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Utility Mapping of GSM Mast within Damaturu Metropolis Yobe State, Nigeria

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Abstract: ***The research focused on the production of utility map of global system for mobile communication (GSM) mast within Damaturu metropolis through field data acquisition, processing and presentation. The geo-metric and attribute data acquired were used to design and to show the position of various masts facilities and their area of coverage. Thus, spatial information and attribute data (area occupied, identification of service providers) of the telecommunication facilities (mast) were determined using simple hand heldglobal positioning system (GPS) equipment. The data generated were analyzed using geographic information system (GIS) application ArcGIS 9.2 software. A total of 37 telecommunication facilities of the various service providers were identified and considered. Most of the facilities (25 out of 37) covers an approximate area of 144 square meters with the remaining having more or less area coverage which are all processed and presented in graphical form.***

Keywords: Damaturu, GSM, GPS, GIS, Nigeria, Telecommunication

1. Introduction

That utility and land use planning mapping due to advance technology for nations that gives attention to them is well documented. Mapping in surveying is now done in a new phase where most conventional methods used in surveying and mappings are transformed into digital format. The production of map for positioning of features was carried out by analogue method before the advent of GIS as a modern technology in surveying, mapping and other fields/disciplines as well. However, geographic information system (GIS) as a multi-disciplinary tool creates a room or make it easy for different types of data from various source to be used for different purposes and assessed by different application in a database, utility mapping, post mapping, land use planning etc. Therefore, GIS plays an important role in utility mapping which is simply put: the mapping of public services such as electricity, telecommunication lines and mapping of communication towers/masts which is the main focus of this particular project.

A utility map is being designed by determining the X, Y, Z coordinates of relevant points or points of interest on the earth surface. The data obtained in the field by GPS was structured in the computer by appropriate software.

Prior to the advent of Global System for Mobile Communication (GSM) there was the establishment of various transmitting and receiver stations in different locations and parts of the country by NITEL and some government television and radio stations. The proximity of any of these stations to our locality ensures the workability of these modes of Telecommunication systems especially the telephone system.

However, the emerging trend in the communication and telecommunication industries in relation to growing economy in developing countries like Nigeria, which places emphasis on information as a cutting edge in a competitive economy, has given birth to the use of GSM phones as a mode of communication. In 2001, the GSM phones as a means of communication was introduced into the Nigerian society with two service providers; MTN and Econet (later called VMOBILE, Celtel, Zain and now Airtel), the third service provider Glo, came on board one year later. The fourth service provider etisalat came five years later and lastly multilink seven years later. This is besides other service providers of fixed wireless phone system such as Starcoms, Boudex, Reltel, Intercellular, M-tel, Visaphone etc. These service providers established receiver and transmitter mast in different parts of the country, and densify these mast structures in cities of their choice to enhance quality delivery of service to their intending customers.

The densification of these masts is highly concentrated in the urban areas and cities (such as Abuja, Kano, Port-Harcourt, Lagos, Kaduna, Calabar etc.).

Consequent upon this, it becomes imperative to have an information system about these various services providers, spatial information of their facilities locations, and the mode of their service delivery. It will equally reveal the relationship between facility locations, their pattern and trend within the neighborhood of Damaturu town the state capital of Yobe state.

1.1 Telecommunication Companies in Nigeria

The Nigerian economy has experience rapid growth over the last couple of years. Apart from oil, telecommunication is the main driver. Since the deregulation of the communication industry, the number of telephone lines has grown from about 400,000 to about 148 million lines. In addition to increasing the teledensity ratio in the country, telecommunication industry have created employment and spurred growth in ancillary industry. The Nigerian Government is taking the telecommunication industry seriously and has launched a satellite in to the orbit to help overcome the communication problems in Nigeria, (http; /black herald.egoong.com) September 3, 2007.

1.2 GSM Telecommunication Mast Description

Typical telecommunication mast tower consists of a body structure of steel beams and materials with a concrete base of an approximate height of between 25 and 55meters. Antennae, transmitters and receivers are mounted on the body of the structure. These antennae receive high frequency radio waves from cell phones. The ranges of these antennas vary from distances as short as 1.5 to 2.4cm to distances as long as 48 to 56km. A power source is provided with other accessories, all fenced either by block wall or steel poles and wire depending on the service providers. The area covered by each mast location is approximately 144sqm (l2mx12m).

Figure 1.1: A Typical GSM Telecommunication Mast Facility (Source field data) 2016.
Location coordinates (822018mE, 1296620mN)

1.3 Statement of the Problem

Over the years there was a massive development in the communication industries where different services has been provided by different service providers such as Globacom, Mtn, Airtell, Etisalat and Multilink, for easy and faster means of communication. Research has shown that, this massive development was from 2001 to date, but the fact still remains that there is no full record of different masts/tower facilities that have been erected in Damaturu town which serves as the state capital of Yobe State and no map has been produced purposely to show the locations of these facilities, which is one of the problem faced by the following organizations.

1) Ministry of environment for environmental impact assessment.
2) Ministry of Land and housing for the purpose of land use planning/distribution and payment of ground rent.
3) The service providers in monitoring and efficient service delivery.

Furthermore, due to problem mention above, the research intents to focus at this area with a view of getting information about the spatial distribution of these masts and produce a utility map showing the location and their area of network coverage**.**

1.4 Justification of the Study

This project provides information regarding the location, area of network coverage and description of utility such as the GSM masts that are available and located in different part of Damaturu metropolis, Yobe State. Repairs and management or replacement of the GSM masts can be carried out in an optimal manner base on the fact that the map produced would provide the necessary information about the different masts in Damaturu as well as their location and extent of service coverage. This has been done in an easy way through the help of efficient GIS techniques. Other significant of this particular project include;

1) Future project planning
2) Efficient data updating
3) Speedy retrieval and compactness of data (query)
4) Easy map distribution via digital or hard copy.
5) Simple comparison of data about different type of GSM masts in Damaturu.

6) Reference for further research and development in the future and easy access to information on communication utilities (masts) in Damaturu.

1.5 Scope and Limitation

The study area is limited to Damaturu metropolis as seen on scanned and geo-referenced land use map of Damaturu as shown in figure 1.2. Though the study can be used as a model for designing similar project elsewhere. The project involved the design and creation of database and map, which will support the integration of records of mast and permit the upgrading, processing and retrieval of updated information on GSM mast /tower.

Study Area

The study area is limited to Damaturu metropolis, Yobe State.

A. Location

The study area covers the entire Damaturu metropolis. Damaturu lies within the latitude 11°43′55”N to 11^{0}44’07’’N. and Longitude 11°54′08’’E to 12^{0}02’27’’E, with an average altitude of 298m above mean sea level.

B. Climate

The climate of Damaturu is hot and dry for most period of the year. The mean temperature for most stations in Damaturu is about 37°C. The highest temperature (about 42°C) is normally experienced in April, while minimum temperatures (about 30°C), during November and December. Rainy season start from May to September, while dry season is from October to April.

C. Vegetation

Vegetation cover is sparse as the grass grows in individual tufts leaving bare surfaces in between. The grasses in the Sahel are short and tussock, 0.5m to 1.0m high which are interspersed with sand dunes.

D. Soil

The soil in most part of Damaturu is derived from drift materials which vary in textural characteristics, but are mainly silt clay or clayey. The profile of the soils is poorly developed, and it has a low water retention capacity, the productivity of the soil is greatly impaired due to lack of adequate vegetation cover to supply organic matter.

E. Population

According to the head count conducted by the National Population Commission in 2006 census, Damaturu Local Government Area has an estimated population of 88,014, however, Damaturu metropolis alone has an estimated population of 44,268 as at 2010 projected population.

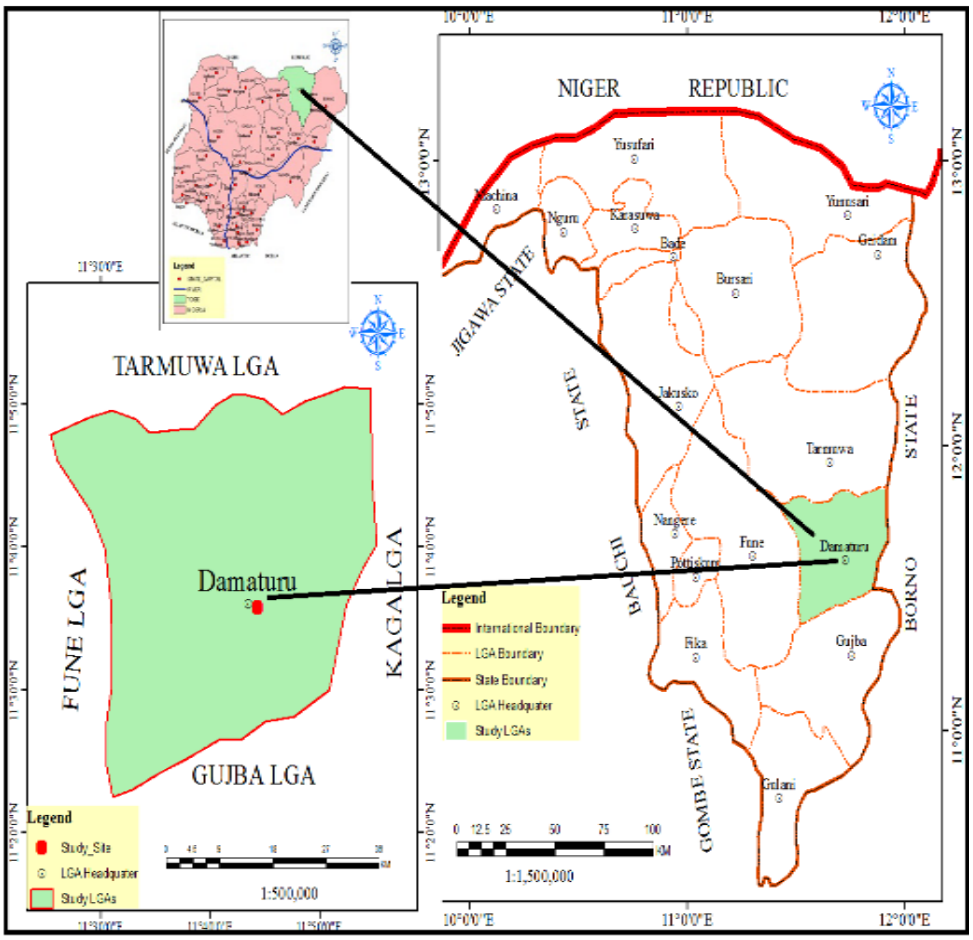

Figure 1.2: The Study Area
Source: Ministry of Land and Housing (2015).

Figure 1.3: Satellite Imagery (IKONOS) of Part of Damaturu Metropolis
Source: Google Earth 15th May, 2015 9:30am

2. Literature Review

Basic Concept of the Research

The introduction of GIS has brought a complete revolution to the traditional method of surveying and mapping as GIS is now vastly used for faster production of map, the present chapter explain related reviews of some past research projects either in form of article or journals conducted by various individuals or organization which are uniquely base on application of GIS and remote sensing in GSM mast locations, distributions in different part of Nigeria.

Review of Related Literature

The introduction of Global System for Mobile Communications (GSM) phone with the un-regulated sitting of communication towers had increased the exposure of great percentage of the population to electromagnetic radiation and the concomitants health hazard in developing countries. With samples from Akure Nigeria, the study examined the variation of the satisfaction of the people living around GSM base stations with distance away from the location of the base station. Using Crosstabs' nominal-by-nominal measures, the study found that the further the distances away from the base station, the higher the percentages of those that are satisfied; When the effect of fear of health problems exhibited by the residents was introduced, the study found that the variation in the satisfaction level with distance was due to those who haboured fear of health problems. In addition, the study used Ordered Logic Regression to model the combined effects of distance, fear and rent on the satisfaction with base station location; in this wise; the study found that statistically significant relationship exists between Distance and satisfaction with the base station. To alleviate the real and perceived fear associated with the location of base station therefore, the residents should be provided with unbiased factual information relating to the negative effects on health and other hazards associated with living in close proximity to a base station. (Bello, 2010).

Case Studies

In a paper titled Towards the Optimal Use of Telecommunication Mast Locations as a Platform for Survey Control Densification in Rivers State of Nigeria, states that;in the past, survey controls were established in major towns and cities which were used for cadastral and engineering surveys. In the light of the need for increased survey controls, most of the major towns and cities have expanded beyond the boundaries that existed at the time of control establishment. This is more critical as the extension of survey controls to the new areas has not kept pace with the rate of expansion in the study area. Moreover, the current survey controls are neither comprehensive nor adequate. This research therefore, seeks to bring to the fore the option of optimal utilization of existing telecommunication mast locations as platform for survey control densification in Rivers State of Nigeria. This 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. The coordinates of existing control stations as established by various agencies were obtained for analysis. The result of the buffering operation of 2km and 5km 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. Besides, the nearest distance of control station to telecommunication mast is 240 meters and the farthest is 1.9km in Rumukwurushi axis. Similarly, the nearest distance of control station to telecommunication mast is 1.2km and the farthest is 4.3km along the East-West Road axis The use of these mast location that are spread all over the study area will reduce the challenge of identifying suitable location for citing higher order survey controls. Also, the removal and destruction of existing controls due to construction activities will be highly minimized considering their secured position. It will further enhance survey control network planning for the urban areas thereby providing quick information regarding proximity of available control points. This spatial information will therefore provide the necessary platform to locate a monument or any permanent mark of which their coordinates will be accurately determined to serve as survey controls for cadastral and engineering surveys. (Hart, 2015).

Intelligent GSM Cell Coverage Analysis System Based on GIS states that: In mobile network, a deviation of cell coverage area influences many network performance indexes. Cell coverage analyses are vital to network optimization. The traditional check method is DT (Drive Test) or FSP (Field Strength Prediction) by manpower which costs much time and resources. This system derives a cell coverage analysis chart and identifies the cells with cross-boundary coverage or poor coverage problem by collecting a huge number of mobile phone measure data in OMC and analyzing multiple factors based on the measure data and the basic data of cells. The measure data analysis aims to compute signal level distribution, sample point distribution, category of interferences. The basic data of cells includes neighborhood relationship, azimuth ward, location and distance between two cells. The base station site level can be computed from the basic data of cells by the triangulation method. The calculation and analysis results are presented in the map based on GIS platform to improve visualization. This method and system are validated by a large number of actual datasets from an in-service GSM network. Contrast with the traditional cell analysis method, this method and system demonstrate advantages in intelligence, accuracy, timeliness, and visualization. (Lan, 2011).

The response of rents from residential properties to the sitting of Global System for Mobile (GSM) Communications' masts in various residential zones in Akure town. The study employed survey approach in order to understand the relationship that exists between location of GSM masts and rental values offered on proximate residential properties within a 300 metres radius of GSM masts. The town was divided into high, medium and Low density zone; and three GSM masts were selected from each of the zones for the study. In all, a total of 180 questionnaires were administered on residents within the radius and 139 (77.22%) were retrieved and good for analysis. Regression analysis was employed to determine the causal effect of GSM mast on the rental values of neighbouring residential properties in the study area. The findings revealed that the location of GSM mast has no significant effect on rental values of residential properties in the high and medium density residential zones of Akure. This is attributable to the fact that demand for residential properties in town is generally very high, and the residents are left without much choice due to attendant high rent charged on existing residential properties. However, there exists a positive effect on rental values of properties in the low density zone. There is need for the Nigerian Communications Commission (NCC) to follow the global trends on new findings about health implication of sitting of GSM base stations around residential neighbourhood and ensure that international standard of safety is strictly adhered to by the operators in Nigeria. **(**Olukolajo, 2013).

In recent years, health care provision policies in Nigeria have addressed distribution and spatial equity questions at a gross or regional level, but have neglected to address the distribution of health care facilities within cities. This paper explores the potential use of GIS for modeling the spatial distribution and accessibility of the health care delivery system in Yola. Several digital and non-digital data sets were collected and transformed into GIS data. Spatial analysis tools, including symbols, overlay operations; Kernel Density Estimations (KDE), buffer operations, and a raster calculator were used for the analysis. All identified public and private facilities were classified as primary, secondary, or tertiary. The majority of these facilities were concentrated in Jimeta. The study also produced the three following accessibility models: (i) the distance to the health facility, (ii) the health facility-to-population ratios, and (iii) the physician-to-population ratios. Based on this analysis, it was concluded that a gross inadequacy exists in terms of health care facilities and physicians. Thus, these results identify the need for urgent improvements in the Yola health care delivery system, including the construction of new facilities, upgrades for existing facilities, increased physician employment, and the adoption of GIS technology by Yola health care planners and policy makers for effective planning and resource. (Ismaila &Usul, 2013).

Can be carried out in the optimal manner when based on an efficient GIS or utility mapping system. GIS/utility mapping system offers some numbers of advantages which include:

1) Location and characteristics are stored systematically
2) Easy access to the information i.e. also for users without any specialist expertise.
3) Simple comparison of data about different types of utility maps and base maps.
4) Flexible extraction and analysis option.
5) Project planning.
6) Easy map distribution via digital or hard copy.

One of the advantages to a utility company, when employing a consultant like GIS landmark to carryout utility mapping is that the bulk of the work in connection with the data capture can be carried out within a short period of time without staff increases or extra investment in equipment thus easing the introduction of digital techniques (http/www.gislandmark.com).

The Experience of MTN Nigeria

The most valuable assets of many companies are not their products or services, but their data. This is particularly true in the communication industry. Trapped inside the customers billing systems is a gold mine of data that holds the key to customers retention, reduce expenses, customer self-service and overall competitive advantage.

In the mobile communication networks, the core business is selling airtime to subscribers. All the information about that airtime is tracked through call data records, CDRs. CDRs are used to bill customers, because of the huge amount of data that would need to be processed, they are usually not analyzed to add business value. However, with shrinking margins and increasing pressure to improve revenues, operators now are looking closely at ways to use these data to their advantage.

GIS is one powerful tool that can be used to analyze call data records (CDRs), allowing the operators to see a precise, up to date picture of the entire network and to better understand the calling patterns of their subscribers, with a view to knowing their networks better and offering subscribers customized services and hence increasing revenue.

This article describes how network providers in Nigeria using GIS to investigate the relationship between the geographic spread of subscribers, using call data records and net stipulated key performance indicator (KPIS) like traffic. A call data record is generated at the switching center of a (ISM network each time a successful call goes through. The switching center generates huge volume of this record, sometimes running into terabytes. It is therefore a serious challenge to analyze these data to enhance the making of informed decisions, subscribers, cells, market shares, handset usage etc. Unlike others, records are analyzed principally from the subscriber's points of view and GIS is used to do this. In telecommunications, WHERE is everything, which is why GIS is a very useful tool in telecommunication and is geographic in nature. (http/www.directions.mag.com.article pdf. Article id 2012).

3. Methodology

General Framework of the Project Research

This section discussed the general procedure and approach to the project research. It also discussed data types and their sources, data acquisition method, and data presentation as well as the steps that followed to obtain the data of the various masts locations and their area of service coverage in Damaturu metropolis.

Instruments and Materials

For the successful execution of this project, the following instruments were used.

Hardware Equipments

1) Garmin 60, hand held Global Positioning System (GPS)
2) Computer system (HP and lenovo Laptops).
3) A Toyota Hilux (Four Wheel Drive) Vehicle.

Software Packages

1) ArcGIS 10.3 (Version)
2) Adobe Photoshop 7.0 (Version)
3) Google Earth

Method of Data Collection

Data source/data acquisition

There are two major sources of data acquisition which was adopted in this research project namely:

1) Primary Source: This is the direct acquisition of data on the site. The data of the mast were obtained by ground survey method using Handheld GPS.
2) Secondary Source: It is the unique information about the attribute data, which was obtained from the office of the service providers and related articles.
   a) Total number of mast in Damaturu
   b) Cell ID
   c) Height of Mast
   d) Location of mast
   e) Extend of service coverage

Data Processing

Data processing shall include the following:

GPS data processing

Satellite image of part of Damaturu were merged using Adobe Photoshop 7.0 software and a composite image of the study area was produced; it was later taken into ArcCatalog environment where it was spatially referenced to WGS 1984 Zone 32 . The image of the study area was added into an ArcMap environment. The image was geo-referenced and digitized, shape files were created.

The coordinate were determined using the Garmin Handheld GPS and was downloaded into the computer system to obtained X, Y coordinates of the mast. The coordinate were obtained using the GPS which is in WGS 84 coordinate system. The data was then imported into ArcGIS 10.3 through Microsoft Excel software for upgrading the map.

Geo-referencing

The Geo-referencing is the process of identifying a prominent point/position on the satellite image and coordinate it using the ground coordinate. The coordinates of the identified points on image are to be insert one after the other using add control on the Geo-referencing toolbar. Geo-referencing ensures that coordinate of pixels on the image correspond with the true coordinate of the point they depict on the ground. The following steps were adopted during geo-referencing;

Prepare the Software

Add the Geo-referencing toolbar, if it is not already showing, by selecting: View > Toolbars > Geo-referencing

Prepare all the spatial layers

- Open all spatial layers you will use to geo reference the image.
- Zoom in to the approximate area that is covered by the image to which these layers will be added. This does not have to be exact, as it is done just to provide you with an easier work space.

- Adjust the colour and shape of any points so that they will be visible when displayed on the image.

Adding Control Points

This is the process of matching points on the image layer to corresponding points on the shape layers. From the Geo referencing toolbar, select the Add Control Points icon. This tool allows you to geo reference the image:

- First, using your mouse, left click on a known point on the image. This will place a cross mark on that location.
- .Next, left click on the matching control point in another layer. This will 'move' the image and better align the control points.
- Repeat this step with each control point. If you would like to input x and y coordinates as an alternative to the method mentioned above, after placing a cross mark on a location, right-click on it and enter in the coordinates.

Note: it is a good idea to zoom in on your image when adding control points for better accuracy. For every set of control points you create, an entry is created in a table that records the original coordinates, the control point coordinates, and the residual error. Access the table by choosing the View Link Table icon from the Geo referencing toolbar.

Adjusting the final product

Residual error is the measure of the fit between the true locations and the transformed locations of the output control points. If there is a link with a high level of error, consider deleting it by highlighting the point in the link table and clicking the delete icon. Depending on the number of control points you have, from the Geo-referencing table you can perform a 1st, 2nd, or 3rd order transformation. The transformations compare the coordinates of the image source with the control points creating two least-square-fit equations to translate the image coordinates into map coordinates. A 1st order transformation shifts the image up, down, right, or left, stretches the image larger or smaller, or rotates the entire image. The 2nd and 3rd order transformations fit higher order polynomial equations to the data, allowing points to be shifted in a non-uniform manner. Most of the time either a 1st or 2nd order will suffice. Try all three and choose the one that works best.

Digitizing

In converting the analogue township map of Damaturu into digital format, this process involves creating a polygon shape file, the procedure involves is called “on screen digitization”. After creating the shape file, the coordinates of points for all canners, thus for every change of direction was inputted in a clockwise direction using the ArcGis 10.3 software package. The on screen digitization will automatically digitized the poly structure as created by the shape file, hence the digitalization of township map of Damaturu is completed.

Database Creation

Database creation is also referred to as database implementation which is the process of creating a generic data structure in the computer system to facilitate ease of data exchange and series of analysis. In case of this project, the following steps were adopted to create a nonspatial table in a database from ArcGIS. Start ArcCatalog or ArcMap and open the ArcCatalog window.

Create a connection to your database.

Right-click the database connection in the ArCatalog tree, point to New, then click Table.

Type a name for the table.

Table names must start with a letter and cannot exceed 160 characters. If you want, type an alias for the table.

You might have a table name standard that isn't user-friendly. In those cases, create an alias for the table.

Define the fields for your table

All tables must contain a unique identifier to be used with ArcGIS. Therefore, ArcGIS automatically adds an Object ID field to the table.

The Object ID value will be populated automatically if you load data into the table.

Click the next blank row in the Field Name column and type a name.

Click in the Data Type column next to the new field's name and choose a data type from the drop-down list.

Optionally, you can create an alias for this field by clicking in the Alias field under Field Properties and typing an alias.

If you don't want any null values stored in the field, click the field next to Allow NULL values and choose No from the drop-down list.

4. Results And Discussion

Presentations of Result

This chapter presents the raw data obtained from the field using handheld GPS instrument. The data are presented in the following categories under listed. This chapter also presents the various categories of maps produced in the task to produce digital utility map of GSM mast within Damaturu metropolis.

This research or project, use six different types of mast as a case study i.e. the MTN, GLO, Airtel, Etisalat, Mtel and Multilink respectively.

Table 4.1: Breakdown of Service Providers in Damaturu

S/N	Cell type	No of cell
1.	Mtn Nigeria	17
2.	Globacom	06
3.	Airtel	08
4.	Etisalat	03
5.	Mtel	01
6.	Multilink	03

Table 4.2: Shows Cell Type, Mast ID, Coordinate, Mast Height and Location

S/N	Mast type	Mast id	Northing	Easting	Mast height	Base area	Location
1	MTN	DAMT001	1303217	821600	35.5	(12*12) 144.00	Works Gashua Rd.
2	MTN	DAMT002	1301162	822480	40	(12*12) 144.00	Pawari Ward
3	MTN	DAMT003	1300703	824683	35.5	(12*12) 144.00	Sabon Pegi Dtr
4	MTN	DAMT004	1298663	824522	40	(12*12) 144.00	GRA Damaturu
5	MTN	DAMT005	1299000	173127	40	(12*12) 144.00	DaboAliyuExtension
6	MTN	DAMT006	1298846	820390	45	(12*12) 144.00	Sani Daura Ahmed
7	MTN	DAMT007	1294019	821063	45	(12*12) 144.00	YBC Gujba Road
8	MTN	DAMT008	1301254	826201	37.5	(12*12) 144.00	Waziri Ibrahim Est.
9	MTN (M)	DAMT009	1299176	821964	50	(12*12) 144.00	NIPOST Office
10	MTN	DAMT010	1300468	820733	25.5	(12*12) 144.00	Nayi-Nawa Tsallake
11	MTN	DAMT011	1300811	824592	40	(12*12) 144.00	Sabon Pegi Dtr
12	MTN	DAMT012	1301425	824523	33.5	(12*12) 144.00	Pompomari Ward
13	MTN	DAMT013	1300940	823561	26.5	(15*12) 180.00	Gwange Ward
14	MTN	DAMT014	1300339	823728	35.7	(15*12) 180.00	Njiwaji Layout
15	MTN	DAMT015	1298499	822587	35.7	(15*10) 150.00	Kirikasamma
16	MTN	DAMT016	1296620	822018	36.5	(12*12) 144.00	3bed room gujba Rd.
17	MTN	DAMT017	1298891	174416	40	(12*12) 144.00	Maiduri Ward Dtr.
16	Glo	YBG001	1296490	822535	45.5	(12*12) 144.00	3bed room gujba rd.
17	Glo	YBG002	1298665	823946	36	(12*12) 144.00	GRAOpp.Gaat Hotel
18	Glo	YBG003	1298962	173265	40	(12*12) 144.00	Ben Kalio White H.
19	Glo	YBG004	1299657	820978	35	(12*12) 144.00	Nayi-Nawa Ward
20	Glo (M)	YBG005	1300051	823299	55	(15*12) 180.00	Gwange Ward
21	Glo	YBG006	1297833	817682.00	40	(12*12) 144.00	Abatoir Dikumari
22	Airtel(M)	YB0007	1299845	823142	45	(15*12) 180.00	CentralRound About
23	Airtel	YB0005	1294086	821111	40	(12*12) 144.00	YBC Gujba Road
24	Airtel	YB0006	1299153	821923	38.5	(12*12) 144.00	Nasarawa Ward
25	Airtel	YB0002	1301086	822489	40	(12*12) 144.00	Pawari Ward
26	Airtel	YB0007	1298846	820390	45	(12*12) 144.00	Sani Daura Ahmed
27	Airtel	YB0008	1299793	825912.00	30	(12*12) 144.00	OPP. Stadium
28	Airtel	YB0009	1301425	824523	40	(12*12) 144.00	Pompomari Ward
29	Airtel	YB0004	1302776	821559.00	30	(12*1) 144.002	Works Gashua Rd.
30	Etisalat	YBT001	1299707	823210	55	(15*15) 225.00	Behind Fidelity Bank
31	Etisalat	YBT002	1299236	826777	50	(15*15) 225.00	Don Etebet
32	Etisalat	YBT003			50	(15*15) 225.00	Nayi-Nawa Tsallake
33	Multilink	Y01	1298140	821001	3.5	(10*12) 120.00	Nasarawa Ward
34	Multilink	Y02	1301084	822791	28	(10*12) 120.00	Emir's Palace
35	Multilink	Y03	1300237	826922	40	(10*12) 120.00	3BR M/guri Road

Key: Mast type (M) Master receiving station

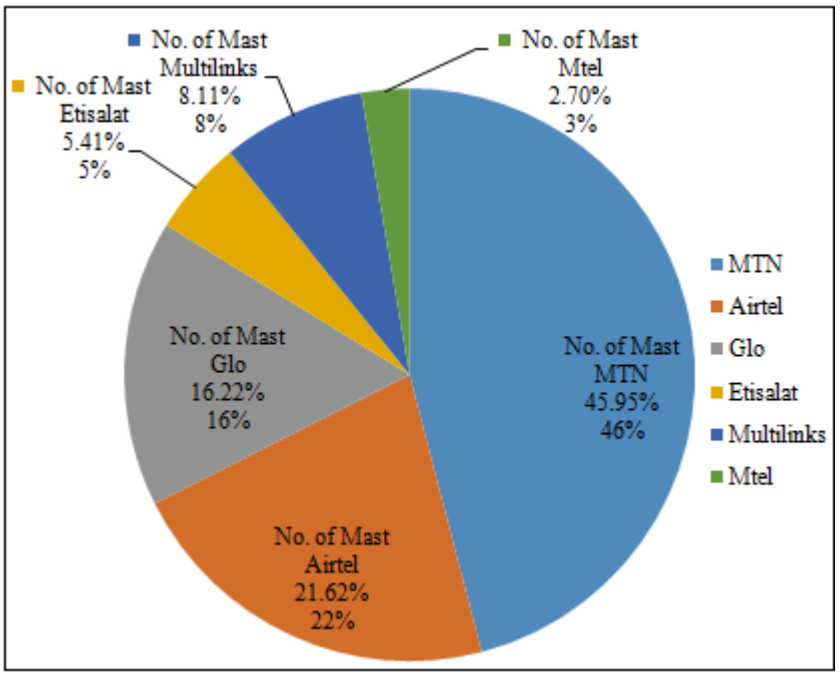

Figure 4.3: The Pie Chart of Sercice Providers in Damaturu Metropolis (2016)

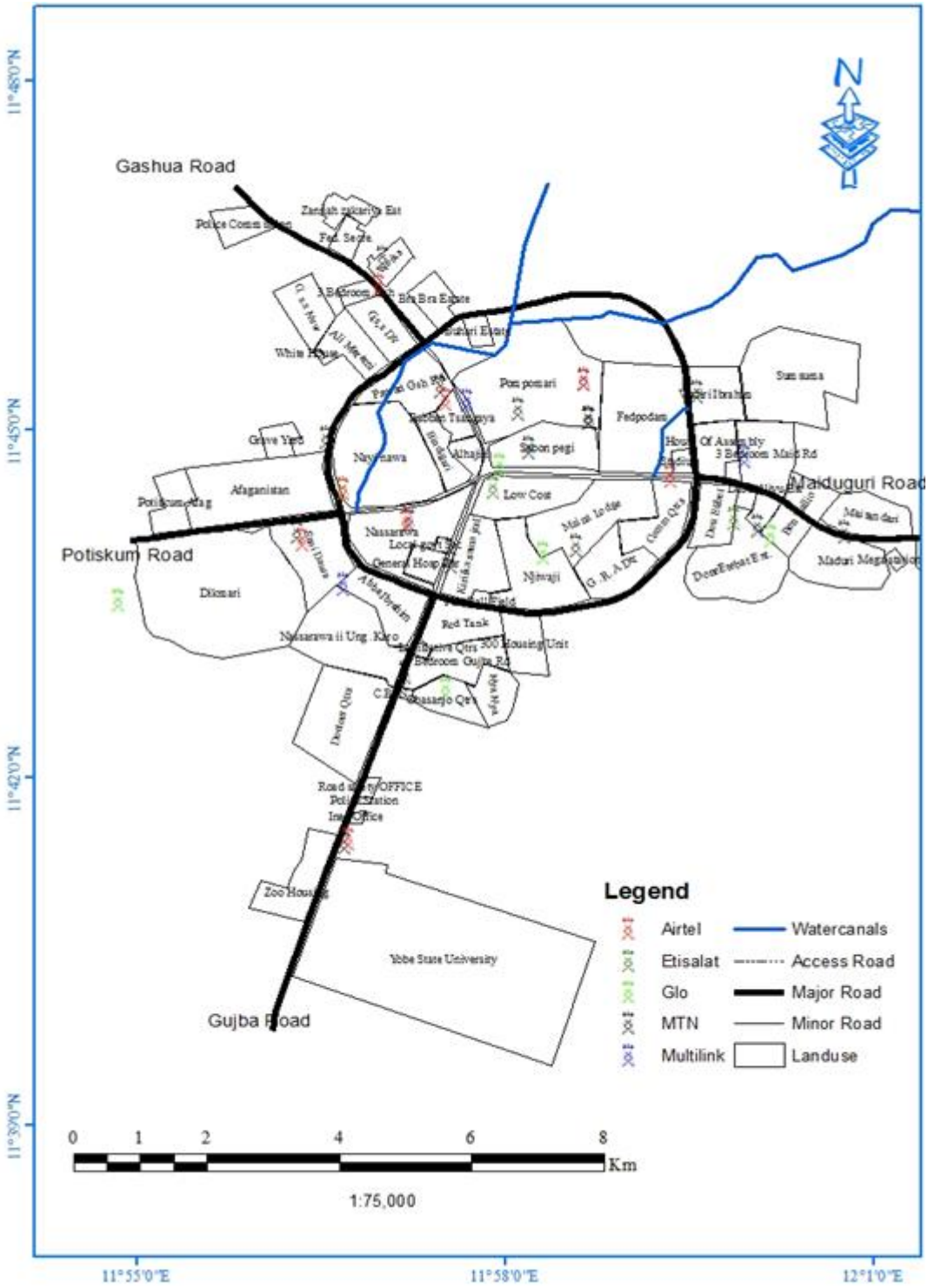

Figure 4.4: GSM Mast within Damaturu Metropolis (2016)

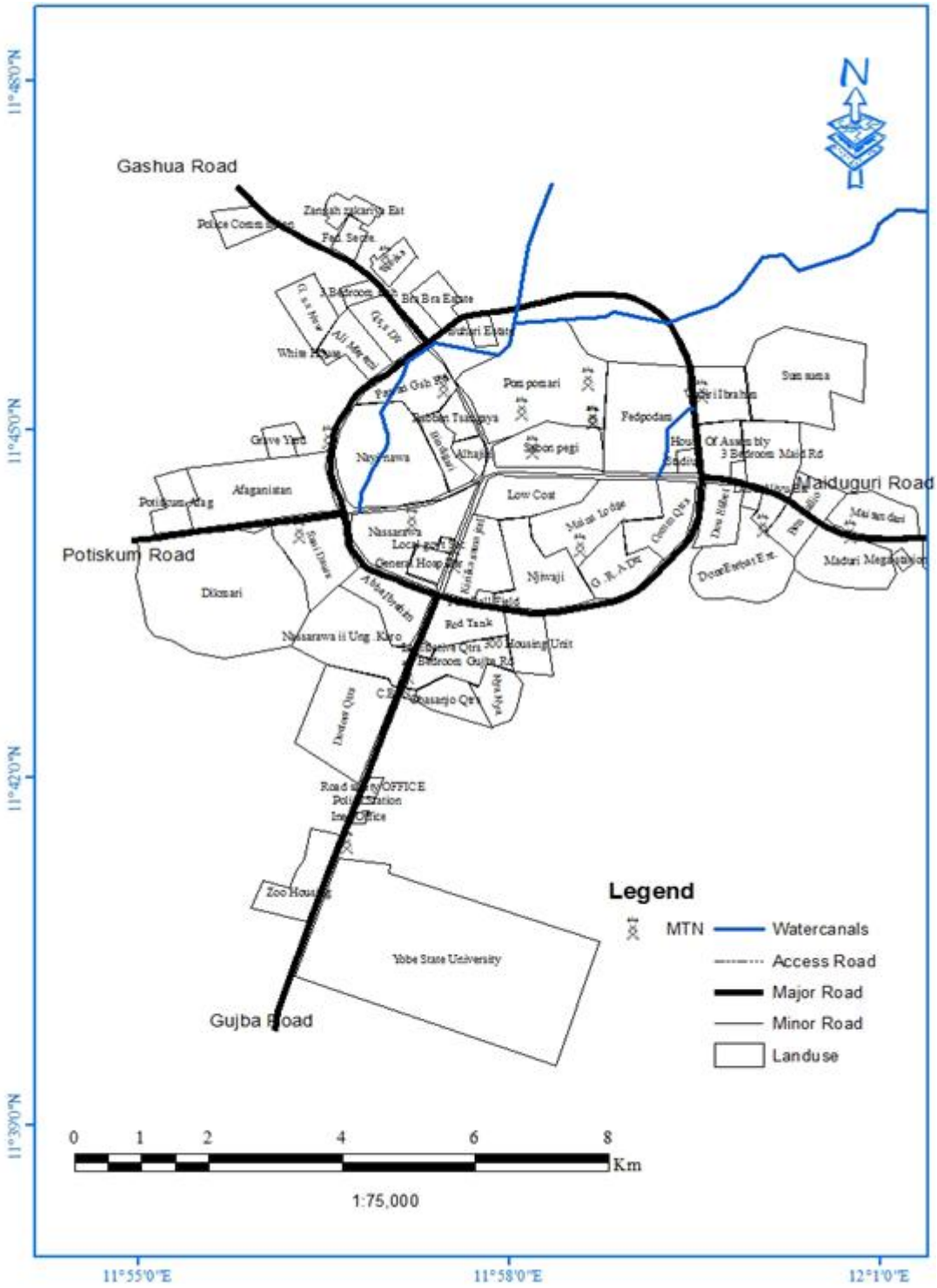

Figure 4.5: MTN Mast within Damaturu Metropolis (2016)

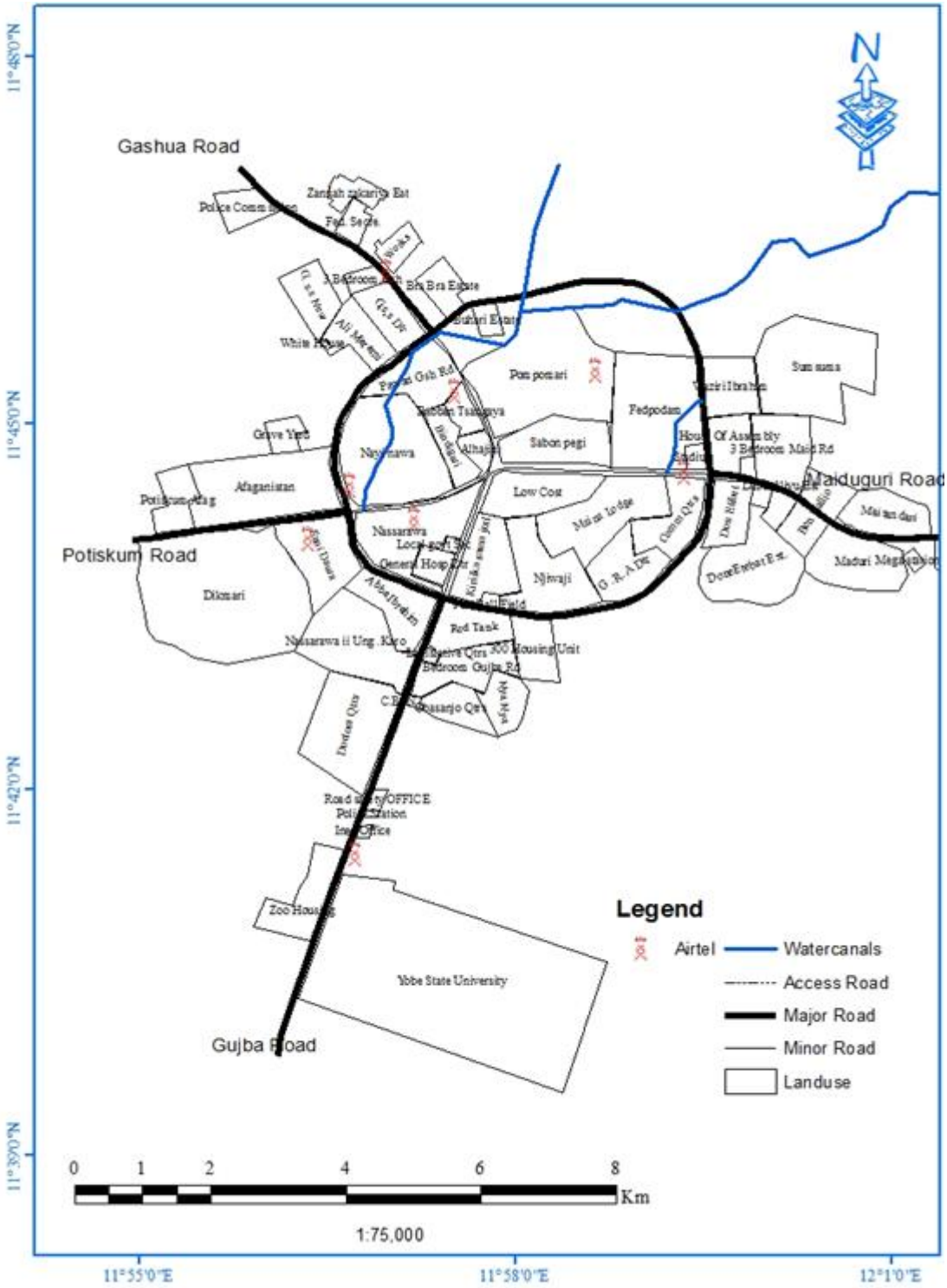

Figure 4.6: Airtel Mast within Damaturu Metropolis (2016)

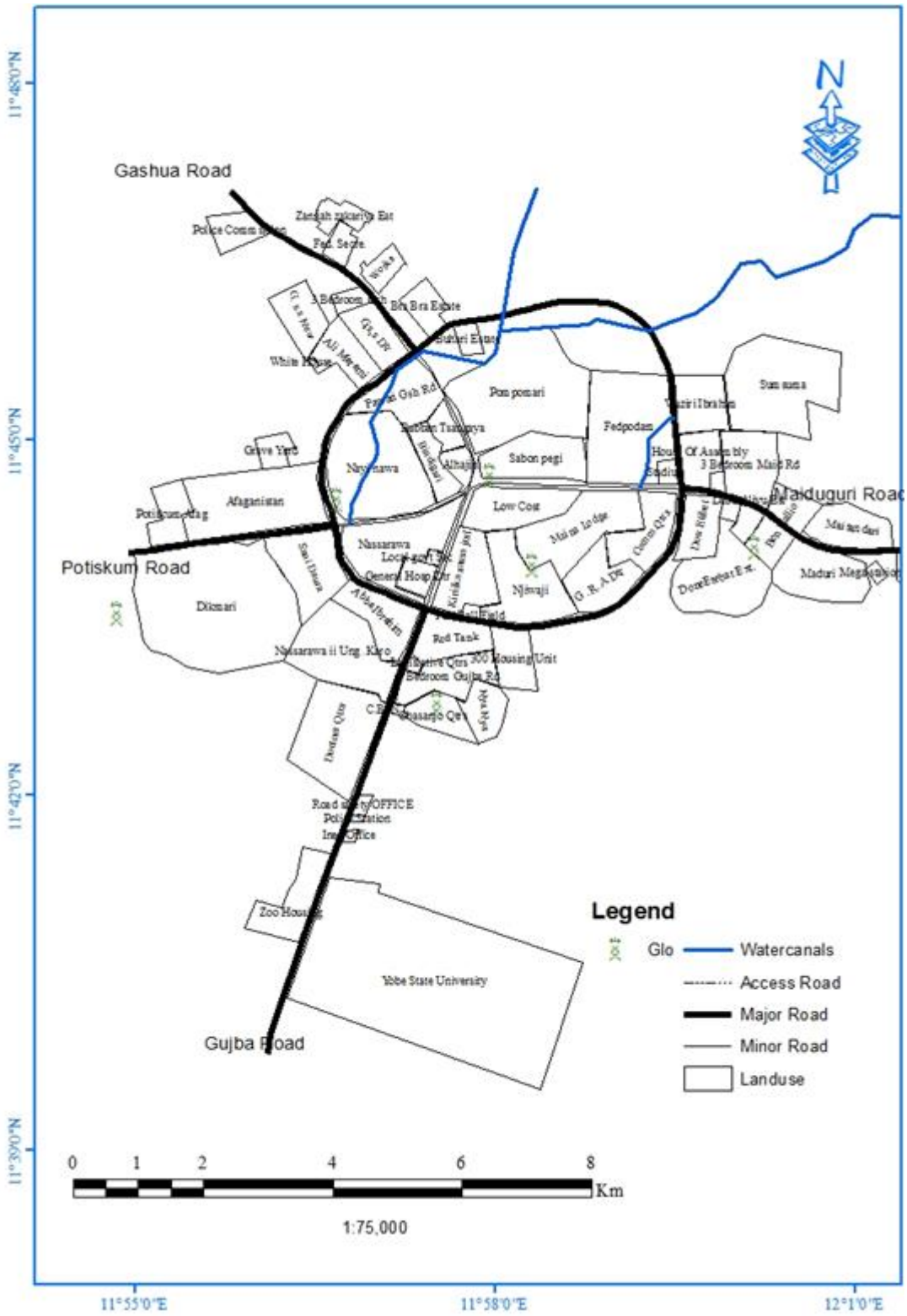

Figure: 4.7: Globacom Mast within Damaturu Metropolis (2016)

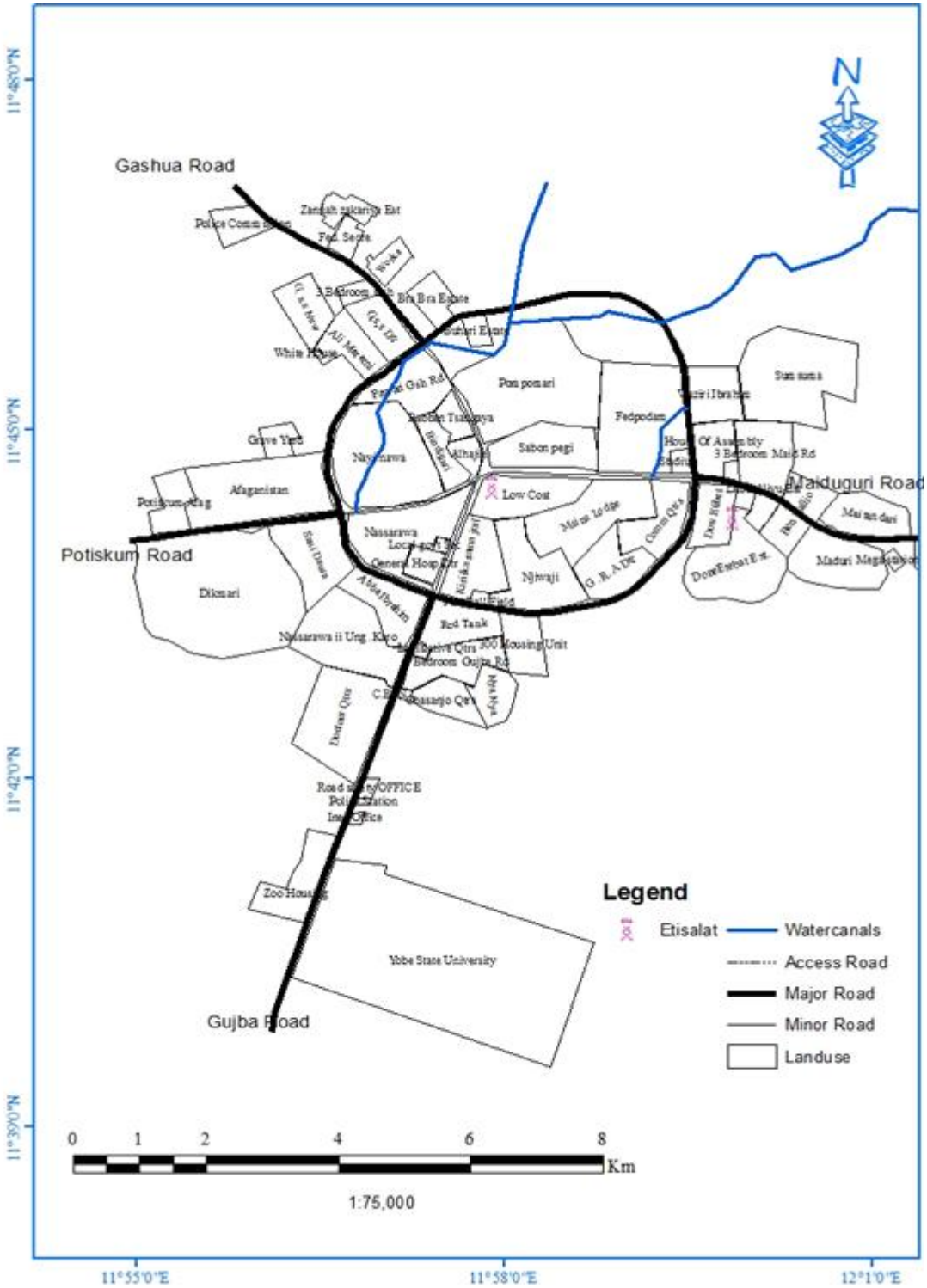

Figure 4.8: Etisalat Mast within Damaturu Metropolis (2016)

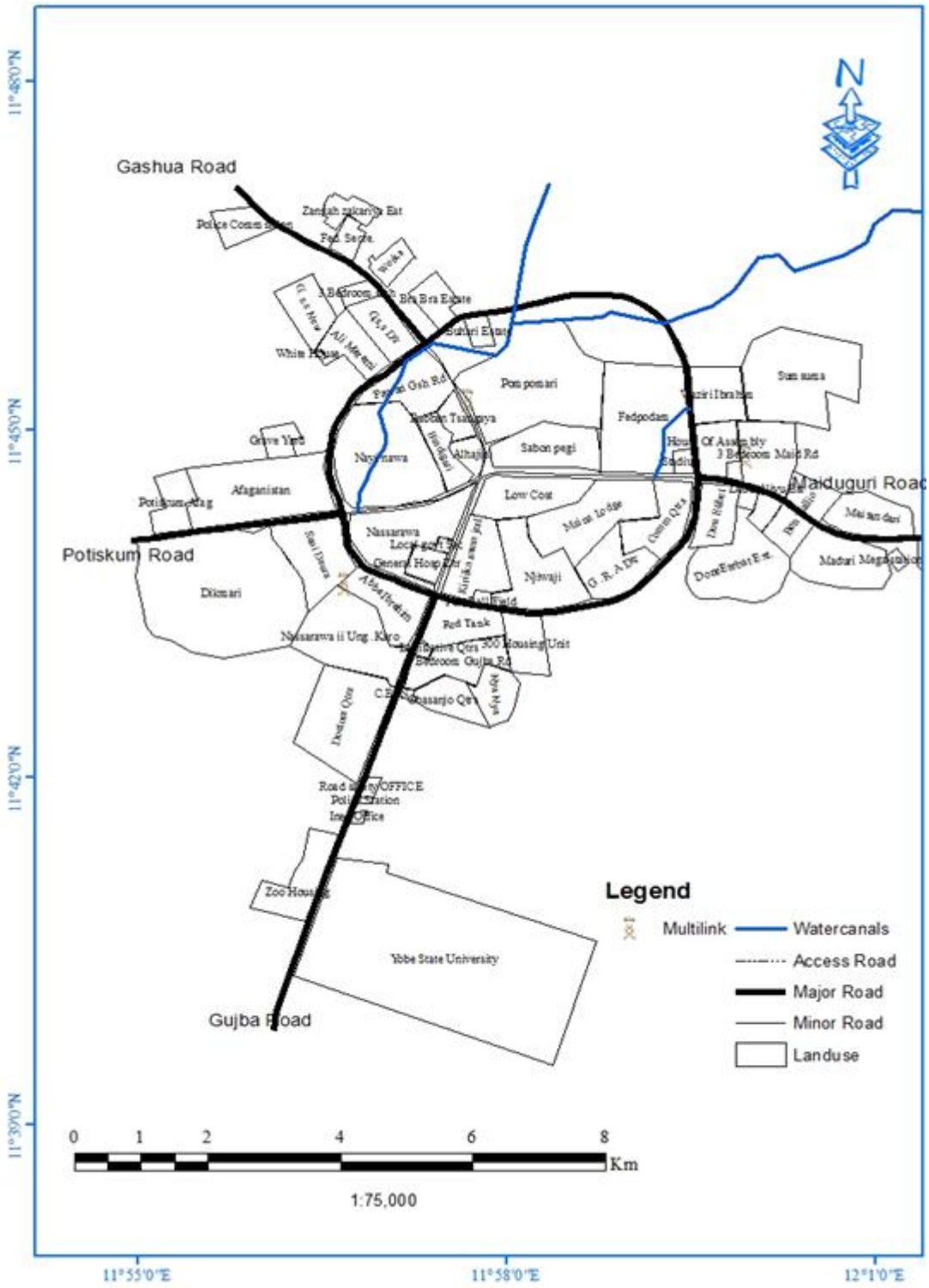

Figure: 4.9: Multinks Mast within Damaturu (2016)

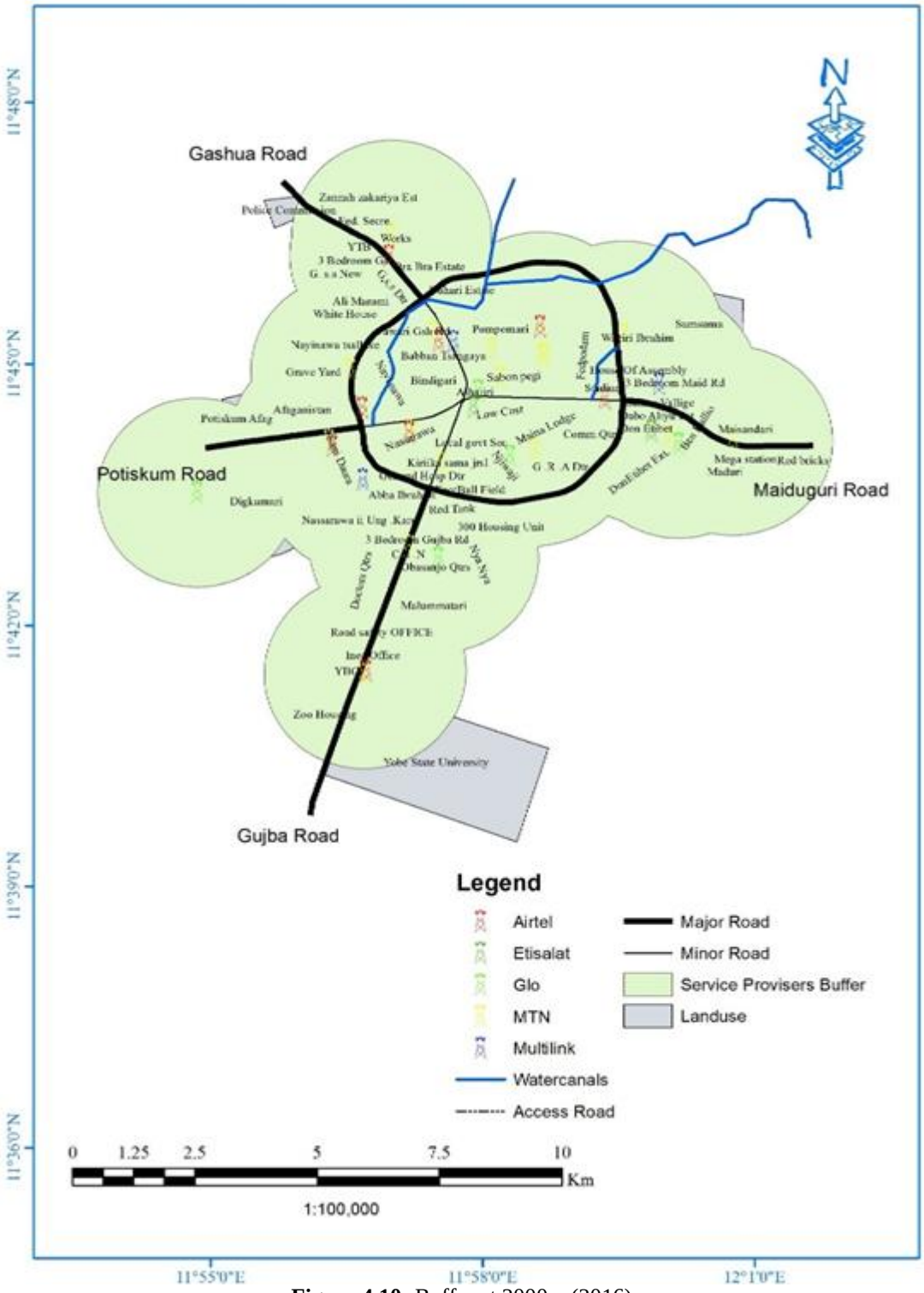

Figure 4.10: Buffer at 2000m (2016)

5. Discussion of Results

As the mobile networks are being deployed across the country, these findings would be extremely important as it reveals issues and challenges for a robust land use planning and to also guide land policy makers and/or managers to appreciate the effect of land use by these GSM service providers in relation to the economic benefit of the individual and government.

1) The service provider with highest number of mast in Damaturu metropolis was MTN=17, AIRTELL=8, GLOBACOM=6, ETISALAT=3, and MULTILINK=3. But multilink are not functional as at the time of this project.
2) It was found out that the majority of the towers sites (28 out of 38) are located very close to residential areas, and even within residential compounds with a high density of human population.
3) There are no precautionary measures taken or put in place by either the service providers, the residents, the community or the government to avoid any possible accident or environment hazards due to the ignorance nature of the people on the consequences of locating

telecommunication mast/tower sites within residential areas.

4) The purchase of land and landed property for siting telecommunication mast/tower by GSM service providers adversely affects property values, though it depends on the uniqueness of each property and the different methods that are adopted by the property appraisers or agents.
5) Most of the facilities (25 out of 37) covers an approximate area of 144 square meters, while the remaining facilities covers more or less (4, 4, 1 and3, with an approximate area of 225, 180, 150 and 120 square meters respectively).
6) Although, a super structure mast can host many transmitters and receivers to achieve the same purpose, most of the service providers erect their structures at a very close range to one another (less than 50metres) in a particular location.
7) It is observed that within 2km radius there are 8 to 12 tower sites respectively,which is contrary to thebuffering operation of the National Communication Commission regulation of 6km radius for the sitting of tower sites for service providers.
8) The service providers considers sitting their tower facility based on some factors(quality of signal reception, etc.) rather than the topographic, land use and other environmental factors.
9) The area occupied by these facilities becomes usable for some economic activities like handset repairs and battery charging points by security and other personnel of theGSM companies who have taken the advantage of the constant electricity supply provided through national grid and generator set at the site.

6. Summary, Conclusion and Recommendations

6.1 Summary

This project discovered thirty five (38) Global System for Mobile communication (GSM) mast/tower, (i.e.) Mtn, Globacom, Airtel, Etisalat, and Multilink within Damaturu metropolis of Yobe state, Nigeria. The purpose of the study was to produce GSM mast location map within Damaturu metropolis, for the purpose of environmental impact assessment, land use planning and for payment of ground rents on land for revenue generation.

The GPS coordinate of the GSM mast were determined and later used to map the location of the mast. Database was created for such mast. The special and the attribute data obtained from the office of the service providers were analyzed using ArcGis 10.3.

The result revealed that, there is indiscriminate siting of mast facilities by different service providers in Damaturu without guide and control by the various agencies that have a stake, especially the National Communication Commission (NCC). Finally, it is recommended that a system to develop an integrated approach in sitting of these facilities and the related societal and economic impact be put in place.

6.2 Conclusion

This paper emphasized the use of GIS to portray the spatial attributes of GSM telecommunication mast location in Damaturu metropolis. It provides an outlook for Land Use Planners and Policy Makers to appreciate the emerging challenges of land encumbrances by these facilities. It becomes imperative for land managers to have an institutional framework that will aid in providing a geographical basis for sitting these facilities.

The telecommunication industry is an emerging one with a massive investment in the development of structures to support effective communication network. The multiplicity of tower sites in the study area by the various service providers without a particular trend and degree of densification is an indication that there is no comprehensive database and graphical representation (thematic map of telecommunication tower facilities) of existing tower sites in terms of their spatial and attribute characteristics. This suggests very strongly, the neglect of the professional that is technically and technologically equipped to provide these geo-information, that is the surveyor and other related professional stakeholders. (Atilola, 2009) asserts that the most basic prerequisite for any land administration is the spatial content of the environment of any nation for sustainable economic development, its physical and economic resources, as well as the natural, cultural and infrastructural features must first be identified, taken stock of and surveyed. Hence, it is evident that meaningful land use planning and policies cannot be implemented without adequate information (geo-information) on the spatial contents of the real world-geographical space of interest.

6.3 Recommendations

Consequent upon this, the findings in this research has necessitated the need to make the following recommendations.

1) There is the need to provide all the necessary geo-information of all lands and its characteristics and/or attributes in both the urban and rural areas of Yobe state and the country at large.
2) The National Communication Commission should as a matter of urgency stop the indiscriminate sitting of more facilities by these service providers until they provides their Environmental Impact Assessment (EIA) reports for approval so that the 6km spacing for sitting mast/tower should be fully enforce by the regulatory body.
3) Government should imposed upon the service providers to embark on implementing Corporate Social Responsibility (CRS) projects such as; construction of primary healthcare centers and primary schools to the benefiting communities.
4) Considering the advantages taken of the portions of land occupied by these telecommunication facilities, they should therefore be made (the service providers) to pay ground rent to the government annually for onward compensation to individual land owners.
5) From the foregoing, all the stakeholders involved, (like, the Nigerian Institution of Surveyors, the Nigerian Institute of Town planners, the Nigerian Institute of

Estate Surveyors among others) should be fully mobilized to carry out the mapping and policy formulation of all lands in Nigeria and produce relevant topographic and cadastral maps of various uses and scales.

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