Evaluation Of Geo-Spatial Proximity Of Mobile Communication (GSM) Base Transceiver Stations To Buildings In Ile-Ife, Nigeria

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Abstract: Efficient placement of radio facilities for the communication base transceiver station (CBS) of the two small global system for mobile communication (GSM) has being an area of research due to fast growing of GSM market in Nigeria. In line with this development, Nigerian Communication Commission NCC and Nigeria Environmental Standard and Regulation Enforcement Agency, NESREA have stated the setback between communication base station and the nearest infrastructure as 5 m and 10 m respectively. To evaluate the degree of the implementation of these setbacks in Ile-Ife (the study area), the research study identified the spatial locations of the CBS using a global communication for satellite GPS receiver and also employed the use of a high resolution satellite imagery which were processed using geo-spatial techniques. The results of this study revealed that 45.6% and 59.5% of the CBS had setback to building structures at 5 m and 10 m respectively, with spatial variability between 30 m to 17074 m, at elevation between 193 m to 377 m.

Keywords: Geo-spatial proximity, Communication Base Transceiver Station CBS, CBS setback, Spatial variability.

1.0 Introduction

Evolution of Global System for Mobile communications (GSM) in Nigeria began in August 2001 [1] and this has facilitated the use of Information and Communication Technology (ICT) in different sectors of the economy. At its inception, there were only two networks in operation. Currently, this has increased to seven networks. Thus, considerable growth in the use of mobile phones has led to increasing demand for land to site GSM communication base transceiver stations (CBS) and associated infrastructures [2]. The siting of CBS within communities has continued to generate serious concern. Since a base station must be sited in close proximity to inhabited areas. The main concern here is the Radio Frequency (RF) emissions from the CBS. In the RF-microwave frequency range of 100 MHz to 300 GHz, exposure limits are set on the power density (W/cm^2) as a function of frequency [3]. The recommended safe power density limit is 0.2 mW/cm^2 at the lower end of the frequency range (fields penetrate the body more deeply at the lower frequencies) and 10 mW/cm^2 at frequencies above 15 GHz [4]. Because, most of the power absorption at these frequencies occurs near the skin surface [1]. In line with these facts, the mobile phone operators and government authorities have consistently insisted that radiations from CBS are not dangerous than any other radio signal [5].

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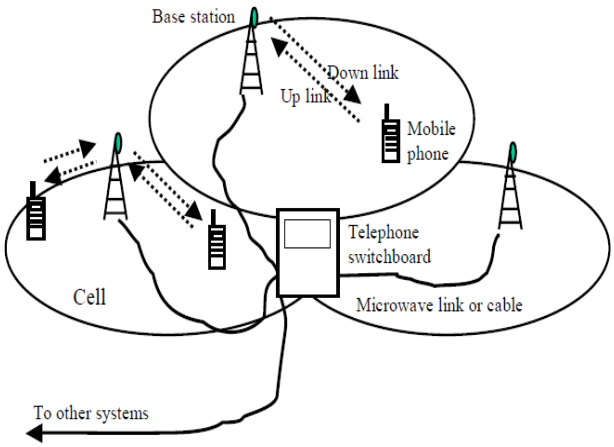
Hence, Nigerian Communication Commission NCC and Nigeria Environmental Standard and Regulation Enforcement Agency, NESREA have stated the setback between communication base station and the nearest building infrastructure as 5 m and 10 m respectively [6]. Despite these, most CBS providers invalidate the range of the setbacks and subject people to danger. Hence, this study tends to assess the spatial characteristic of CBS to building infrastructures in the study area with a view to provide information on the level of compliance with the stated regulated standards.

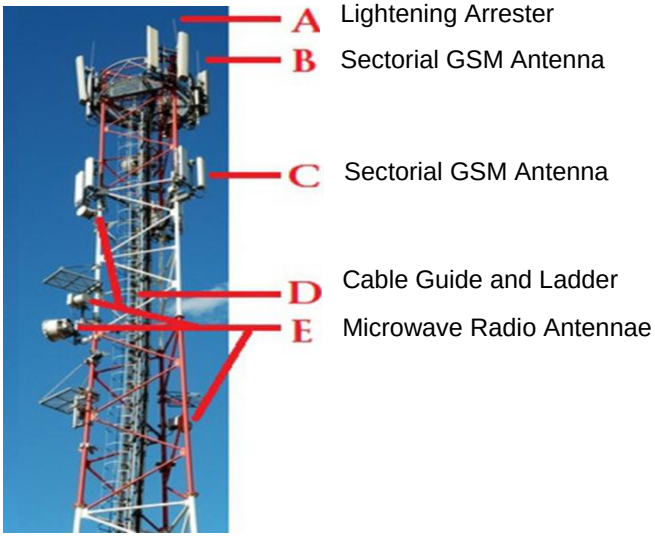
2.0 Mobile Telephone System

The mobile (cellular) phone system works as a network containing the communication base transceiver stations CBS. Within each cell, a base station (with an antenna) can link with a number of mobile phones. The mobile phones and the CBS communicate with each other, sharing a number of operation frequencies. Other transmission links connect this CBS with switches connecting to base stations in other cells, or with switches connected to conventional phones. The cell exists in order to permit re-use of frequencies (the same frequency can be used in different cells), given a sufficient distance. The uplink from mobile phone to base station and downlink from base station to mobile phone, employ high frequency electromagnetic fields; illustrated in Figure 1.1. [7]. The outdoor base station antennas is usually mounted on the roof or walls of buildings or a free standing masts, as shown in Figure 1.2. The size of the cells may vary, from several km in rural areas with low traffic density to 10 meters, in high traffic density areas in cities. Small indoor cells occur, using either normal mobile telephone systems such as GSM, or systems for cordless telephony [8]. A particular base station may operate several channels (typically 2 or 3), where each channel uses a specific set of frequencies, one for the uplink and one for the downlink.



(Bergqvist, *et.al*., 1990)

Figure 1.1: *The structure of the mobile system.*



http://tommakau.com/author/tmakau

Figure 1.2: *The structure of CBS Antenna.*

2.1 Regulations on CBS Networks in Nigeria

Allocation of communication frequencies are strictly regulated globally by the International Telecommunication Union (ITU), and locally in Nigeria by Nigeria Communication Commission (NCC). The NCC makes provision on the collocation and infrastructure sharing of the CBS, establishes the siting of CBS towers and masts with the objective of protecting and promoting public safety in other to mitigating the adverse visual impacts on the community whilst promoting the provision of telecommunication services to the public. The CBS superstructure in accordance to NCC is really being designed to resist various pressures and wind load [9]. Also, the proximity and discharge from the CBS to the environment is regulated by Nigeria Environmental Standard and Regulation Enforcement Agency, (NESREA) [6] while the guidelines on color code of the antenna's tower is regulated by National Air Space Management Agency (NAMA) [9]. Despite these guidelines, accidents of antenna from the CBS have claimed several lives and properties that worth millions of naira. An instance of such mishap is given in Figures 2.1.

The fallen mast that killed Adeleke. INSET, the late Adeleke being carried from the scene.

www.google.com/mastaccident/nigeria.

Figure 2.1: *A typical accident of CBS Mast*

3.0 The study Area: An overview

Ile-Ife the study area is predominantly a Yoruba speaking city. It was also known as the cradle of the Yoruba tradition. The city is situated in the south western part of Nigeria. It lies between longitude $4^0$27'22.5 and $4^0$35'40.61" East and latitudes $7^0$28' 4.35" and $7^0$34' 51.41" North. The areas had a spatial extent of around 191 km^2. The population of the study area has been increasing tremendously like most urban areas in Nigeria. It grew from 92,862 people in 1963, 178,409 in 1991 and over 480,000 people in 2006 [10]. The city is a home to Obafemi Awolowo University, Oduduwa University, Ife Polytechnic, among others. With the population growth, the need of the city in terms of basic infrastructural facilities began to increase. This ranges from provision of domestic water, electricity, road network as well as communication and other services. The study area being an ancient town had most of it development in a densely populated manner which could be traced to the pre-colonial era. Most of the land were allocated to residential development with very few allocated to other uses such as market and public place. With the introduction of GSM in 2001, the need for space to allocate CBS becomes an issue. However, it was discovered that most of the CBS within the study area are either located around the little available open space within the residential buildings or on an undeveloped lands within the city. This situation was usually done with little consideration for safety. Therefore, the need to evaluate the spatial location of CBS in the study area becomes necessary so as to provide information on the existing situations and proffer mitigate or control measure that can ensure safety of lives and property within the study area.

3.1 Methodology: Data collection and analysis

Data for this study include both primary and secondary data. The primary data was obtained with the aid of a Global Positioning System (GPS) receiver, for mapping out the spatial location of the CBS in the study area while a high resolution image of the study area (secondary data) was used as a base map of the study area. The coordinate location of the CBS stations (Longitude, Latitude and Height) was obtained using the GPS receiver. The

secondary data was used to extract road network and also to identify infrastructures that were located around the CBS in the study areas. The flowchart of the methodology is depicted in fig 3.1. The data extracted from the GPS receiver was processed using Geographic Information System (GIS). This includes plotting of the CBS coordinates on the satellite imagery (remotely sensed data) of the study area. Some of the spatial analysis preformed includes buffer at 5 meters, 10 meters and 20 meters radius from the CBS. Query was also performed at the respective buffers to identified residential infrastructure that were within the parameters. (See fig 3.2 and 3.3).

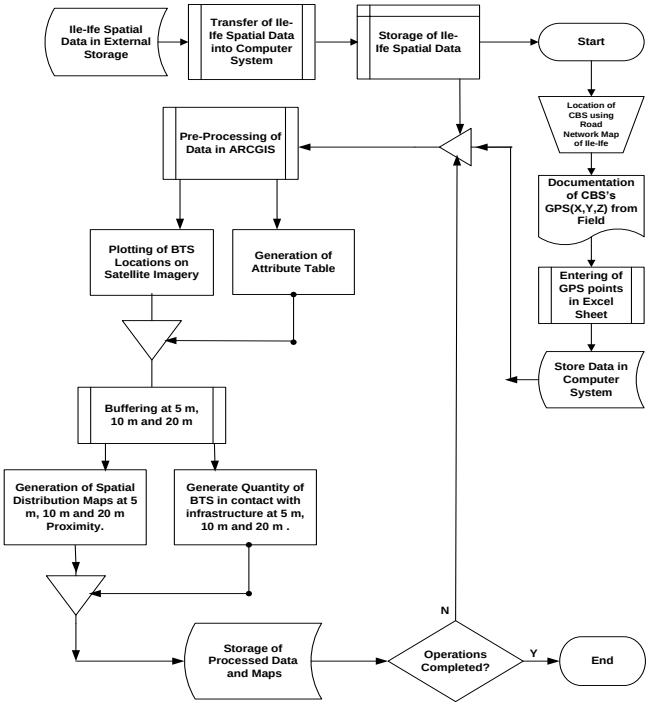


Figure 3.1: *Flowchart of Research Methodology*

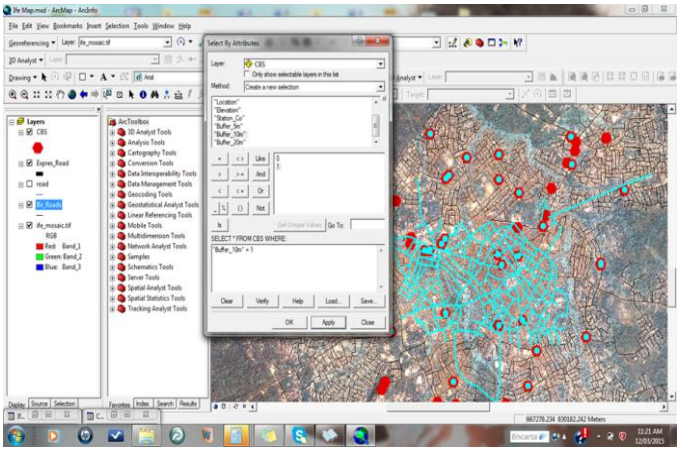


Figure 3.2: *Buffering operation in ArcGIS.*

Figure 3.3: *Proximity of Infrastructures after*

4.0 Research Findings

4.1 Proximity of GSM Base Transceiver Stations

The study revealed that the study area had about 79 CBS distributed around the 191 km^2 aerial extend of the study area. Those CBS were noticed to be located around the city centre with very few located around the peri-urban areas of the study area. This implies that most of the CBS are located within the activity areas and the residential neighborhoods. One major characteristic of the CBS was its location along the major route within the study area. It was also discovered that out of the 79 CBS, only 53 are operational. In other word only 72.5% were in operation. The study also discovered that minimum distance between one CBS to another within the study area is 30 m while the maximum and the average were 1093 m and 17074 m respectively. Sample of CBS visited is shown in Figure 4.1. The spatial distribution of these CBS is shown in Figure 4.2. The percentage of building structures for each category of the spatial distributions of the CBS are illustrated in Table 4.1 while Figure 4.3 (a – c) show the spatial proximity distribution at 5m, 10m and 20m, respectively.

Figure 4.1: *Sample of CBS visited at Ile-Ife.*

The result of the findings also shows that 40.5% of the CBS were in contact with building structure at 5 m while 54.5% and 77.2% were in contract within the radius of 10 m and 20 m respectively. It was also discovered that only 22.8% of

the CBS in the study area are not in contact with any CBS at 20 m (see table 4.1). This implies that most of the CBS in the study area are within 20 m radius to building structures of which this can be injurious to human health and the safety of the inhabitants.(see fig 4.2, 4.3a, 4.3b, 4.3c)

Table 4.1: *Results on Proximity of CBS*

S/N	Proximity of CBS at	5 m	10 m	20 m
1	CBS in contact with Infrastructures CBS_C	32	43	61
2	CBS not in contact with Infrastructures CBS_N	47	36	18
3	Percentage (%) of CBS_C	40.5	54.5	77.2
4	Percentage (%) of CBS_N	59.5	45.6	22.8
5	Infrastructures affected by CBS_C	Mostly residential houses	Mostly residential houses	Mostly residential houses
6	Infrastructures affected by CBS_N	Houses, Schools and Vegetation	Mostly vegetation	Mostly vegetation

Field survey, 2015

5.1 Conclusions

The siting and location of GSM Communication Base Transceiver Station (CBS) in Ile-Ife has been investigated in other to verify the compliance of CBS providers in accordance to NCC and NESREA guidelines on installation and siting of CBS. The results of the research show and conclude as follows:

i. 79 CBS were installed and 72.5 % are in operation.
ii. 45.6% of the CBS has setback to building structures at 5 m while 59.5 % executed setback of 10 m (in accordance to NESREA and NCC guidelines).
iii. 97.5% of the respondents are aware of the existence of CBS in their environment.

5.2 Recommendations

The collapse of Mast from CBS had claimed several lives and properties. Due to these hazards, regulating agencies should exhibit proper monitoring during construction of the frameworks for CBS foundations. In addition to this, the following recommendations should be considered:

i. Monitoring agencies should ensure that CBS provider pay substantial compensation that will enable the citizen whose landed property fall within 5 m to re-locate to new location whose proximity to CBS is within acceptable range.
ii. Geo-Spatial research based agencies should be funded in other to investigate the CBS sites or infrastructures that are not within stipulated setbacks throughout the federation.

6.0 References

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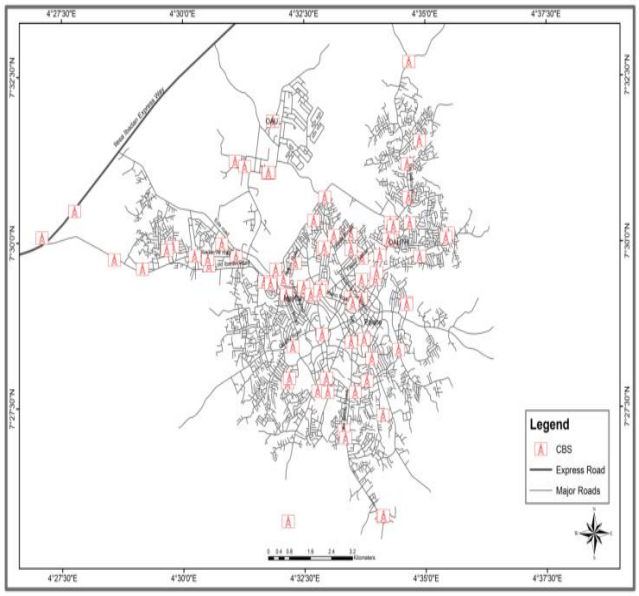

Figure 4.2: *Spatial Distribution of CBS in Ile-Ife*

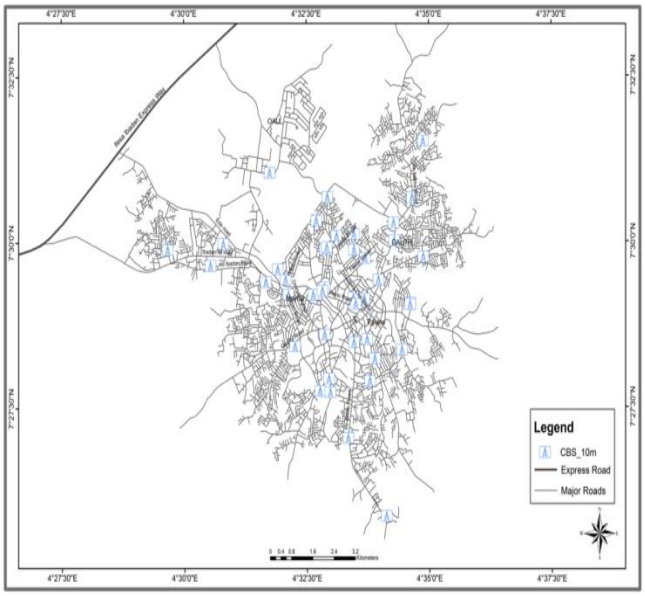

Figure 4.3 (b): *Spatial distribution of CBS at 10 m buffering*

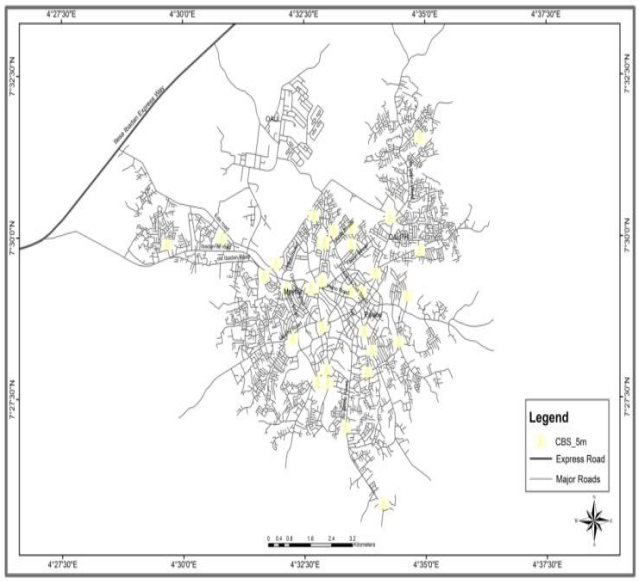

Figure 4.3 (a): *Spatial distribution of CBS at 5 m buffering*

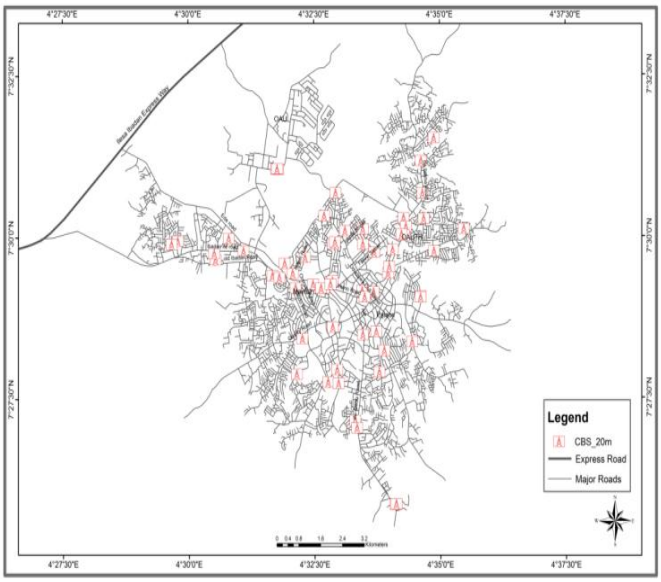

Figure 4.3 (c): *Spatial distribution of CBS at 20 m buffering*