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# DEVELOPMENT OF TELECOMMUNICATION TOWERS GIS-BASED SATELLITE IMAGE PROCESSING (GSIP) MAPPING IN KANO STATE

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**ABSTRACT**

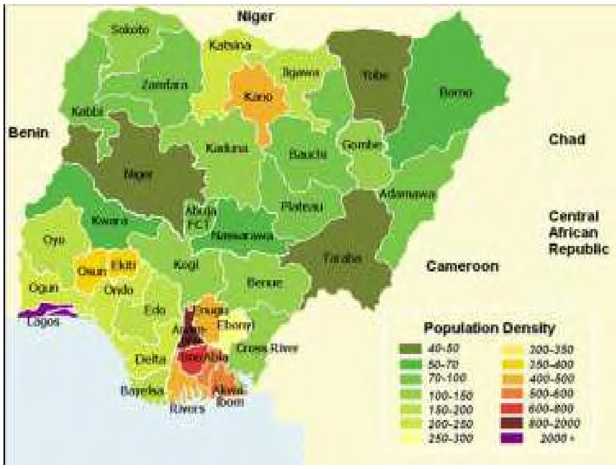
*In this proposed paper, Quantum Geographical Information System QGIS is used to analyze Kano south local government's population data for telecommunication tower development and also to develop telecommunication tower mapping in the pilot state. This research has interesting ways that would provide valuable information which can help and guide in better planning of developing new telecommunication towers in order to improve the coverage, marking radiation affected zones within the proposed study areas. Furthermore, the research work reported the suitable location to add BTS station for network improvement. The generated telecommunication towers atlas, maps will be useful to Nigerian Communication Research Centers, policy makers, and private investors (local and foreign).*

## 1. INTRODUCTION

GIS is a tool which is utilized by individuals and organizations seeking innovative ways to solve problems. GIS store information about the world as a collection of layers that can be linked together by a common location component such as latitude and longitude, a postal zip code, census tract name, or road name [1].These geographic references allow locating features on the terrain for analysis of patterns and trends. GIS will be integrated with Global Positioning System (GPS) to improve the mapping and analysis of terrain data collected.

According to Environmental Systems Research Institute's (SRI's), GIS as a collection of computer hardware, software, and geographic data for capturing, storing, manipulating analyzing, and displaying all forms of geographically referenced information [2]. Demographic originates from demography that involves how the scientific study of the size, distribution and composition of spaces vary over time [3]. Demographics are characteristics such as sex, age, or ethnic group, marital status, or educational background, etc., that can be collected and compiled to provide statistical profiles of a population [4].

According to the house to house 2006 population census, Kano state has the highest population of 9,383,682; summary of the Nigerian states map based on the population density is shown in Figure 1 [4]. The annual population growth rate of Nigeria is 2.8% at it is expected to grow exponentially in the next couple years.




Fig, 1. Map of Nigerian states by population density

Spatial mapping using GIS is a multi-disciplinary area of conducting research studies. Development of GIS-based mapping has received considerable attention by many researchers in recent years. For example, Internet-Based GIS Mapping in Support of K-12 Education has been reported in [6]. Combining Google Earth and GIS mapping technologies in a dengue surveillance system for developing countries studied in [7]. An extensive GIS studies for water and environmental engineering reported [1]. Other areas applied GIS technology for mapping were, wind energy [8], solar potentials [9]. Researchers around the world have applied GIS in electrical and electronics engineering, example of best cases are, GPRS/GPS/GIS Based Vehicle Navigation and Monitoring System extensively reported in [2].

A distribution network analysis model based on GIS is proposed [10], in which the constituent elements of the network are divided into single sides, complex sides, single points and complex points, according the kind of equipments the data classes and sub-classes are established respectively and on the basis of concatenate rule their models are built. Taking the display of local transmission line for example, the method to develop the function of distribution network topological analysis is also described. Application Study of Spatial Database Technology Based on ArcSDE was reported in [11], the spatial database is one of the important parts of the application of GIS, SDE is the middleware to connect the GIS application program with relative database system. It stores and manages spatial data and attributes data all together.

Application of GIS technology in the area of telecommunication has received considerable attention in recent years. In recent years GIS and GPS technologies are being used in various service industries like telecommunication. The GIS and image processing techniques can be helpful for site selection in the cities for telecommunication utilities such as tower or mast. the main aim was to analyze and perform various spatial and non spatial analyzes such as marking of radiation affected zone, coverage area calculation, slope of terrain, kernel density of the tower and identification of alternative routes in the case of fault at take place on digital intelligent map.

Telecommunication tower construction is the most widely growing sector at the present time. Development of telecommunication towers is economically expensive. According to the recent survey conducted in Nigeria, a single Base transceiver Station cost about NGN 35, 000,000-NGN 50,000,000, at present exchange rate. Also, the process required to generate terrain, survey data is also very tedious and time consuming. The recent increase of mobile subscribers and services in cellular network will lead to the new installation of the telecommunication tower in order to improve coverage. Unfortunately, not all the area is covered by the signal coverage. Some areas have low and poor reception coverage. Kano is the country's highest populated state. Most of the demographic information / data are not easily available. Application of GIS technology can helps tremendous to overcome the aforementioned problems [5].Development of this project will help in improving management of resources, which it can link data sets together. Some of these maps can actually put in a more comprehensive GIS facility and uses the latest GIS technology, where each map becomes a separate layer within the GIS facility, so that the users do not need to visit the links one by one [8].

Maps generations with GIS are more flexible than conventional manual techniques. Analyzing process will be better than the descriptive numerical analysis. GIS is an interactive medium for presenting data rather than numerical display. Because of the aforementioned problems and justifications "Development Of TelecommunicationTowers GIS-Based Satellite Image Processing (GSIP) Mapping in Kano State" is required.

Based on the preceding statements, various studies have been conducted in order to develop telecommunication tower map around the world. Seismic mapping for telecommunication towers in Malaysia was studied in [12], a proper management of telecommunication structures will allow transmission of news is not affected during the disaster strikes. Using the existing Peak Ground Acceleration (PGA) map, a seismic map locating all telecommunication towers in the country was developed.

The Indian Telecom industries have witnessed a tremendous growth in network services and data utilization from the last few years which have resulted in installation of large number of towers to increase the coverage area and network consistency. But the construction of new towers takes long time and needs huge initial capital investment. The time delay during construction of new towers and installation of new antennas causes a great interruption for customers in their network services. To avoid these congestions the existing towers should be utilized to their full capacities instead of constructing new towers. The geometrical details of the existing towers can be availed using the mapped data done by the tower climbers and this process of climbing the tower, measuring the dimensions of members and mapping that datais called Reverse Engineering [13].

Infrared Radiation Zone and Mobile Tower Mapping discussed in [14], the study showed the mapping of mobile towers of Sahaspur block in Dehradun District of Uttarakhand State. It also shows the analysis of network area coverage and Impact of Infrared radiations in human life. The mobile tower location has been identified using GPS, for the mapping of mobile towers GIS Software was used.

Towards the Optimal Use of Telecommunication Mast Locations as a Platform for Survey Control Densification in Rivers State of Nigeria reported in [15]. The research adopted the mapping of the telecommunication mast location and producing a thematic map in addition to the attribute information of these facilities. The Map76Cs handheld GPS receiver and the ArcGIS 10.1 Software were used in data acquisition and analyses. The study obtained the coordinates of 251 telecommunication mast locations in Port Harcourt, Obio Akpor and 34 in Bori all in Rivers State Nigeria. The coordinates of existing control stations as established by various agencies were obtained for analysis. The result of the buffering operation of 2-km and 5-km radius revealed a ratio of 1:19 (5%) and 8:28 (28.6%) for Rumukwurushi and East-West road axis of the study area respectively in terms of existing control stations and telecommunication mast locations.Dynamic population mapping using mobile phone data was studied in [15]. Mapping telecommunication towers has recently reported in the United Kingdom [16]. Similarly, other countries of the world have utilized different methods to carry out telecommunication tower maps. For example, base station mapping with angle-of-arrival and timing advance measurements [17].

Method of apparatus for channel mapping with relative service identification studied in [18]. Method of apparatus for performing position-based call processing in a mobile telephone system using multiple location mapping schemes was demonstrated [19]. Recently, New Delhi: Telecom department (DoT) has urged the telecom service operators in the country to put 584,000 telecommunication towers on Geographic Information System (GIS) for quick visual analysis in order to plan manage and administer strategy that could facilitate necessary incentives.

According to the Nigerian Commission (NCC), teledensity of mobile subscribers in Nigeria based on the population density has reached a scale up development as shown inFigure 2.

From the deep literature survey conducted, different methods have been identified for mapping telecommunication towers in different parts of the world. To the best of our knowledge, it is evident that none of the studies used population density, marking of radiation affected zone, coverage area calculation, slope of terrain, kernel density and GIS to map the

telecommunication towers. Based on the aforementioned research gaps. The present study proposed this research work in order to fill up the gaps

and also to apply a new optimize approaches for mapping telecommunication towers in some local government of Kano State, and can be extended to the other states.

Months: November 2014 - February 2016

| | Operator | Feb '16 | Jan '16 | Dec '15 |
|---|---|---|---|---|
| Connected Lines | Mobile (GSM) | 210,202,453 | 210,465,003 | - |
| | Mobile (CDMA) | 3,677,676 | 3,678,068 | - |
| | Fixed Wired/Wireless | 353,923 | 351,625 | - |
| | Total | 214,234,052 | 214,494,696 | - |
| Active Lines | Mobile (GSM) | 149,288,370 | 149,022,919 | 148,681,362 |
| | Mobile (CDMA) | 2,147,323 | 2,147,982 | 2,148,727 |
| | Fixed Wired/Wireless | 184,666 | 186,868 | 187,155 |
| | Total | 148,620,359 | 151,357,769 | 151,017,244 |
| | Teledensity | 106.16 | 108.11 | 107.87 |

Fig.2: Nigeria monthly subscribers data

## 2. METHODOLOGY

### 2.1 GIS Technology Model

The first step in developing a successful GIS project is to identify the problem. A specific problem must be identified before GIS application is developed.

This is important in understanding the character of the problem. Next step is to design and decide a suitable data model. To create an appropriate model is an important understanding that will oblige a conceptual data model, which confines the elements and problem aspects, and physical data model. This has to be considered on how to come out with the software development. The final step is the analysis of the design. In design, analysis cartographic modeling are the techniques that can be used and require by GIS application. Cartographic modeling is a generic way of expressing and organizing the methods by which spatial variables, and spatial operations, are selected and used to develop an analytical solution with a GIS and offers a rigorous procedure for integrating mapping layers and designing analysis the schema for spatial data. Figure 3 shows the flowchart of the GIS design.

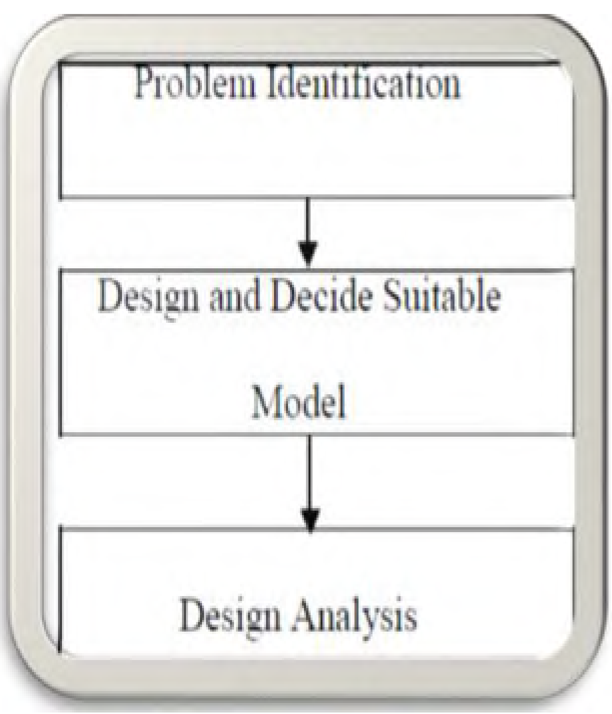



Fig 3: GIS Design Flow Chart

## 2.2 Conceptual Frame Work of the study

Development of methodology for this project is determined by referring to the main objective listed in previously. Data and technical information for GIS are the main source in developing this project. The overall sequential steps of this project development are described in Figure 4.speed and energy mapping as shown in the figure.

In this section, the current situation problem is identified. It aims to describe the issues and problems related to the study. The problems on this research are the long time mappingprocess, parameter to be included, data collection and digitization of the same and repeated information. Based on the listed problems, the categorization will be divided into two, there are problem related to the telecommunication tower and GIS development. The activities in mapping development are most important to ensure that the mapping development using GIS is progressing well.

When the problems have been identified, data is collected. But the data depend on the situation of the study area. After data collection, a reliable database will be developed. The database will be used to describe the scenario of telecommunication towers. GIS development will be accomplished using spatial data and non-spatial data. Following the analysis model is successful, the map can be created.

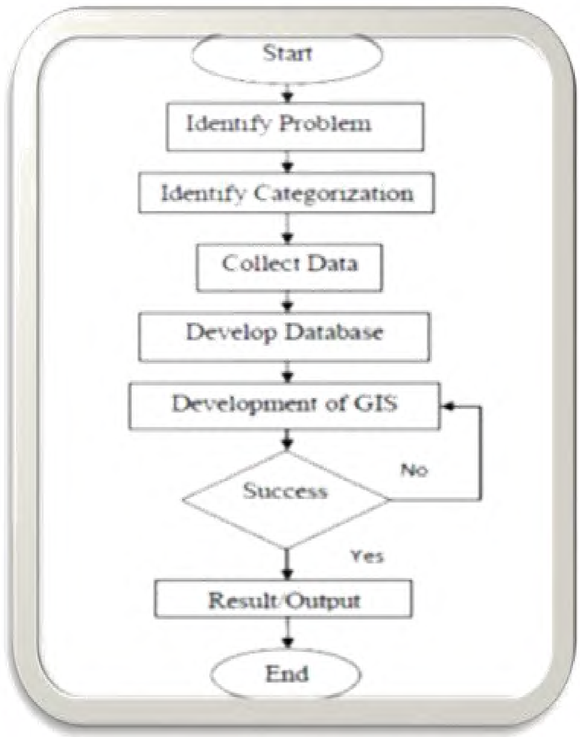



Fig. 4: Flow charts of telecommunication tower mapping development

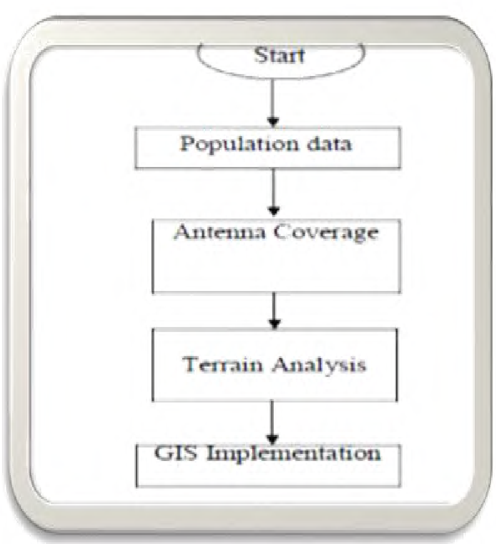



Figure 5: Flow Chart of Telecommunication Tower Study

### 2.3 Telecommunication Tower Flow of Study

In tower development, there are parameters, rules and regulations to be complied. There is a procedure in telecommunication tower implementation. The sequential step is described in the Figure 5. After data collection from the organization involved, the parameter for telecommunication tower will be used in GIS implementation. The process flow of GIS is implemented in this paper.The selection of most fitted GIS software based on the data in each study area is to adhere withthe following flow process (Figure 6).

In earlier stages, data are collected and required to fulfill the needs of GIS function. There are several tools available and the best equivalent to the data requirement will be chosen. Quantum GIS 10.0 will be selected because it is the latest version and also provides a variety of enhancements in cartography, modeling and analysis, 3D visualization, and developer tool to enable high-quality map production. For the cartography it embeds feature attributes, map layers, and coordinate system information when exporting to PDF file.

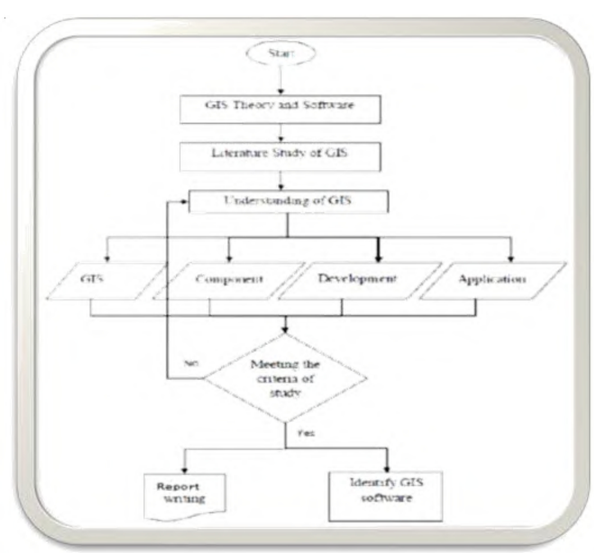



Figure 6: GIS Methodology Development of GIS Application

Attribute data for this project is the existing telecommunication tower data which will be obtained from telecommunication companies, population data will be obtained from National Population Commission Residence Offices. Raster data which is in Data Terrain Elevation (DTE) files will be synthesized using models and compared with the one that will be obtained from United States Geographical System (USGS) website.

In this paper, attribute data analysis isused. Thematic maps is constructed and saved as layers that can be edited, if there are any changes in the boundaries of the districts. Figure 7 describes the process of this project development for the GIS application.

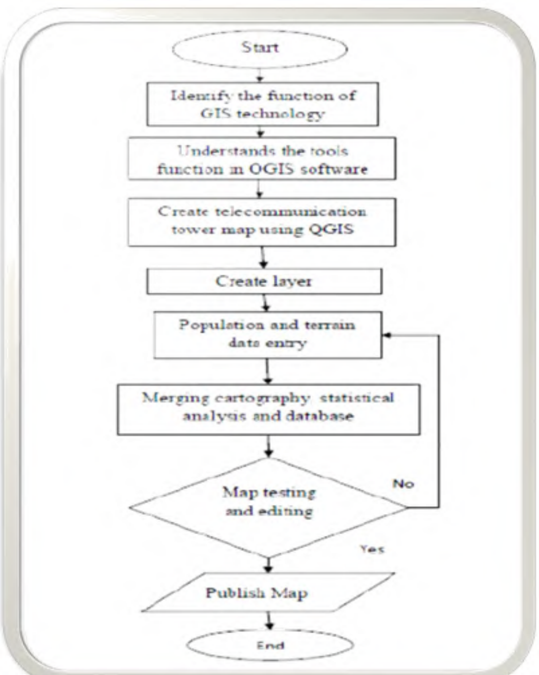



Figure 7: Flow Chart of GIS Application

## 3. RESULTS AND DISCUSSION

### 3.1 Multilayer SDGIS (Telecommunication Towers)

In expanding the application of the SDGIS, the core layer of SDGIS is integrated with another point's layer that consist of the telecommunication tower locations. A structure which has guy-wires to support it generally referred to as a mast. A structure which is freestanding generally referred as a tower. These are generalized by SACOFA as lamp pole, monopole, self-supporting lattice towers (i.e. 3- and 4-legged tower), guyed mast, and monopole tree which is shown by map in Fig 8. The numbers of tower located in Kano south which is differentiated by different type of structure is summarized in Table 1.

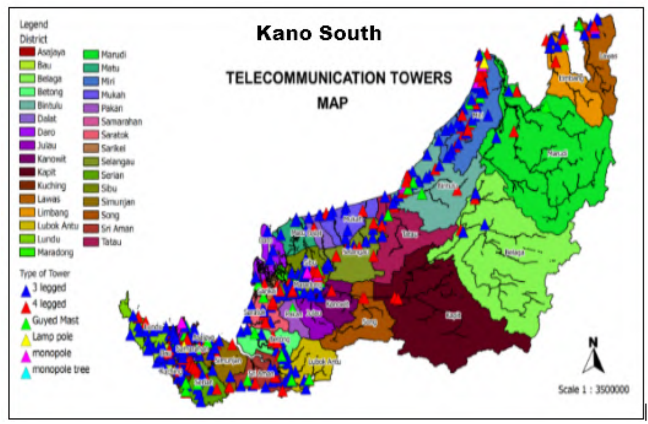



Figure. 8 MTN Telecommunication Towers in Kano South

TABLE I
NUMBERS OF TELECOMMUNICATION TOWERS IN SARAWAK

| Structure | Count |
|---|---|
| 3-Legged | 238 |
| 4-Legged | 186 |
| Monopole | 126 |
| Guyed Mast | 50 |
| Monopole Tree | 5 |
| Lamp Pole | 5 |

One striking fact about the telecommunication infrastructures in Sarawak is the population. Due to the large size of the state, its development of telecommunication infrastructure is limited and only covers certain part of the state largely the main districts only. Table II summarizes the analysis for highest population distribution, population density, and count towers followed by the small number.

Table 1: Influence of population on tower placement

| District | Population Distribution | Population Density | Area (km$^2$) | Count Towers |
|---|---|---|---|---|
| Madobi | 191,500 | 707.9 | 270.5 | 12 |
| Wudil | 262,400 | 956.7 | 274.3 | 8 |
| Rimin Gado | 143,800 | 262.3 | 548.2 | 7 |
| Gaya | 288,500 | 492.0 | 586.4 | 8 |
| Garko | 225,300 | 478.0 | 471.3 | 8 |
| Gwarzo | 255,400 | 564.2 | 452.7 | 12 |
| Kabo | 213,000 | 608.7 | 349.9 | 12 |
| Karaye | 200,400 | 477.3 | 419.9 | 23 |
| Shanono | 193,500 | 423.4 | 457.0 | 9 |
| Kura | 199,000 | 981.9 | 202.7 | 14 |
| Warawa | 183,400 | 568.6 | 322.5 | 6 |
| Dawakin Kudu | 313,700 | 740.6 | 423.6 | 13 |
| Kiru | 371,600 | 396.5 | 937.1 | 7 |
| Bebeji | 266,900 | 371.4 | 718.6 | 8 |
| Rogo | 316,600 | 394.8 | 801.8 | 6 |

## 4. CONCLUSION

This paper presents telecommunication tower map based on population density in selected local government areas of Kano State. The concepts of GIS are studied. GIS provides the functions and tool needed to efficiently capture, store, manipulate, analyze, and display the information about places and things. The selection of appropriate GIS software depending on cost and skill available are crucial. Due to a tedious descriptive analysis displaying a numerical analysis without any interactive medium, hence the GIS application can overcome it. Consequently, this GIS application produced SDGIS that provides spatial information by linking locations with information about that location.

For further improvement of this paper, SDGIS should be more informative as the Sarawak demographic resources, so that this SDGIS have its own value towards the GIS audiences. There are few limitations while developing the SDGIS such as the demographic data provided by the Statistical Department of Kano State is too general. The data only covers the population, ethnic, age, households, and living quarters, whereas there are other important aspects related to demographic that covers economy, education, health, transports and so forth. Furthermore, the distribution area only covers until the sub-districts whereby this project could be more effective for if the data is distributed by settlements (small town, housing area, kampong, etc.) in the state. Hence, the focus of the analysis would be more detail.

Besides study the population as one of the factors, it would be more focusing to study another factor that influences the decisions of placing a telecommunication tower in a certain area that is the terrain. Surface analysis such as the elevation, slope, and aspect of the terrain should be done for future project enhancement since the location of telecommunication towers had been taken as an example of the use of SDGIS. To include another layer of contour contains elevation values could be added value for SDGIS.

## 5. ACKNOWLEDGEMENT

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