odaci, E. Effects of long-term exposure to 900 megahertz electromagnetic field on heart morphology and biochemistry of male adolescent rats. *Biotech. Histochem., 11*: 1-10, 2016.
2. Hyland, G. J. (2000). The Lancet, 356, 1833 – 1836. Scientific Advisory system: (mobile phone and health, HM Government 1999; Vol. II Appendix 15, pp 86 – 91.
3. Aderoju, O., Godstime, J., Olojo, O., Ademuyiwa, O., Eta. J., Onuoha. H., Nwadike. B.K., Salman, K. (2014) Space-based assessment of the compliance of GSM operators in establishing base transceiver stations (BTS) in Nigeria using Abuja municipal area council as case study. Journal of environmental science, toxicology and food technology 8(10).46-57.
4. Mathur, N. and Chakraborty, S. (2005) *Efficient Administration through E-Governance, Knowledge Management in Asia Pacific*. Victoria University of Wellington, New Zealand.
5. Olapeju O. (2008) Assessment of the Location of Telecommunication Base Stations in Nigerian Cities: Akure as a case study. Unpublished Undergraduate Thesis at the Department of Urban and Regional Planning, Federal University of Akure.
6. Ndukwe, K.N. (2001). Digital Technology in surveying and mapping. Enugu, Nigeria: Rhyce Kerex Publishers.
7. Olukolajo, M. A., Ezeokoli, N. B., & Ogungbenro, M. T. (2013). Locational Effect of GSM Mast on Neighbouring Residential Properties ' Rental Values in Akure , Nigeria, 2(3), 147–156. http://doi.org/10.5901/ajis.2013.v2n3p147 Retrieved 11/12/21
8. Michael A. Enahoro & David B. Olawade. (2021). GSM and the Nigerian Economy: The Journey from 2004 to 201. International Journal of Economics and Finance; Vol. 13, No. 7; 2021 ISSN 1916-971X E-ISSN 1916-9728
9. Oruonye ED et al. (2021). An Assessment of the Level of Compliance of GSM Mast Location to Environmental Standard Regulations. Sch Acad J Biosci, 2021 Apr 9(4): 103-110
10. Nigeria Bureau of Statistics (2015): Nigeria Telecommunications Sector: Quarter 1 2015 summary report.
11. Akin, S .A. (2014).Studied location adequacy of Telecommunication Masts and residents livability. International Journal of Research in Applied, Natural and Social Sciences(IMPACT: IJRANSS) , ISSN (E): 2321-8851; ISSN (P): 2347-4580 Vol. 2, Issue 11, Nov 2014, 7-16.
12 Punch (2009). Telecommunications Installations and Environmental Pollution in Nigeria: A Case for Taming a Growing Monster in an Emerging Economy.
13. Peter Chibuike, C., Alozie M. C. and Ezirim, O.T. (2018). “Analysis of the geospatial relationship of global system for mobile communications base transceiver stations to buildings in umuahia municipal, Abia State Nigeria. (gis and remote sensing)”, Asian Journal of Science and Technology, 10, (07),
14. Dalil, M., Abbas, A. Y., Umar, F. Y. and Adeleye, B. M. (2016): Assessment Of Spatial Distribution Of Telecommunication Base Stations And Compliance Level Of The Operators To The Regulations In Federal Capital City Abuja, Nigeria. Journal of Sustainable Development in Africa. 18:3. Clarion University of Pennsylvania
15. Ikinci, A., Mercantepe, T., Unal, D., Erol, H. S., Sahin, A., Aslan, A., Bas, O., Erdem, H., Sönmez, O. F. Kaya, H., & Odaci, E. (2016) Morphological and antioxidant impairments in the spinal cord

of male offspring rats following exposure to a continuous 900MHz electromagnetic field during early and mid-adolescence. *J. Chem. Neuroanat., 75(Pt. B)*:99-104, 2016.

16. Otitoloju, A. A., Obe, I. A., Adewale, O. A., Otubanjo, O. A. and Osunkalu, V. O. (2010): Preliminary Study on the Induction of Sperm Head Abnormalities in Mice, Musmusculus, Exposed to Radiofrequency Radiations from Global System for Mobile Communication Base Stations. Bull Environ. Contam. Toxicol. 84:51–54.
17. Victor, U.J., N. Norbert, S. Silas, A. Abraham, and U. Patrick. 2012. "Assessment of RadioFrequency Radiation Exposure Level from Selected Mobile Base Stations (MBS) in Lokoja". Kogi State, Nigeria. October 2012. 5.
18. Wolf, R. and Wolf, D. (2004): Increased Incidence of Cancer near a Cell-Phone Transmitter Station. International Journal of Cancer Prevention. 1(2):1-19.
19. Tukka, A.A. (2019). "Vulnerability Mapping and Assessment of Global System for Mobile Communications (GSM) Mastsin Akure South Local Government Area", published in International Research Journal of Innovations inEngineering and Technology (IRJIET), Volume 3, Issue 1, pp 14-19, January, 2019
20. Navarro, E.A., Segura, J., Portolés, M., Gómez-Perretta de Mateo, C. (2003): The Microwave Syndrome: A Preliminary Study in Spain. *Electromagn. Biol. Med*. 22:161-169
21. Shahbazi-Gahrouei, Daryoush&Karbalae, Mojtaba&Moradi, Habib&Baradaran-Ghahfarokhi, Milad. (2013). Health effects of living near mobile phone base transceiver station (BTS) antennae: A report from Isfahan, Iran. Electromagnetic biology and medicine.33. 10.3109/15368378.2013.801352.
22. Santini, R., P. Santini, P. Le Ruz, J.M. Danze, and M. Seigne. 2003. "Survey Study of People Living in the Vicinity of Cellular Phone Base Stations". Journal of Electromagnetic Biology and Medicine.
23. Abdel- Rassoul, G., Abou, E .O., Abou, S., Micheal, A., Farahat, F., EL-Batanouny, M., Salem, E. (2006). Neurobehavioural effects among inhabitants around mobile phone base stations.
24. Bolaji, O. A. and Idowu, P. F. (2012): Risks Associated with Low Level Radiofrequency Exposure at Close Proximities to Mobile Phone Base Stations. Pacific Journal of Science and Technology Vol. 13 Number 2.
25. Onifade, O.O., Jelili, M.O., Asani, M.A. (2015): Telecommunication Mast Location and Health Implication for Residents in Ogbomoso, Nigeria. Journal of Civil and Environmental Research. 7(9).ISSN 2224-5790(paper) ISSN 2225-0514 (online)
26. World Health Organization.(WHO, 2014). Electromagnetic fields and public health: Mobile Phones. https://www.who.int Accessed 7/6/2021
27. Mohammed, H. I. (2011).Spatial distribution of MTN base station masts and its implication on health through the use of GIS techniques in Kaduna North LGA, Nigeria. Unpublished project, geography department Ahmadu Bello University, Zaria.
28. Dürkop, H. J. and Englert N. (Editors) 2004. Environmental health in Germany Every Day examples: Status as of April, 2004. Published by Bundesamt für Strahlenschutz, Federal Office for Radiation Protection, Postfach
29. Ford, D. (2005): The Effect of Microwave Radiation from Telecommunication Mast. Retrieved from www.tetrawatch.net/paper/ford-tower/pdf
30. Thisday (2013): "Nigeria: Menace of Indiscriminately-Mounted Communication Masts retrieved June (2022) from https://allafrica.com/stories/201305231136.html
31. Nigerian Communications Commission (2009). Guideline on technical specifications for the installation of telecommunication masts and towers *http://www.ncc.gov.ng Accessed 05/04/21*
32. National Environmental Standard Regulatory Agency - NESREA (2011). Standards for telecommunications mast and broadcast facilitie *https://www.gazettes.africa/archive/ng/2011/ng-government-gazette-dated-2011-04-29-no-38.pdf* Accessed *04/04/2021*
33. Nigerian Communications Commission (2010)). Guidelines on Collocation and Infrastructure Sharing https://www.ncc.gov.ngg Retrieved 11/04/21
34. Aminu, Z., Yakubu, M., Mohammed, A .A., & Kumar, N. (2013) Impact of land use on soil quality in Suleja, Niger State, Nigeria. Indian Journal of Life Sciences 292);1-7