# SPATIAL DISTRIBUTION OF TELECOMMUNICATION MASTS AND THEIR EFFECTS IN KANO METROPOLIS, NIGERIA

**BY**

**ISIAKA, Usman Abdulhameed**

**DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL MANAGEMENT**

**FACULTY OF PHYSICAL SCIENCES**

**AHMADU BELLO UIVERSITY,**

**ZARIA**

**DECEMBER, 2017**

# SPATIAL DISTRIBUTION OF TELECOMMUNICATION MASTS AND THEIR EFFECTS IN KANO METROPOLIS, NIGERIA

**BY**

**Abdulhameed Usman ISIAKA**

**(MSC/SCI/25849/12-13)**

**P16PSGS8530**

**A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADATE STUDIES, AHMADU BELLO UNIVERSITY IN PARTIAL FULFILLMENT FOR THE AWARD OF MASTER IN GEOGRAPHICAL INFORMATION SYSTEM AND REMOTE SENSING**

**DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL MANAGEMENT**

**FACULTY OF PHYSICAL SCIENCES**

**AHMADU BELLO UNIVERSITY,**

**ZARIA**

**DECEMBER, 2017**

## DECLARATION

I declare that the work in this dissertation entitled 'Spatial Distribution of Telecommunication Masts and Their Hazards in Kano Metropolis' has been carried out by me in the department of Geography. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any institution

| | | |
|---|---|---|
| Abdulhameed Usman ISIAKA | _____ | _____ |
| Name of Student | Signature | Date |

## CERTIFICATION

This thesis entitled 'SPATIAL DISTRIBUTION OF TELECOMMUNICATION MASTS AND THEIR HAZARDS IN KANO METROPOLIS' by Abdulhameed Usman, ISIAKA meets the regulations governing the award of M.Sc. Geographical information system and Remote Sensing of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

| | | |
|---|---|---|
| Dr. R.O. Yusuf | _____ | _____ |
| Chairman Supervisory committee | Signature | Date |
| Dr. A. K. Usman | _____ | _____ |
| Member, Supervisory Committee | Signature | Date |
| Dr A. K. Usman | _____ | _____ |
| Head of Department | Signature | Date |
| Prof. Sadiq Z. Abubakar | _____ | _____ |
| Dean, School of Postgraduate Studies | Signature | Date |

## ACKNOWLEDGEMENTS

All praise and salutation are due to the Almighty Allah out of whose guidance and inspiration my program became a reality. I am grateful to my supervisors, Dr. R.O. Yusuf who despite his tight schedule as the postgraduate coordinator gave the research the needed academic guidance and attention and Dr. A. K. Usman, the head of department for his guidance also.

Great appreciation goes to the staffs of Geography department of Ahmadu Bello University and Surveying and Geoinformatic department of Federal Polytechnic Birnin Kebbi for their contributions to the successful attainment of the goal of this study. Worthy of appreciation also includes all the respondents who completed and returned the questionnaire administered. This of course, provided the needed data for the study.

Finally, my gratitude goes to my parent, beloved wife, Ummulkhair Yaqoob and daughter, Farhana for the inconveniences they encountered during my absence from home in course of this work. I appreciate your prayers, patience and understanding.

## DEDICATION

This work is dedicated to my late brother and best friend, Kabir Usman. May Allah grant you eternal peace.

## TABLE OF CONTENTS


| | | |
|---|---|---|
| Title Page- | | i |
| Declaration | | iv |
| Certification | | v |
| Acknowledgement | | vi |
| Dedication | | vii |
| Table of Contents | | vii-x |
| List of Tables- | | xi |
| List of Figures | | xii |
| List of Appendices | | xiii |
| Abstract | | ix |
| **CHAPTER ONE: INTRODUCTION** | | |
| 1.1 | Background to the study | 1 |
| 1.2 | Statement of research problem | 4 |
| 1.3 | Aim and Objectives | 7 |
| 1.4 | Scope of the Study | 7 |
| 1.5 | Justification of the Study | 8 |
| **CHAPTER TWO: CONCEPTUAL ISSUES AND LITERATURE REVIEW** | | |
| 2.1 | Introduction | 9 |
| 2.2 | Conceptual Issues | 9 |
| 2.2.1 | Radiofrequency Radiation around Telecommunication mast | 10 |
| 2.2.2 | Concept of Geographical information System | 10 |
| 2.2.3 | GPS/GIS Application | 13 |
| 2.2.4 | Application of GIS to Health and Medical Research | 14 |
| 2.2.5 | GSM Network Structure | 16 |

2.3 Literature Review 21

2.3.1 Review on Location and Distribution Pattern of Telecommunication Mast 21

2.3.2 GIS and Telecommunication Mast- 24

2.3.3 Telecommunication Masts and Environmental Effects 28

2.3.4 Precautionary Principle on Mobile Telecommunication Masts 34

**CHAPTER THREE:STUDY AREA AND RESEARCH METHODOLOGY**

3.1 Introduction 37

3.2 The Study Area 37

3.2.1 Location and Size 37

3.2.2 Weather and Climate 38

3.2.3 Relief and Drainage 39

3.2.4 Population and People 39

3.2.5 Socio-Economic Activities 40

3.3 Research Methodology 40

3.3.1 Reconnaissance Survey 40

3.3.2 The Research Design 41

3.3.3 Types of Data Used 41

3.3.4 Sources of Data 41

3.3.3 Digitisation and Database Creation 42

3.3.4 Sample Size and Sampling Techniques 43

3.3.5 Method of Data Analysis 44

**CHAPTER FOUR: RESULTS AND DISCUSSION**


| | | |
|---|---|---|
| 4.1 | Introduction | 47 |
| 4.2 | Location and Distribution Pattern of Mast in Study Area | 47 |
| 4.2.1 | Location of Mast in the Study Area | 47 |
| 4.2.2 | Distribution Pattern of GSM Masts | 49 |
| 4.3 | The Level of Compliance to Set Standards | 51 |
| 4.4 | Reported Environmental Effect Telecommunication Mast | 57 |
| 4.4.1 | Socioeconomic Characteristics of Respondents | 58 |
| 4.4.2 | Observed hazards Reported by Residents at Distances Away from Mast- | 61 |
| 4.4.3 | Relationship between Telecommunication Masts and Effects Cases | 71 |


**CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATION**


| | | |
|---|---|---|
| 5.1 | introduction | 73 |
| 5.2 | Summary of Findings | 73 |
| 5.3 | Conclusion | 74 |
| 5.4 | Recommendations | 74 |
| 5.5 | Recommendation for Further Studies | 75 |
| REFERNCE | | 76 |
| APPENDICES | | 83 |

## LIST OF FIGURES


Fig 2.1: Simplified GSM Network Architecture Diagram 18

Fig 3.1: Kano Metropolis 38

Fig 4.1: Spatial Distribution of Masts 44

FFig 4.2: Average Nearest Neighbor Report- 49

Fig 4.3: Gestis Ord General Result 50

Fig 4.4: Map showing both compliant and non-compliant 52

Fig 4.5: Distribution of non-compliant mast (residents fault) 54

Fig 4.8: Distribution of Non-compliance Mast (Service Provider Fault) 56

## LIST OF TABLES


Table 3.1: Sample Size by LGs 43

Table 4.1: distribution of Mast in kano Metropolis 48

Table 4.2: Average Nearest Neighbour Summary 50

Table 4.3: Level of Compliant 53

Table 4.4: Non compliant mast (resident fault) 55

Table 4.5: Non compliant mast (service provider fault) 57

Table 4.6: Selected Location for Questionnaire 58

Table 4.7: Socioeconomic activities 59

Table 4.8: Results on Observed Effects as Reported in Fagge LGA 61

Table 4.9: Results on Observed Effects as Reported in Dala LGA 62

Table 4.10:Results on Observed Effects as Reported in Gwale LGA 64

Table 4.11: Results on Observed Effects as Reported in Kano Municipal LGA 65

Table 4.12: Results on Observed Effects as Reported in Tarauni LGA 66

Table 4.13: Results on Observed Effects as Reported in Nassarawa LGA- 67

Table 4.14: Results on Observed Effects as Reported in Kumbotso LGA 68

Table 4.15: Overall Total Observed effects by Respondents in Metropolis- 69

Table 4.16: Relationship between Masts and Reported Cases of Effects 71

## LIST OF APPENDICES

Appendix I: Questionnaire 84

Appendix II: Sample Database 86

Appendix III: Mast in Compliance 89

## ABSTRACT

*Everyday life is dependent on telecommunication and as population increases so the need to cover more area for effective coverage thus the need for more telecommunication infrastructure to take advantage of the benefit attached to it. The study examined the spatial distribution of telecommunication mast and its environmental effects. Both primary and secondary data were collected from Kano metropolis. The GPS receiver was used to collect the coordinates of the mast locations and analysed with the Nearest Neighbour Ratio (NNR) in ArcMap 10.2. A total of 82 masts were identified within the metropolis. A total 400 copies of questionnaire were administered purposively and 355 retrieved for analysis. Random (balloting) sampling was used to select a total of 14 masts (two in each of the LGA in the metropolis) among those that do not meet the minimum setback distance. Distances were marked at 5m, 10m, 15m and 20m away from the masts to capture the varying spread of effects from the respondents. Results shows that the masts are clustered with NNR of 0.612568, critical value of <-2.58 and test of significant of P-value of 0.000 and Z-score of -6.75250 which implies that there is less than 1% likelihood that the pattern is as a result of random chance. The degree of clustering was also measured using Gestis Ord General statistical tool and result shows that the degree of clustering is low. Result also shows that 46% of the masts are in compliance with NCC/NESREA regulation out of the 82 captured and 54% violated the regulatory setback. The data collected were tabulated and result shows that reported effect cases decreases as distances increases from the mast and even at 10m the effect are still high which implies that the regulatory setback may still need to be reviewed. The varying effects observed at distances away across the metropolis was subjected to correlation analysis and the result shows that there is a strong relationship between the location of telecommunication mast and their effects on the wellbeing of residents. The study recommends that there is need to review the regulatory setback distance and service provider should embrace co-location to avoid clustering. Also, there is the need for public awareness and sensitization on the dangers of residing close to a mast and further research should be carried out to unveil other factors affecting the residents close to mast location.*

# CHAPTER ONE

# INTRODUCTION

## 1.1 BACKGROUND TO THE STUDY

The need for functional telecommunication services through the use of mobile phones has increased significantly in recent years. The optimal socioeconomic functioning of any nation is greatly dependent on communication that corresponds to its scale of development. Thus, the world is rapidly moving towards an economic system that heavily depends on continuous and widespread availability and dissemination of information, as such, Nigeria as a nation is not left out (Akwule, 2009). The growing population in urban areas and serious transportation problems justify the necessity for effective communication system like the Global System for mobile (GSM) Telecommunication; the use of which started around 2001 in Nigeria. The service providers will maximize their profit and productivity when a large population within a relatively small space can pay for their services. Today services like mobile television, electronic payment, mobile tracking services, cheaper international calls, internet banking and mobile banking among others occasioned by mobile telecommunication are common place in the country. GSM has become a vital and indispensable tool for transmitting and exchanging information for a modern man (Ajala, 2005).

Telecommunication has been defined as a technology concerned with communicating from a distance. Telecommunication masts tower consist of a body structure of steel beams and materials with a concrete base of an approximate height of between 25 to 55meters. Antennae, transmitter and receivers are mounted on the body of the structure. These antennae receive high

frequency radio waves from cell phones. The range of these antennas varies from distances as short as 1.5 to 2.4km 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 144m$^2$ (Hart, Jackson, Akpe and Moka, 2012).

Wireless digital telecommunications such as the internet and information communication technology has revolutionized the world and the impact of information technology (IT) has been felt in all economic and social activities in every conceivable manner. The convergence of all forms of communication on the digital playfield is opening up immense new possibilities for achieving speed, versatility and space-time independence. The use and deployment of cellular phones and other wireless communication facilities around the world is phenomenal as it has not only reduced the world into a global village but more importantly into a global household. What was once solely a business tool; wireless phones are now a mass market consumer device contributing positively to the Gross Domestic Products (GDP) of various countries and providing job opportunities to millions of youths, professionals and even petty traders (Otubu, 2012).

In Nigeria, rapid increase in the use of GSM in the last few years has led to increasing number of cell phone transmitting mast being erected in or near residential areas. According to Nigeria Communication Commission (NCC) technical specification for the installation of telecommunication mast and tower dated and issued on 9$^{th}$ of April, 2009, all structures in excess of 150m in height shall be set back by a minimum of 50m from the right -of-way of all controlled access, federal and state road/highways designated as freeways, in order to provide unobstructed flight paths. Also, the distance for setback shall be 5m from any property excluding the fence (NCC, 2009). There have been clashes between the NCC and the National Environmental

Standard and Regulatory Enforcement Agency (NESREA) over telecoms mast regulations. Both agencies have contradictory regulations on the setback that should be observed by telecom operators in the location of their base stations. While the NCC regulation stipulates a minimum of five meters (5m), NESREA regulation stipulates a minimum 10m (Prince and Laide, 2012). Telecommunication service providers are expected to comply with the minimum of 7m setback guideline when citing base station. The NCC and NESREA announced this after harmonizing their positions in a conference held in Lagos (2014) (Second West Africa Conference on Electromagnetic Fields Exposure and Health) that deliberated on the acceptable setback guidelines for erecting Base Transceiver Station (BTS) (Daily independent Newspaper, 2014, December 17).

According to Diaz-Bordenave, (1977), the key to the sensitive location and design of telecommunication equipment in rural areas is an understanding of the landscape. The effect of the radiation emitted by phone and their base stations on human is the subject of recent interest and study. The radiation emitted by fixed infrastructure such as base stations which provides the links to and from mobile phones is of great concern. This is because in contrast to mobile handsets, it is emitted continuously and is more powerful at close quarters. On the other hand, field intensity drops rapidly with distance away from the base of the antenna because of the attenuation of power with the square of distance. Following the current confusion over the health and safety issue to non-ionizing radiation emitted by GSM telephony base stations, the link between radiation emitted by GSM base station/cellular phones and its health effect in human remain subject of continuing debate in research (WHO, 2000).It is known that the demand for mobile communication is on the increase which demands for proper monitoring by the authority and effective planning, development and management of their facilities. They need to put in place

relevant supporting tools to cope with the increasing demand from prospective subscribers (Godin, 2001).

Kano is referred to as the center of commerce in the country due to its marketing activities. This is based on the fact that marketing and trading has been the dominant economic activity of the populace of the metropolitan Kano (Adzendeh, Fabiyi and Bello, 2014). Kano metropolis has experienced a high pace of urbanisation compared to other emerging cities in Nigeria and there is increasing need to service the populace with telecommunication infrastructure due to population growth. This has led to indiscriminate location of many GSM base stations in the metropolis. The city has about 5.25% of the active voice subscription and 4.47% of active internet subscription making it the third and fifth largest in the country respectively. It was observed that its official population figures exceed the number of active voice subscribers as at first quarter of 2016 compared to the other states with larger subscribers (National Bureau of Statistics (NBS), 2016). In spite of many perceived health-related problems associated with electromagnetic emissions from GSM base stations, the proximity of the stations do not appear to influence decision of many individuals on where to reside in the community.

Most of the base stations are sited in close proximity to landed properties in the metropolis due to the presence of commercial activities and those that were located away from the residential properties have been encroached by residence due to demand for land and population increase among other reasons. The inconclusive position on relationship between location of telecommunication masts and health of nearby resident informs this research in Kano metropolis.

## 1.2 STATEMENT OF THE RESEARCH PROBLEM

The establishment of more telecommunication infrastructure such as GSM base station has raised some environmental concerns. It has become a part of the environment to see tall masts in

different locations around the country. These masts though helpful, are believed to have negative effects on people living near them. It is argued that telecom towers interfere with aircrafts that are approaching landing. The erection of masts clustered close to built-up areas are thus said to be hazardous. The rapid growth in the use of mobile phone in recent years has been accompanied by public concern over the issues of health and safety risks attributable to microwave radiation and the adverse visual amenity aspect of the siting of telecommunication masts (Santini, Santini, Danze, LeRuz and Seigne, 2003).

Some waves emitted by masts are not hazardous but most mast emit more than $100w/m^2$ which is said to be hazardous if human being stays around the mast for a long time (Abdel-Rassoul *et al*, 2007). Also, the effect of exposure to these waves for short time include burn to the skin, nausea, vomiting and diarrhea while long time exposure can cause epilepsy, short term memory loss, sleep disorder, increase in leukemia, and speed up cancerous growth which might lead to death. The authors also stressed further that micro waves emits high radioactive frequency which causes damage to children's brain. Also, noise, vibration and fumes are generated from the standby power generators positioned at the telecommunication base station. The noise pollutes the environment and this causes partial deafening of the ear if it persists. Fumes from the generator emit carbon monoxide which may block the respiratory organ when inhaled in large quantity and this may result to death. The vibration from the mast may cause headache, sleepless night and risk of brain tumor for people living around the area.

Hamblin and Wood (2002) suggested that exposures to electromagnetic radiation can affect the natural rthyms of the brain electrical activity. Fernie and Reynolds (2005) iterated that studies of the effect of exposure to electromagnetic fields on population of wild birds can provide further insight into the potential impacts on animal and human health. According to Cherry

(2002), cell sites are risk factors for cancer, specifically brain tumors and leukemia; heart disease, particularly arrhythmia; neurological effects including sleep disturbance, learning difficulties, depression and suicide; reproductive effects, especially miscarriage and congenital malformation; viral and infectious diseases because of reduced immune system competency associated with reduced melatonin and altered calcium ion homeostasis.

Several efforts have been made to study the spatial distribution of telecommunication mast and their effects to resident's health, rental properties and the environment in different part of the world. Among such studies include Mohammed (2011); Akindele and Adeniji (2014); Cherry (2002); Wale, Hakeem and Olufemi (2011); Micheal, Nnaemek and Mathew (2013); Santini *et al* (2003); Onifade, Jelili and Asani (2015): Bond, SiYeoul and MacMahon (2003); Brandt and Maening (2012); Mohammed and Abdulrahman (2014) and Akintonwa, Busari, Awodele and Olayemi (2009). Kano is considered the commercial nerve centre of northern Nigeria, increasing population and need for commerce will continue to make the use of GSM relevant. This consequently will increase the number of GSM base stations in residential areas. To allow for commercial development, the health and safety of residents are paramount which calls for this study.

In all the aforementioned works accessible to the researcher none has examined the spatial distribution of telecommunication masts and their hazards in Kano metropolis, despite the increasing number of telecommunication masts and the severe environmental effects posed by telecommunication masts in a densely populated metropolitan area. This is therefore the gap which the work intends to fill. Based on this research problem, the study addresses the following research questions:

1. Where are the GSM telecommunication masts located in Kano metropolis?
2. What is the distribution pattern of GSM telecommunication masts in Kano metropolis?
3. To what extent does the GSM service provider comply with NCC/NESREA set standard of GSM mast location in the study area?
4. What are the effects experienced by residence in the GSM mast location in the study area?

## 1.3 AIM AND OBJECTIVES OF THE STUDY

The aim of the research is to examine the spatial distribution of telecommunication mast and their environmental effects on residents of Kano metropolis. The objectives are to:

i. locate and identify the GSM telecommunication masts in Kano metropolis
ii. determine the spatial pattern of distribution of telecommunication masts in Kano metropolis
iii. examine the level of compliance with NCC/NESREA set standards in Kano metropolis
iv. examine the environmental effects of telecommunication masts location experienced by resident in the study area.

## 1.4 SCOPE OF THE STUDY

The study is confined to the environmental effects of spatial distribution of telecommunication masts in Kano metropolis. The study covers the telecommunication mast in the study area, which comprises of Tarauni, Gwale, Kano Municipal, Fagge, Nasarawa, Dala and part of Kumbotso and Ungoggo LGAs. The study focus on examining the spatial pattern of distribution of GSM masts in Kano metropolis. Also, to examine the level of compliance to NCC/NESREA set standard and determine the relationship between location of telecommunicated masts and identified effects cases in Kano metropolis. The temporal scope covers information on

GSM telecommunication masts from 2001. The year 2001 is chosen as the base year due the fact that the year marks the beginning of a mobile telecommunication in Nigeria.

## 1.5 JUSTIFICATION OF THE STUDY

Telecommunication has a role to play in the development of any city since life has evolved under the influence of two forces: gravity and electromagnetism (Firstenberg, 1997). It should be expected that both forces play important roles in the functional activities of all organisms. Since the introduction of wireless telecommunication in the 1990's the rollout of phone networks has caused a massive increase in electromagnetic hazard in cities and the countryside (Firstenberg, 1997). In recent years, individual household has been chronically exposed to microwaves and radiofrequency radiation signals from various sources, including GSM masts that are erected indiscriminately without studies of environmental impact that measures long-term effects. The greater portion of this exposure is mobile telecommunications (Hutter, Moshammer, Wallner and Kundi, 2006).

In Kano like other parts of Nigeria, everyday life is dependent on telecommunication. Advance communication technologies are transforming the form and function of large metropolitan regions. Industrialized nations rely more heavily upon information-based services; the viability of a metropolitan region will depend on its communications infrastructure to facilitate the movement of ideas (Moss, 1990). Kano was choose as a study area because according to the National Bureau of Statistics (2016) noted that as at first quarter of 2016, the number of active voice call subscription in Nigeria stood at 148.74 million and Kano accounted for about 7.81 million (5.2%) , also of 92.4 million active internet subscription recorded , Kano accounted for 4.47%. This research when published would help the regulatory bodies (both the

NCC and NESREA) in monitoring if their guidelines are adhered to by telecommunication service providers. Also, to would-be researchers on this area, it will provide an additional literature and information for future research.

# CHAPTER TWO

# CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

## 2.1 INTRODUCTION

This chapter comprises mainly of the conceptual framework and literature review on the spatial distribution of telecommunication masts and their effect in the environment which are discussed using the following; radiofrequency radiation around telecommunication mast, concept of geographical information system (GIS) and global positioning system (GPS), GSM network structure, empirical works on location, distribution pattern and effects of telecommunication mast. The chapter concluded with the precautionary principle to be observed around telecommunication masts.

## 2.2 CONCEPTUAL FRAMEWORK

### 2.2.1 Radiofrequency Radiation around Telecommunication Mast

Electromagnetic radiations consist of waves of electric and magnetic energy moving together through space at the speed of light. All forms of electromagnetic energy are known as electromagnetic spectrum and radio waves and microwaves emitted by transmitting antennas are one form of electromagnetic energy. They are collectively called radiofrequency energy of radiation. The radiofrequency emanating from masts are generated by movement of electrical charges in the antenna (Ayinmoda, 2010). Electromagnetic waves can be characterized by a wavelength and a frequency. The wavelength is the distance covered by one complete circle of the

electromagnetic wave, while the frequency is the number of electromagnetic waves passing a given point in one second. The frequency of a radiofrequency signal is usually expressed in terms of a unit called the 'hertz' (Hz). One Hz equals one cycle per second and One megahertz (MHz) equals one million cycles per second (Elieen, 2006).

Exposure from mobile phone telecommunication mast is basically divided into the near field exposure and the far field exposure, where far field exposure measurement are used for public exposure level assessment. The radiation from a mast depends on its antenna characteristics, like the antenna gain, emitted power, directivity, height and the tilt angle of the antenna. Also, it is known theoretically that at the far field of the antenna the radiation intensity reduces according to the inverse square law. Typically, radiation from the GSM antenna reaches the ground level at 50- 300meters (Mann, Cooper, Allen, Blackwell and Lowe, 2000). Thus it is expected that under the mast, low radiation levels can be found.

In real life situation, the variation of radiation exposure with distance can be very difficult to predict. Factors like the number and position of building and vegetation, concentration of base station, and base station to base station distance, can make the radiation level within 10meters to vary by a thousand fold. Thus, practical experience shows that exposure level to the feet of some base stations can be quite high. Radiation levels may have an increasing pattern within 30 to 50meter radius of base stations in dense populated areas where many stations are sited but as one moves away from 200meter radius of the base station, the exposure may begin to have a reducing pattern (Miclaus and Bechet, 2007).

### 2.2.2 Concept of Geographical Information System (GIS)

Geographical information systems are the combination of spatially reference data, appropriate computer hardware and software, and user competent to employ the data and technology to solve problems. It is also a system of computer hardware, software and procedures designed to support the capture, management, manipulation, analysis and display of spatially referenced data for solving complex planning and management problems. GIS is typically used to store and analyze extensive information in a map-based format. This allows relatively easy retrieval and manipulation of information and provides new analytical capabilities based on spatial relationships between sites of interest and any combination of available data sets (Hart, Jackson, Akpee and Moka, 2012).

GIS is capable of acquiring spatially indexed data from variety of sources, changing the data into useful formats, storing, retrieving and manipulating the data for analysis and then generate the output required by the user. The great task is based on the ability to handle large multilayered database and to query it existence, location and properties of wide range of spatial data objects. The main advantage of GIS is it rapid analysis and display of data, with flexibility not possible using manual method because it does not hold maps or pictures rather its holds database (Chang, 2010).GIS is a computer software which can be used to create, manage, analyse, and visualize geographic data (Steiniger and Weibel 2009).

Above all is the ability of GIS to visualize. The entire telecommunication masts network can be visualize as it islaid on ground. Just by looking at the map and clicking at a particular feature (e.g a mast), all the information is displayed both location and other feature from its database. This provides a more flexible understanding of the network and faster approach to access information.

*2.2.2.1 GIS Data Input*

This involves entering or transferring the analogue or digital geographical data (map aerial photograph, or satellite imagery) and statistical (attribute) data into the GIS. The data input function thus enables GIS to convert the original input data into a machine-readable GIS-compatible format (Oluocha and Ogbale, 2007). Data input operate at three levels; geo-referencing, registering the source materials, and analogue data conversion.

*2.2.2.2 GIS Data Storage*

Data storage is a function GIS. A typical GIS is equipped with commands and facilities to store both spatial and non-spatial in a number of formats or file structures. GIS data are normally stored in any of the common computer storage devices available. Geographic data are often large; hence a storage device with a large storage capacity is often required for GIS operations according to Oluocha and Ogbale (2007).

*2.2.2.3 GIS Data Manipulation*

Geographical (map) data and the attribute (tabular) data held in GIS are subjected to manipulative operations, to generate results. Some of the standard data manipulative functions perform in GIS which the research adopted are: data integration, map overlay analysis, cartographic functions, buffering, network analysis, feature measurement, database querying or searching, and geospatial analysis.

*2.2.2.4 GIS Data Output*

The data sub-system in GIS is used to obtain copies of the result of a data manipulation operation. Based on the choice of the user, the output may be in form of soft copy or hard copy.

The output could be graphic displays or tabular reports. The data output sub-system should be capable of allowing the user to prepare or format the document for the final printing or plotting.

This study was also guided by these processes in data presentation. GIS helps in making the presentation of data more attractive than traditional static maps. Projecting tabular data onto maps helps in recognizing unexpected situations which, now noticed, call for closer examination. When considering geographical (spatial) factors, the analysis becomes finer and more precise, increasing the likelihood that ensuing strategies will be more pertinent. More flexible assistance can be provided in prospective planning at multiple levels or units of analysis: national, regional, provincial/district, and local.

### 2.2.3 GPS/GIS Application

The beauty of GPS and GIS applications is the simplicity and directness of data acquisition. For all intents and purposes, GPS receiver can collect the necessary information and feed it directly into a computerized GIS with little effort expended in between. The combination of GPS and GIS is well knitted, where GIS provides spatial information about a wide variety of objects and features; GPS provides the real-world connection for the GIS information to be meaningful. Beyond just simple map-making, typical GPS/GIS applications includes utilities management, police incident reporting, postal addressing, a wide range of demographics etc.GIS has been used not only to organize, update, and query addressing databases, but has also been used in the creation of postcodes (Rogers and Vivas, 2014). Rajeshkumar and Shashikant (2014) for example carried out a project on design and development of a utility based management system for housing colony in Ahmadadad using GIS/GPS approach. The purpose of the project was using GIS/GPS capabilities in network monitoring and providing instant information access to all concerned engineers, minimizing time for maintenance of water supply, fire fighting, drainage and power

systems, and for efficient planning and preventive maintenance. Power industry consequently has to keep track of numerous poles, circuits, power lines, and transformers. Information on location, voltage, and distribution of electricity facilities seem to be very overwhelming thus, the need for a GPS/GIS approach for easy retrieval of information (Surendra, 2013).The GIS with the integration of GPS has extensive potential to resolve problem since the GPS field surveys are versatile of traditional information and capable of providing accurate and efficient data that is useful for planning and preservation of cumbersome data for future references (Prashant and Sunil, 2015).

The way and manner GPS is used to provide GIS data can be categorized in two; applying a controlling reference point to some other data from which the GIS can collect the information that it needs and using GPS to acquire the GIS information directly(Duggal, 2004).

### 2.2.4 Application of GIS in Health and Medical Research

The ability of GIS to overlay different entities based on their common geographic occurrence makes it a very valuable tool in epidemiological research. The idea that place and location can influence health is a very old and familiar concept in Western Medicine (Lang, 2000). As far back as the time of Hippocrates, the father of modern medicine, physicians have observed that certain diseases seem to occur in some places and not in others. Hippocrates was constantly seeking the causes of disease. He studied such things as climate, water, clothing, diet, eating and drinking and the effect they had in producing diseases. The Hippocratic concept of health and disease stressed the relation between man and his environment. People have also been aware of the process of disease diffusion across geographic regions for centuries, even during times when the cause of the disease –etiology- was a mystery. However, in the increasingly information-intensive environment of health care, the role of GIS will have greater importance due to its abilities to

integrate a wide range of data sources, from legacy systems to image data, and to make complex data more quickly and easily understood (Coggen, 2006).

Geographical Information Systems (GIS) are now well established both as a technology and a set of tools for the manipulation and display of spatial data in an ever increasing range of applications areas. One of the most important services areas that to date has not been addressed to the same extent, however, is the provision of health and welfare services. Signs are now evident that this is beginning to change too as the significant potential of GIS is being increasingly recognized in the management of health data, mapping health indicators and disease incidence, the analysis of patterns and distributions, facilities location, and in studies of access and health delivery (Twigg, 1990). The capability of GIS has been used in a medical research to evaluate the survival from cardiac arrest in a United State county. The result shows that there was no clustering of survival rates for cardiac arrest in the study area (Warden, Daya and LeGray, 2007). Kernel density estimation in ArcGIS with default bandwidth settings has been used to identify out of hospital cardiac arrests in Rochester, New York. By integrating census data with the data from a cluster analysis using kernel density estimation, they were able to discover that out of hospital cardiac arrest clusters were associated with communities with lower income, higher number of African-American residents and more residents without a high school diploma than the population of the city in general (Lerner, Fairbanks and Shah, 2005). The identification of clusters of events could lead to an increased understanding of where health care resources should be allocated.

The spatial analysis of health services is based on the principle that populations and their need for healthcare vary across space. People are not located randomly about the earth and it is often observed that different areas are populated by groups with differing characteristics (e.g. socio-economic status, race, age, income, education, etc.) and these varying characteristics of a

group often influence their need for health services (McLafferty, 2003). Studies have used GIS and the principles of location analysis to evaluate optimal locations for pre-hospital helicopter emergency medical services (Schuurman, Bell and L'Heureux, 2009) and to evaluate how patient access can change depending on where cardiac services are located (Pereira, Niggerbrugge and Powels, 2007).

Inherent in the definition of epidemiology as the branch of medical science that deals with epidemics, is measurement of frequency, distribution and determinants of diseases. In contemporary world, they require GIS application to make the information easy to understand, interpret and action to be taken. Until recently, doctors and public health professionals measured health strictly in terms of indicator of ill-health such as morbidity and mortality. There is however, a long tradition in the allied fields of medicine and medical geography to examine the distribution of disease and death at various geographic scales, in an attempt to determine if the presence or absence of a particular illness is associated with some factors in the physical environment. Also there is the added dimension of examining the diffusion of disease through space over a given period of time. Even though mapping of disease can be relatively straightforward, interpreting spatially reference disease data can sometimes be challenging (Lang, 2000).

Epidemiology studies has since then played a critical role in trying to find a link between radiofrequency exposure and some health symptoms. The essential role of epidemiology in the 'global strategy for health for all' was recognized in a World Health Assembly resolution in May 1998 urging member states to make use of epidemiological data, concept and method in the preparation, updating, monitoring and evaluations of their work in this field (Beaglehole, Bonita and Kjellstrom. 1993).

### 2.2.5 GSM Network Structure

The GSM technical specifications define the different elements within the GSM network architecture. It defines the different elements and the ways in which they interact to enable the overall system operation to be maintained. The GSM network architecture is now well established and with the other later cellular systems now established and other new ones being deployed, the basic GSM network architecture has been updated to interface to the network elements required by these systems. Despite the developments of the newer systems, the basic GSM system architecture has been maintained, and the network elements described below perform the same functions as they did when the original GSM system was launched in the early 1990s (Mouly and Pautet, 1992).

The GSM network architecture as defined in the GSM specifications can be grouped into four main areas:

- Mobile station (MS)
- Base-Station Subsystem (BSS)
- Network and Switching Subsystem (NSS)
- Operation and Support Subsystem (OSS)

The different elements of the GSM network operate together and the user is not aware of the different entities within the system. The public networks comprises of the Public Land Mobile Network (PLMN), Public Switch Telephone Network (PSTN), Integrated Service Digital Network (ISDN) and Public Switch Data Network (PSDN). A basic diagram of the overall GSM system architecture with these four major elements is shown in Figure 2.1. For clarity these four elements are expatiated briefly in the subsections that follow (Rappaport and Prentica-Hall, 1996).

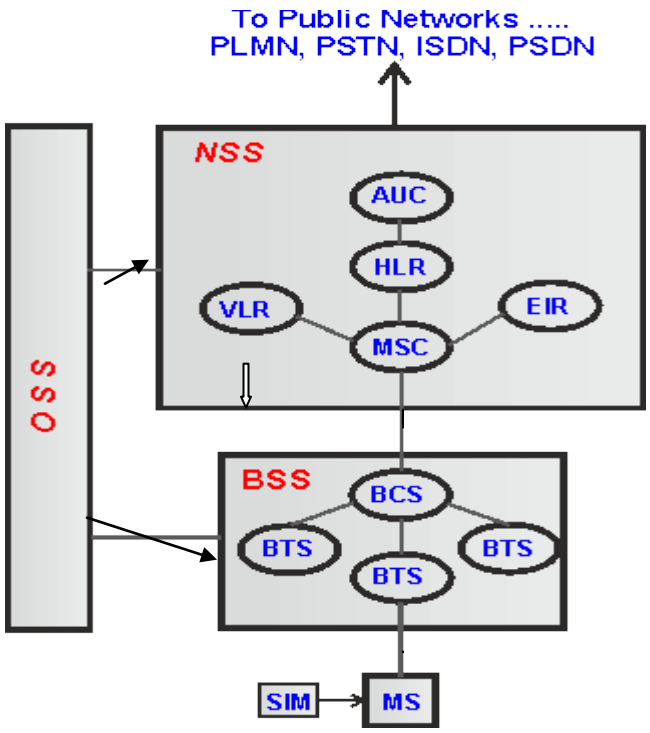



**Fig 2.1: Simplified GSM Network Architecture Diagram**

**Source:** Rappaport and Prentica-Hall, (1996)

*2.2.5.1 Mobile station*

Mobile stations (MS), mobile equipment (ME) or as they are most widely known, cell or mobile phones are the section of a GSM cellular network that the user sees and operates. In recent years their size has fallen dramatically while the level of functionality has greatly increased. A further advantage is that the time between charges has significantly increased. There are a number of elements to the cell phone, although the two main elements are the main hardware and the SIM.

The hardware itself contains the main elements of the mobile phone including the display, case, battery, and the electronics used to generate the signal, and process the data receiver and to be transmitted. It also contains a number known as the International Mobile Equipment Identity (IMEI). This is installed in the phone at manufacture and "cannot" be changed. It is accessed by the network during registration to check whether the equipment has been reported as stolen.

*2.2.5.2 Base Station Subsystem (BSS)*

The Base Station Subsystem (BSS) is the section of the GSM network architecture that is fundamentally associated with communicating with the mobiles on the network. It consists of two elements:

- *Base Transceiver Station (BTS):* The BTS used in a GSM network comprises the radio transmitter receivers, and their associated antennas that transmit and receive to directly communicate with the mobiles. The BTS is the defining element for each cell. The BTS communicates with the mobiles and the interface between the two is known as the 'Um' interface with its associated protocols.
- *Base Station Controller (BSC):* The BSC forms the next stage back into the GSM network. It controls a group of BTSs, and is often co-located with one of the BTSs in its group. It manages the radio resources and controls items such as handover within the group of BTSs, allocates channels and the like. It communicates with the BTSs over what is termed the 'Abis' interface.

*2.2.5.3 Network Switching Subsystem (NSS)*

The GSM system architecture contains a variety of different elements, and is often termed the core network. It provides the main control and interfacing for the whole mobile network. The major elements within the core network include:

- Mobile Switching services Centre (MSC): The main element within the core network area of the overall GSM network architecture is the Mobile switching Services Centre (MSC). The MSC acts like a normal switching node within a PSTN or ISDN, but also provides additional functionality to enable the requirements of a mobile user to be supported. These include registration, authentication, call location, inter-MSC handovers and call routing to a mobile subscriber.
- Home Location Register (HLR): This database contains all the administrative information about each subscriber along with their last known location. In this way, the GSM network is able to route calls to the relevant base station for the MS. When a user switches on their phone, the phone registers with the network and from this it is possible to determine which BTS it communicates with so that incoming calls can be routed appropriately.
- Visitor Location Register (VLR): This contains selected information from the HLR that enables the selected services for the individual subscriber to be provided. The VLR can be implemented as a separate entity, but it is commonly realised as an integral part of the MSC, rather than a separate entity. In this way access is made faster and more convenient.
- Equipment Identity Register (EIR*)*: The EIR is the entity that decides whether given mobile equipment may be allowed onto the network. Each mobile equipment has a number known as the International Mobile Equipment Identity.

- Authentication Centre (AuC): The AuC is a protected database that contains the secret key also contained in the user's SIM card. It is used for authentication and for ciphering on the radio channel.
- Gateway Mobile Switching Centre (GMSC): The GMSC is the point to which a ME terminating call is initially routed, without any knowledge of the MS's location.
- SMS Gateway (SMS-G): The SMS-G or SMS gateway is the term that is used to collectively describe the two Short Message Services Gateways defined in the GSM standards. The two gateways handle messages directed in different directions.

*2.2.5.4 Operation and Support Subsystem (OSS)*

The OSS or operation support subsystem is an element within the overall GSM network architecture that is connected to components of the NSS and the BSC. It is used to control and monitor the overall GSM network and it is also used to control the traffic load of the BSS. It must be noted that as the number of BS increases with the scaling of the subscriber population some of the maintenance tasks are transferred to the BTS, allowing savings in the cost of ownership of the system.

## 2.3 LITERATURE REVIEW

### 2.3.1 Review on Location and Distribution Pattern of Telecommunication Masts

GSM is one of the wildest growing and most demanding telecommunication applications in the world now and Nigeria. 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 mast and its associated infrastructures (Shalangwa, 2010). It presents a constantly growing telephone subscription around

the globe. Nigeria is one of the major consumers of GSM for communication in Africa; over 60% of the whole populace in Nigeria depends on the GSM as the fastest means of communication (Zain, 2005). The masts are a free standing structure which supports antennas at a height where they can transmit and get radio waves; a mast is usually 15m high and plays no part in the transmission of radio waves. The base stations are sites that enable mobile phones to work. They can be big or small and have transmitters and receivers in a cabin or cabinet attached to antennas (Mobile Operators Association, 2015). GSM telecommunication masts represent part of the infrastructure required for effective communication system. In order to have effective network coverage, several masts are located close to the target users; the reason telecommunication operators also place their masts in residential neighbourhoods (Bello, 2010).

As the population continues to grow and so does the number of subscribers using GSM phones, more and more masts are going to be required to meet subscribers demand for reliable coverage. A number of environmental issues have been raised since the introduction of this technology. This includes the indiscriminate siting and erection of base trans-receiver stations all over Nigeria. A conservative estimate of over 20,000 base trans-receiver stations are scattered around the country. Many of the masts are sited within residential, commercial, industrial and transit routes (NBS, 2015). Several empirical studies have been carried out relating to the spatial location and distribution patterns of masts in different study areas. A review of these studies will give us the present picture which would aid subsequent analysis and conclusions in our case study.

Ubabudu, (2013) investigated the effectiveness of GSM providers' services in Nigeria and concluded that the services have helped to reduce travelling and facilitated social interactions. The author also noted that the services have been premiered by a myriad of issues that include exorbitant tariffs, poor audio quality, poor location of masts in residential area, non-delivery of

short messages (SMS), multiple billing system and poor customer care services. Mast distribution pattern in Lagos state shows that the service providers are more interested in areas where population density is high, commercial centres of the state and areas where income per capital head is high. This is appreciated in the number of masts sited in Ikeja, Lagos Island, Surulere, Agege and Alimosho (Omogunloye *et al*, 2013). In another study carried out in Lagos metropolis, it was revealed that 33% of the masts are located in low density residential areas, 26% in medium density, and 41% in high density residential areas and in general they were observed to be neither clustered nor dispersed but random in nature (Wale, Hakeem and Oluwafemi, 2011).

Also in the Federal Capital City, Abuja has a total of 92 masts. It was revealed in Abuja that the telecommunication masts distribution pattern are clustered (uneven) with Wuse I and II districts having 41 masts, 22 masts in Garki I and II,15 masts in Maitama, Central Business District with 4 masts while Asokoro have 14 and most of the location of the base stations are close to residential areas and there are situation where two or more base stations are sited side by side at a close range in a particular location especially in Wuse, Garki and Maitama districts (Musa, Abbas, Umar and Adeleye, 2016). Badru *et al* (2016) revealed that there are about 79 masts distributed around the 191 $km^2$ aerial extend of Ile-Ife, Nigeria. The masts were noticed to be located in clustered manner around the city centre with very few located around the peri-urban areas of the study area. This implies that most of the masts are located within the activity areas and the residential neighborhoods. One major characteristic of the masts situation was that most of them were located along the major route within the study area. It was also discovered that out of the 79 masts, only 53 were operational. In a study also conducted by Mohammed and Abdurrahman (2014) in Jimeta, Yola found that there were 59 telecommunication masts distributed in the area with a high concentration in the central part of the city compare to other

part. Mohammed (2011) revealed that MTN has met the criteria of the regulatory authority (NCC) for the location of base stations (Kaduna North local government area) in terms of distance (10meters)from residential area and the health status of people associated with the location of these masts was discovered to be in danger.

Akindele and Adeniji (2014) in their study investigated the location adequacy of telecommunication masts and residents livability in Osogbo Local Government Area of Osun State. The study enumerates 35 masts located in different locations in the study area and random sampling was used to select 12 masts in different locations. The study uses NESREA's stipulated minimum safe distance to a mast (10m), with cognizance to the acceptable standard, four zones were marked using 3m, 5m, 10m and 20m radii for zones 1 to 4 respectively. Correlation analysis was used to test the relationship between building-mast proximity and residents' livability. In their conclusion, most masts were built very close (<10m) to residences. These houses were observed to experience high disturbance due to noise from the mast, vibrations, fumes from generator and pollution. Health problem like headache and sleep disorder due to noise and vibration from mast, respiration disease were also observed among such residents, property value decline and reduced patronage were experienced by landlords of houses closest to mast. The study therefore recommends that planning authorities should be involved in the development of masts.

### 2.3.2 GIS and Telecommunication Masts

Telecommunication and information technology are set to overtake the automotive sector in the line-up of the world's biggest industries (Shu, Hong and Guodong, 2011). According to the International Telecommunications Union (ITU) (2011), telecommunications equipment and service revenues annually exceed US$575 billion (£360 billion) globally. Technological convergence means that, in future, almost any telecommunications technology will be able to carry

out almost any broadcast transmission medium. This will create a completely new competitive environment, where telephone companies are able to compete with TV networks, and where software companies will have the same ability to distribute information as telecommunication companies.

In the telecommunications world, a GIS is ideally suited for network planning and development. The ability to layer information onto the earth's surface, complete with attribute data, allows engineers the unique ability to model and assess a network from the office. This saves valuable time and reduces the number of trips, if any, that the engineer must make to the field. Furthermore, the powerful automation capabilities offered by a GIS increase the speed and accuracy of the network design process and can help reduce, and even eliminate, the downstream impacts of design-phase errors on cost and schedule during the network deployment phase. Rule-based features found in a GIS can also offer network designers the ability to produce better products, optimized for cost, shortest routing distances, or other user-defined metrics. The skill level and design time involved in hand-producing comparable designs would be significantly higher (Demers, 1997). Franz, Ledner and Walcher (1998) stated that GIS technologies have the capabilities to provide cost effective solutions in the maintenance, display, recording and analysis of scenarios with the association of different aspect. Thus, GIS mapping for telecommunication helps to identify and locate appropriate locations of sites geographically since it is an integrated system that performs manipulation and analysis of spatial data.

GIS is an essential tool in the telecommunication industry. Most wireless network engineers are familiar with GIS as the backbone of many wireless design tools already in use. By incorporating digital elevation models (DEMs), land clutter (LC) data, and building elevation models, wireless engineers are able to assess radio coverage before the network is built,

identify areas that require enhanced capacity or coverage, and plan for trends in network and application performance. However, GIS can be used even before engineers set pen to paper. For marketing efforts, population data can be added to enable network traffic and resource utilization calculations. Aggregating block-level population data into rough coverage rings yield statistics on expected network complexity and required capital expenditures before network design even begins. Such numbers can be extremely effective when used in business development proposals because they originate from real-world models (Galati, 2006).

In 1993, Telecom Italia used GIS to locate and repair faults in its public telephone network, and to set up a network for authorising electronic payments for telephone calls. It chose an open, rather than a proprietary system, so that it could operate various subsystems and integrate existing technology. The primary task for the GIS was to improve Telecom Italia's response to reported telephone faults and the average roadside telephone terminal recorded 14 faults a year. For each faulty terminal, the company needed to know which company manufactured the equipment and who was responsible for repairing it. The GIS has a separate function to collect information concerning the fault recording and the payment method. However, both the information on the fault repairs and the status of payments are stored centrally in a database (Nicola, 1996).

GIS can further be used in business development efforts at both the strategic and operational scales to determine where coverage expansion should be directed and how the ensuing network should be deployed. Demographic data can be leveraged to identify population centres and areas of high income. A demographic approach removes the need for strategic planners to ―throw darts at the map .Income estimates further allow engineers to target geographic areas with high disposable income that will be most likely to subscribe to new services. The benefits of this approach are obvious and are further validated by its increasing use in

diverse business lines. Simply by picking up a business atlas or doing internet research, planners can identify underserved markets and provide opportunities for revenue generation. Also the GIS allows the engineer to add existing and competitive coverage to the map to improve the context of the data provided (Jones, 2005).

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

Alenoghena, Emagbetere and Aibinu (2014), developed a comprehensive city structure data base system (CSDS) for the placement of base stations in Minna, Niger state of Nigeria. The researchers developed an effective data collection process for the acquisition and collation of spatial data of the city. The result shows that the created database, radio planners could now be able to access and get hold of relevant map information of the city easily also it serves as a tool required by an intelligent decision making process of base station placement in the city.

Having sited relevant literature on GIS and telecommunication masts, this research tends to used GIS tools to map and anlysed the telecommunication masts location and its spatial distribution with regards to their environmental effects.

### 2.3.3 Telecommunication Masts and Environmental Effects

There has been significant concern raised about possible effects from exposure to electromagnetic fields, especially after the rapid introduction of mobile telecommunication systems. People who live around the base of mobile phone telecommunication mast are generally more concerned about the possible hazards associated with living close to them (Wolf and Wolf, 2004). Several empirical works have been carried out regarding its effect and some of these are examined.

*2.3.3.1 Effects on Expose Animals*

i. Reproduction

Magras and Xenos (1997) reported that there is a progressive drop in the number of rodent births exposed to radiofrequency. The mice exposed to 0.168μW/$Cm^2$became sterile after five generations, while those exposed to 1.053μW/$Cm^2$ became sterile after only three generations. In town of Casavieja (Avila, Spain) telephony mast was installed that had been in operation for about five years, farmers began blaming the antenna for miscarriages in many pigs, 50-100m from the antenna. The issue became so bad that the town council decided to dismantle the antenna. It was removed in the springs of 2005. From then on, the problem of pig miscarriage stopped (Alfonso, 2009). In pregnant rats exposed to 27.12MHz continuous waves at 100W/$Cm^2$ during different periods of pregnancy, half the pregnancies miscarried before the twentieth day of gestation, compared to only 6% miscarriage rate in unexposed controls and 38% of the viable fetuses had incomplete cranial ossification compared to less than 6% of the controls (Pearsson, 1997).

ii. Nervous System

Microwaves may affect the blood brain barrier which lets toxic substances pass through the blood to the brain (Adang, Camp and Vorst, 2009). Elieen (2006), examined the effect of

microwave exposure to a GSM-like frequency of 970MHz pulsed waves on the memory in rats by means of an object recognition task. The rats that have been exposed for 2 month show exploratory behaviour. They do not make the distinction between a familiar and an unfamiliar object. In some area that received radiation directly from 'Location Skrunda Radio Station' (Latvia), exposed children had less developed memory and attentions, their reaction time was slower and neuromuscular apparatus endurance decreased (Ayinmoda, 2010).

Exposure to mast prenatally and to a lesser degree, postnatal was associated with behavioural difficulties such as emotional and hyperactivity problems around 7yeas of age (WHO, 2006). Electromagnetic radiation caused modification of sleep and alteration of cerebral electric response (Elieen, 2006). Alfonso (2009) also reported that microwave radiation from cell masts may cause aggressiveness in people and animals. In terms of deterioration of health, there was proof of frequent death in domestic animals; such as hamsters and guinea pigs, living near mobile telecommunication mast. A link between electromagnetic field exposure and higher levels of oxidative stress appears to be a major contributor to aging, neurodegenerative diseases, and immune system disorder and cancer in mammals (Pearsson, 1997).

*2.3.3.2 Effect on Exposed Human*

The driving force behind mobile phone technology is effective communication in the information society at a lower cost, in a safe way and with more convenience which cannot be achieved without the installation of telecommunication masts.

Empirical works have however shown that there is a salient long term problem that may affect the residents' health (especially living very close to mast location). In United Kingdom, it was shown that a mobile phone company was asked to remove its telecom mast from a block of

flats after seven clusters of cancer and other serious illnesses were discovered (Santini *et al*, 2003). Report from Northern Ireland Statistics and Research Agency shows that in its Dunanon Local Government District, residents that are within the range of 1-5km from masts have several cancer cases including prostate, breast cancer, lungs cancer, leukaemia, lymphoma and hematopoietic cancer (Abdel *et al*, 2007).

Several medical reports have linked illnesses to radiation emitted by telecommunication masts. The Leadership Newspaper (2012) reported a case example of a medical report issued to Mr Afolabi Oyekanmi (who has a mast sited within his premises) at the Ado Ekiti University Teaching Hospital. It was apparent that locating a telecom mast too close to his house is detrimental and hazardous to his medical condition if not the cause .The man was taken to the accident and emergency unit of the hospital in January 2011 with complaints of loss of consciousness associated with convulsion. The reason the doctors gave for their conclusion was that he was not a known epileptic, diabetic, hypertensive or asthmatic patient (The Leadership Newspaper, 2012). Similarly, the doctors at the University College Hospital, Ibadan linked emission of electromagnetic impulses from the masts located close to the homes of the Adebusola Ogundipe family of Ibadan to their ailments. The health of the whole family was said to be in danger. The matriarch of the family suffers from sensation of pain and tingling on her legs and in addition has been diagnosed to have developed leukaemia. Her children suffered memory loss, dizziness and bleeding from their noses. It was obvious that these ailments were not coincidental; they were a result of certain environmental factors (Ogboru, 2015).

Despite these claims being refuted, there is said to be vast scientific, epidemiological and medical evidence that confirms that exposure to the radiofrequency emitted from cell towers, even at low levels can have adverse effects on biological systems (Cherry, 2002). In a study carried out

at the Institute of Research in Berlin, it was revealed that during the first 3 – 5 years of exposure, people suffer sleep disorders, melatonin reduction which leads to immune deficiencies. From 5–7 years, neurological problems become noticeable with headaches, confusion and memory loss. After 10 years, serious disorders such as cancer occur and health damage becomes irreversible.

Likewise, a report from the University of Washington states that when considering the effect of radiation from wireless transmitters, one has to consider the effect of long-term exposure. Even though the level is low, it would matter if the effects of radiofrequency radiation turn out to be cumulative. Small doses cumulate over a long period of time (i.e. add up over time) will eventually lead to harmful effects. Children are said to be at the greatest risk because of their special vulnerability during periods of development before and after birth. Over 100 physicians and scientists at Harvard and Boston University Schools of Public Health have called cell towers a radiation hazard while 33 delegate physicians from seven countries have declared cell phone towers a ‘public health emergency (Kauppi, 2000).

Cell phone towers expose the public to involuntary, chronic cumulative radiofrequency radiation. Harmful low levels of radiation can reach as far as a mile away from the cell tower location. A study involving roughly 1000 patients in Naila, Germany, concluded that the proportion of newly developing cancer case was significantly higher among those who lived up to 10years at a distance within 400m from cellular transmitter site, compared to those patient living farther away (Eger, Hagen, Lucas, Vogel and Voit 2004). Also in Austria, a study shows that people whose homes are 100m or less from base station had higher score in psychological strain scales, with significantly higher concentration of alpha-amylase in their saliva, obsessive compulsive, anxiety and so on (Hutter, Moshammer, Wallner and Kundi 2006). Besides emission of radiations, there is also the problem of heat from the transmitters, smoke and noise emanating

from the generator sets that power these facilities. Heating effects become insignificant when distance from a microwave transmitter exceeds a few metres (Ford, 2005). With the way telecommunication masts are sited in Nigeria, it is uncertain how much of the heat residents suffer from. Undoubtedly, the smoke and noise is an aspect Nigerians are familiar with.

Also in Nigeria, empirical works has been carried out by researchers to show that indiscriminate locations of mast have relative effect on the residents. Onifade, Jeliliand Asani (2015) in their study in Ibadan reported that indiscriminate location of masts in Egbeda Local Government Area of Oyo State caused partial deafness, affect television/radio reception even the diesel from generating set also pollute the underground water around the mast locations which can as a result lead to water based diseases. Akintonwa, Busari, Awodele and Olayemi (2009) study carried out in Lagos showed that proximity and duration of mast radiation is directly proportional to hazard effect. From the study, most respondents stayed closest to mast in the range of 1-50m accounting for 31.5% of the respondents, 24% were in the range 50-100m and 18% were in the range of 100-1000m; and average power density within 200m radius was 1.32± 0.075mW/cm2. Akintowa *et al* 2009, argued that majority of the respondents were having different symptoms with headache being the most frequent similar to other established findings. The authors also showed that there is a significant relationship between high voltage cables and telecom mast on the health effect of the respondents.

*2.3.3.3 Effect on Property Values*

Understanding the effects of cell phone base stations on property values is important to telecommunications companies in planning the siting, and handling likely opposition from property owners. Similarly, property valuer need to understand the valuation implications of this when valuing properties which are in close proximity to cell phone base stations (Bond, SiYeoul

and MacMahon, 2003). Considerable growth in the use of mobile phones has led to increasing demand for land to site telecommunication base stations and associated infrastructures (Biebuma and Esekhaigbe, 2011). The literature on the impact of GSM base station on property values is still very scanty especially in developing countries. Bello (2010) examined the variation in the satisfaction of people living around GSM base stations with samples drawn from Akure, Nigeria. Using Crosstabs' nominal-by-nominal measures, the study found that resident' satisfaction increases with distance away from the base station. 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. However, the result of the study did not show how property values respond to base station situation whether it increases or reduces rent passing on these properties.

Bond, SiYeoul and MacMahon (2003) studied residents' perceptions toward living near Cell Phone Base Stations (CPBS) and how they evaluate the impacts of these structures. Two case study areas in the city of Auckland, New Zealand were selected in order to understand how residents' perceptions impact on property values. The study revealed mixed responses from residents ranging from being prepared to pay the same to being prepared to pay more than twenty percent less for a property located near a station. Bond and Wang (2005) assessed the perceived impact of cellular phone towers on residents and property values in Christchurch, New Zealand. The study revealed that people who live close to a station perceive the sites less negatively than those who live further away.

Brandt and Maennig (2012) examined the impact of cell phone base stations on prices of condominiums in Hamburg, Germany. The study distinguished between individual masts and groups of masts and it was found that only immediate proximity to groups of antenna masts is

perceived as harmful by residents of nearby condominiums. For individual masts no effect on residential property prices in the surrounding areas was observed. It was recommended that cell phone service providers should prevent installation of groups of masts in a single location. Michael, Nnaemeka and Matthew (2013) studied the locational effect of mast on residential properties in Akure, Nigeria. The study 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.

### 2.3.4 Precautionary Principle on Mobile Telecommunication Mast

When human activities may lead to morally unacceptable harm that is scientifically plausible but uncertain, actions shall be taken to avoid or reduce that harm. Morally unacceptable harm refers to that on humans or the environment that is threatening to human life or health, or serious and effectively irreversible, or inequitable to present or future generations, or imposed without adequate consideration of the human rights of those affected. The judgment of plausibility should be grounded in scientific analysis. Analysis should be ongoing so that chosen actions are subject to review. Uncertainty may apply to, but need not be limited to, causality or the bounds of the possible harm. Actions are interventions that are undertaken before harm occurs that seek to avoid or diminish the harm. Actions should be chosen that are proportional to the seriousness of the potential harm, with consideration of their positive and negative consequences, and with an assessment of the moral implications of both action and inaction. The choice of action should be the result of a participatory process (COMEST, 2005).

The precautionary principle requires a science that better reflects uncertainty and complexity in the assessment of risks. Both qualitative and quantitative dimensions of uncertainty need explicit treatment. Uncertainties along with the key assumptions on which knowledge claims on risks are conditioned need to be made explicit and communicated clearly to the various factor involved in the discourses on these risks. This requires the further development and dissemination of multidisciplinary and multidimensional uncertainty analysis, which enables the delivery of policy-relevant quantitative information on risks together with the essential warnings about its uncertainties, limitations and pitfalls. The precautionary principle imposes a clear need to improve communication and reflection on various levels and types of uncertainty in scientific assessment (Andorno, 2004).

What is pertinent about the impasse in the pros and cons of GSM mast locations is that it has led to the adoption of the innovative interpretation of the concept of precautionary principle. The idea of precautionary principle is regarded as an important component of the concept of Ecologically Sustainable Development. Generally, it is concerned with the management of scientific risk relating to environmental protection. It is defined in Principle 15 of the Rio Declaration, where it states that "Where there are threats of serious or irreversible environmental change, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation" (United Nation, 1992).

According to Wager, Eugster, Hilty and Som (2005), precautionary principle provides a framework to anticipate and minimize the risks of novel technologies and foster their positive potential. It aims at minimizing risks that could be caused by human activities as early as possible and thus to keep a space open for future developments. Precautionary principle has internationally been accepted in judicial decisions in many countries citing Australia, Britain, India, Indonesia,

New Zealand, Pakistan and South Africa. In Australia, a judge has accepted the precautionary principle as a valid component of Environmentally Sustainable Development (Cole, 2005). That means "the burden of proving the acceptability of a proposal where there is scientific uncertainty about its impact lies with the developer or proponent". Nonetheless, these concerns have not prevented approval of GSM mast in populated parts of urban areas in Nigeria, without coherent measures to prevent the RF potential harm as recognized globally. In that regard, the precautionary principle is, therefore, a useful tool in addressing public concerns about the potential harm of GSM mast located within built-up and populated areas. It is also useful where institutional authorities lack the capacity of scientific evidence to determine harmful effects in time. Some countries have already set spatial limits within which the precautionary principle could be exercised. For instance, the standard limits of 500-600 meters are usually imposed around GSM mast as precautionary consideration (GSM Association, 2012). This type of technical criteria is useful in determining how GSM mast can be accommodated within built-up areas.

Having examined available literature on several issues on location of GSM based station and potential or real harm to nearby residents, it is now adequate to analyze empirically collected data in Kano, Nigeria to analyse the spatial distribution and the environmental effect of telecommunication mast. The subsequent chapters address these.

# CHAPTER THREE

# STUDYAREA AND RESEARCH METHODOLOGY

## 3.1 INTRODUCTION

This chapter discusses the study area (geographical and socioeconomic characteristics) as well as the methodology of the study. Specifically, the chapter covers the following: The area of the study, GIS techniques (ArcGIS analyses tool), sampling procedure, sources of data, determination of sample size, and statistical method use for data presentation and analysis.

## 3.2 THE STUDY AREA

### 3.2.1 Location and Size

Kano metropolis is one of the largest cities in the country due to commercial activities. It is located between Latitudes $12^{o}$ 25′N and $12^{o}$ 40′N north of the Equator and Longitudes $8^{o}$ 35′E and $8^{o}$ 45′E east of the Greenwich meridian. The metropolitan area covers 499$km^{2}$ and comprises eight local government areas, these are the six mentioned above and part of Ungogo and Kumbotso. Kano metropolis is bounded by Dawakin Kudu and Minjibir LGAs to the north, Gezawa and Warawa LGAs to the east, Madobi and Dawakin Kudu LGAs to the south and Tofa and Rimin Gado LGAs to the west (Ahmad, 2010). This description is presented in Figure 3.1.

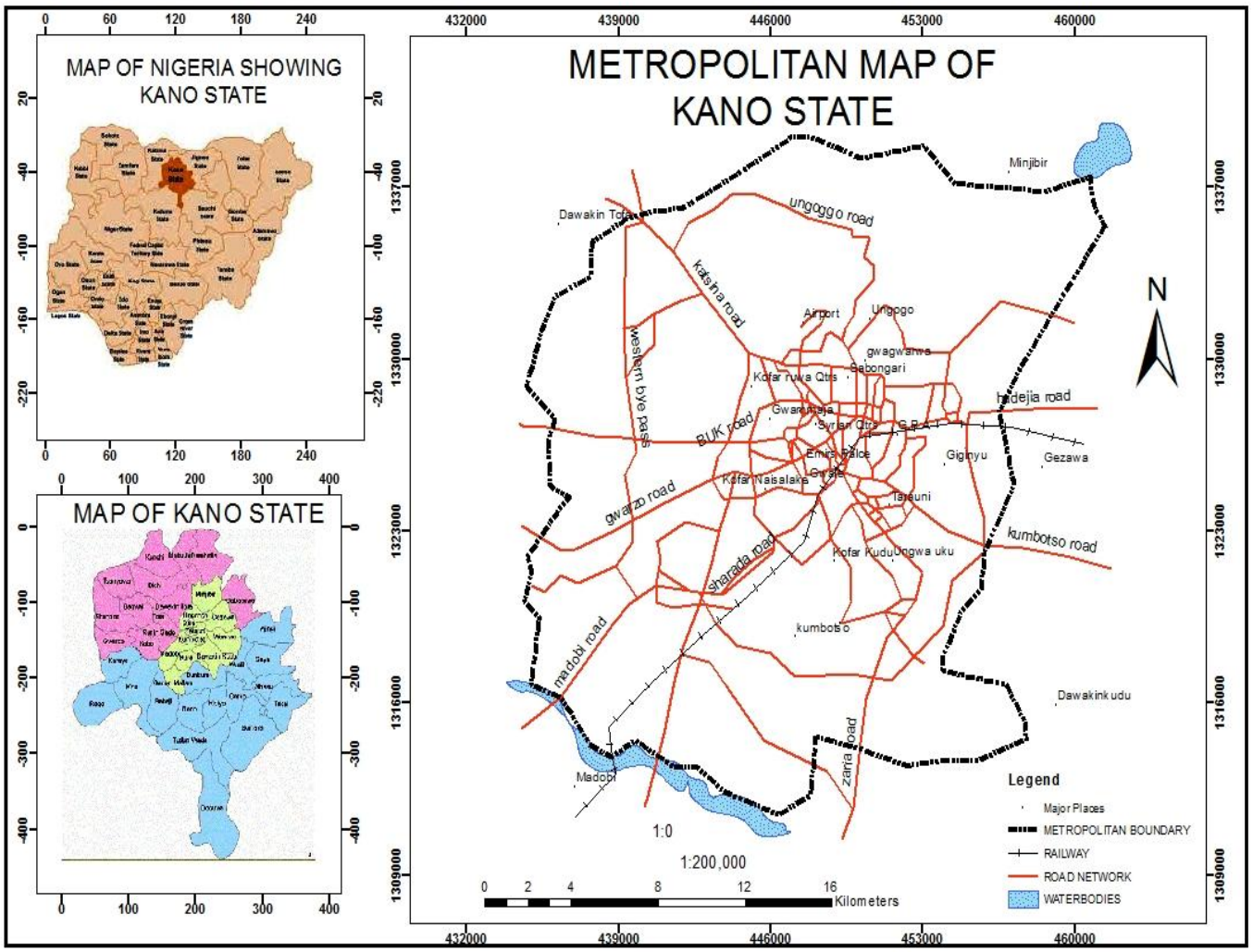



**Fig 3.1:** Kano Metropolis

**Source:** Modified from Administrative Map of Kano State

### 3.2.2 Weather and Climate

The climate of Kano is typical dry and wet climate. This is largely controlled by the two air masses; tropical maritime and tropical continental air mass. The southwesterly winds are normally associated with the tropical maritime air that blows from Atlantic Ocean and have a lot of moisture in them. The north easterly winds are associated with the tropical continental air mass

that blows from the Sahara desert and are dry with no moisture and are associated with the harmattan season (Ojo, Ologe and Ezechukwu, 2013).

The annual rainfall of the study area is about 850-870mm. On the average, the area enjoys a rainy season of about five (5) months with great variation across the year. The temperature is averagely warm to hot throughout the year at about $27^0$C (Olofin and Tanko, 2002).

### 3.2.3 Relief and Drainage

The area is made of basement complex rocks that are hard and impervious in nature with rivers that flows in north-south direction. There is considerable relationship between groundwater and drainage pattern with the highest network of rivers in the basement complex rock therefore the small area of Chad sediment in Danbatta and Gaya LGAs are expected to have more groundwater and limited channel development. Kano state has two hydrological areas, the upland area that includes rivers like River Kano, River Challawa, River Iggi and Gaya. The second hydrological area includes the Gari area which comprises of River Gari, Thomas and Jakara. The upland area receives rainfall of over 800mm annually while the Gari area receives annual rainfall of less than 800mm. Several dams have been constructed to meet the rural demands of about 25 small to large including those at; Gari dam, Wasai dam, Kafin-Ciri dam, ChallawaGorg dams, Ruwan-kanya dam, Watari dam, Kanye dam, Gude dam and the Bagauda Lake (Ahmad, 2003).

### 3.2.4 Population and People

Kano city has for a long period of time been experiencing massive population increase. For instance, in 1952, the total population in Kano metropolis was 127,000, the population increased to 295,432 in 1963, 760,000 in 1973, 1.5 million in 1991 and it is expected to reach 2,935,500 by the year 2020 based on the annual growth rate (NPC, 2007). Kano is a typical example where the

house and land stock has seriously been at far with demand. Being an ancient centre of trade and commerce, Kano also became prominent as an industrial nucleus of Northern Nigeria. Besides, it became a collection and distribution centre of imported manufactured goods because of its geographical and nodal advantages. Thus, the city attracts high influx of population from far and wide and therefore is confronted with pressure on all available facilities and infrastructure such as telecommunication, who are more interested in area of high population.

### 3.2.5 Socio-Economic Activities

Kano city for centuries has been the most important commercial and industrial nerve centre of northern Nigeria attracting millions from all parts of the country and beyond. Immigration and natural growth rate of 3% is expected to continue to increase the population (Census, 2006). It is also one of the most crowded and its metropolitan population makes it the second largest city in the country. Kano has been known as a center of commerce due to different business activities in the city, the presence of major markets and industries in the metropolis attracts population increase, the success of its various socioeconomic activities cannot be fully achieved without communication thus, making it a big market for the telecommunication operators and therefore the need to erect masts in the metropolis.

## 3.3 METHODOLOGY

### 3.3.1 Reconnaissance Survey

Reconnaissance survey was carried out in order to give the researcher information on the location of telecommunication masts and nature of distribution in the metropolis and other relevant information such the visiting the Nigeria Communication commission and some cell site, in-situ check of the handheld GPS receiver and numbering the masts in the study area. Also, some

important roads were identified so as to get familiar with masts location for questionnaire administration.

### 3.3.2 The Research Design

A survey research method and geoinformation designs were employed to carry out this research work. According to Ezeh, (2005) survey research design is a plan of study, which allows researchers to make use of reliable techniques for the collection of data from a well defined or systematically selected segment of the population. Thus, the survey research instruments adopted for the conduct of the research were: questionnaire, personal interview and field observations.

### 3.3.3 Types of Data Used

i. Administrative map of the study area from the state ministry of lands
ii. Coordinates of the GSM base stations' locations. The Geographic Positioning System (GPS) receiver was used to collect the coordinates
iii. list of telecommunication masts

### 3.3.4 Sources of Data

The data used for the study were gathered from two different sources, namely: primary source and secondary source;

*3.3.4.1 Primary Sources*

These are set of data that were obtained using handheld GPS (easting and northing of masts). Also a structured questionnaire was administered to seek information on the demographic, socio-economic characteristics of respondents and series of effect experienced by residents with respect to distance away from the telecommunication mast.

*3.3.4.1 Secondary Sources*

Specifically, sources of secondary data came from the following sources:

i) The Nigerian communication commission

ii) The State ministry

### 3.3.5 Digitization and Database Creation

The study area was imported into the ArcGIS environment, projected to a geographical coordinate system using World Geodetic System (WGS 1984) for Georeferencing. The 'heads up' digitization (converting features into digital format) was used to digitized relevant features for the research. Railways and roads were digitized as line features to show access to the mast locations and the metropolitan boundaries as polygons to show the extent of the study area after creating the shapefiles in ArcCatalog.

The geodatabase is a collection of geographical dataset of various types used in ArcGIS and manage in a file folder. Database of the telecommunication masts was created using Microsoft excel containing the location of each of the operational mast captured (82) in the study area, their coordinate and distances to the nearest building/resident (to help in determining which of the mast violate the setback standard). The database table (excel sheet) was saved in .csv format acceptable in the ArcGIS environment as shown in Appendix II.

The coordinate of each mast contained in the database table was imported into the digitized study area. At first, the data imported cannot be queried and analyse, so the data was exported as a shapefile to create a new layer as an overlay on the map to enable further analyses of the masts.

### 3.3.6 Sample Size and Sampling Techniques

The 2006 population of the study was projected for 2016 using the growth rate of 3% for Kano State and exponential method of projection recommended by the National Population Commission (NPC, 2006). The National population commission recommends the use of exponential method to project population as a result of the inadequacies of Nigeria's Census data. It is believed by the NPC that the exponential method will give high variance.

Given as: $Pt=P\ e^{rn}$

The formula of Yamane (1976) was used to calculate the sample size for the study. The formula is as: $S = \frac{N}{1+N(e)2}$

which gives approximately 400

The number of questionnaire to be administered will be proportionate to the population of each LGA. Thus, Proportion = $(n/N) \times 400$

Table 3.1: Sample Size by LGAs

| S/N | LGA | 2006 Population | 2016 Projected Population | Sample size |
|---|---|---|---|---|
| 1 | Fagge | 198,828 | 260,458 | 32 |
| 2 | Dala | 418,777 | 548,583 | 68 |
| 3 | Gwale | 362,059 | 474,284 | 58 |
| 4 | Kano Municipal | 365,525 | 478,825 | 61 |
| 5 | Tarauni | 221,367 | 289,983 | 36 |
| 6 | Nassarawa | 596,669 | 781,615 | 97 |
| 7 | Kumbotso | 295, 979 | 387,722 | 48 |
| **Total** | | **2,459,204** | **3,221,470** | **400** |

*Source:* Author's Computation

The sample sizes for each of the Local government were calculated as shown in Figure 3.1. Purposive sampling technique was used because the researched purposely selected respondents living close to the telecommunication masts and are expected to be exposed to the effects with distances away. Random sampling (balloting) was used to select a total of 14 mast locations for administration of questionnaire (two (2) in each local government areas). This was to ensure the gathering of data from respondents that can provide necessary data to the study and to ensure that the sample was an adequate representation of the study area.

### 3.3.5 Method of Data Analysis

*3.3.5.1 Location of Telecommunication Mast*

The coordinate of each mast was obtained using a handheld GPS device and a database created with attribute data of each masts captured (which was saved as comma separated value (.csv) file format) were imported into the ArcMap environment and the coordinate layer overlaid on the base map, which appears as a point showing the location of each masts in the study area. These features layer were then exported as a layer/shapefile to enable relevant queries.

*3.3.5.2 Distribution Pattern of Telecommunication mast*

The spatial statistic toolbox in ArcMap was used to assess the average nearest neighborhood analysis tool which is used to explain degree of regularity, randomness or clustering. A total number of eighty two (82) masts were captured in the study. The Average Nearest Neighbor tool measures the distance between each feature centroid and its nearest neighbor centroid location. It then averages all these nearest neighbor distances. If the average distance is less than the average for a hypothetical random distribution, the distribution of the features being analyzed is considered clustered. If the average distance is greater than a

hypothetical random distribution, the features are considered dispersed. The average nearest neighbor ratio is calculated as the observed average distance divided by the expected average distance. The database created was used as an input in the toolbox to generate the pattern of distribution of masts in the metropolis using Euclidean distance method. Also, the degree of clustering was measured using the Getis-Ord General G statistical tools. These measures how concentrated the high or low values are for a given study area, it gives a critical value (z-score) in the output generated. A positive z-score indicate clustering of high values and a negative z-score indicate clustering of low values while a z-score near zero indicate no apparent clustering within the study area.

*3.3.5.3 Level of Compliance to Stipulated Set Standards*

In examining the fulfillment of stipulated regulatory distance of 7meters agreed upon by both NCC and NESREA, among the mast in the study area, the query tool was used. A query could be viewed as a means of precisely obtaining information from a map or database. A query function can be carried out in ArcMap either by using identifier button on the tool bar for simple querying or as the case may be using the query builder. Since the database created contain the minimum distance to the nearest residential building from each mast obtained during the field work, spatial query were carried out to show those masts that were within the set standard of seven meters (7m). The results were highlighted on the map and a table showing the affected masts. Relevant information on the nearest residents that are within the setback distance were gathered also during the field work on if the properties were build before or after the telecommunication mast which are also in the database.

*3.3.5.4 Telecommunication mast location and Reported Effects by Residence*

Questionnaire was used to collect data residence experiencing the identified effects in the study area. Four zones were marked away from the telecommunication masts for questionnaire distribution. A distance of 5m, 10m, 15m and 20m radii away from the masts were marked to capture the varying spread of the suspected effects in the area and also to ascertain the level of effects experienced beyond the setback standards. The sample size for each local government was divided into two for the two locations in each local government and equally distributed to each zone. A total of 400 copies of questionnaire were administered across the study area and 355 copies were retrieved and valid/used for analysis (Table 4.4). The data collected from the questionnaire regarding response on effects experienced were subject to tabulation. This was carried out in phases and later on summed together for further analysis. Correlation analysis was used to ascertain if there is association between location of telecommunication mast and the effects in the study area.

# CHAPTER FOUR

# RESULTS AND DISCUSSION

## 4.1 INTRODUCTION

This chapter presents all the results from the analysis carried out and discussions on the analysis. Results are displayed using maps, graphs and tables.

## 4.2 LOCATION AND DISTRIBUTION PATTERN OF MASTS IN THE STUDY AREA

### 4.2.1 Location of Mast in the Area

The map was design showing the spatial location of the masts as shown in Fig. 4.1.

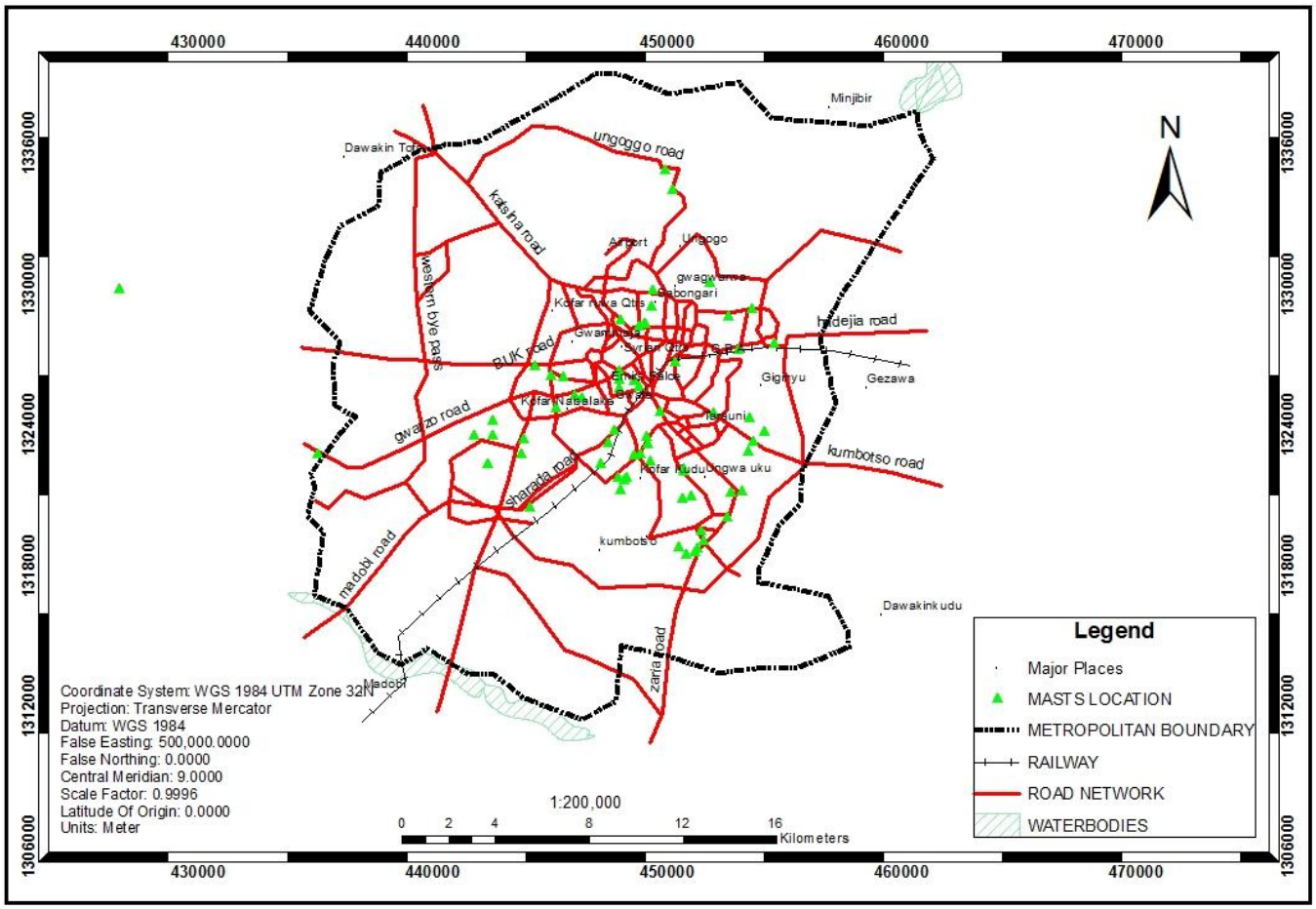



**Fig. 4.1: The Spatial Distribution of Masts**

**Source: Author's GIS analysis (2016)**

**Table 4.1: Distribution of Masts in Kano Metropolis**

| LGA | Number of Masts | Percentage |
|---|---|---|
| Fagge | 8 | 9.8 |
| Dala | 12 | 14.5 |
| Gwale | 9 | 11 |
| Kano Municipal | 16 | 19.5 |
| Tarauni | 10 | 12.2 |
| Nassarawa | 18 | 22.0 |
| Kumbotso | 9 | 11 |
| Total | 82 | 100 |

Source: Field survey, 2016

The map (figure 4.1) shows the spatial location and distribution of the masts (depicted in green symbol) captured in the study area. It can be seen that there is high concentration of these masts in the central part of the metropolis (Kano municipal, Gwale, Nassarawa and part of Kumbotso and Fagge as shown from the number of mast captured in Table 4.1) with very few located around the outward which can be attributed to the presence of commercial activities mostly in the central area and the need for effective coverage. The road network is in red colour and some of the major roads are named (Gwarzo road, Kumbotso road, Western by pass, Zaria road etc). The rail line cut across the metropolis from the southern part to the eastern part towards Gezawa LGA and the water bodies in the northeastern and southern parts of the study towards Minjibir and Madobi LGA respectively are shown.

### 4.2.2 Distribution Pattern of GSM Masts

The distribution pattern of telecommunication masts in the study area was carried out with the aid of the average nearest neighborhood and gestid ord general G tool in ArcMap. Results generated are shown in Table 4.2, Figure 4.2 and Figure 4.3.

**Table 4.2: Average Nearest Neighbor Summary**

| PARAMETERS | VALUE |
|---|---|
| Observe Mean Distance | 774.401966 meters |
| Expected Mean Distance | 1264.19028 meters |
| **Nearest Neighbor Ratio** | **0.612568** |
| Z-score | -6.752520 |
| P-value | 0.00000 |

Source: Author's GIS Report

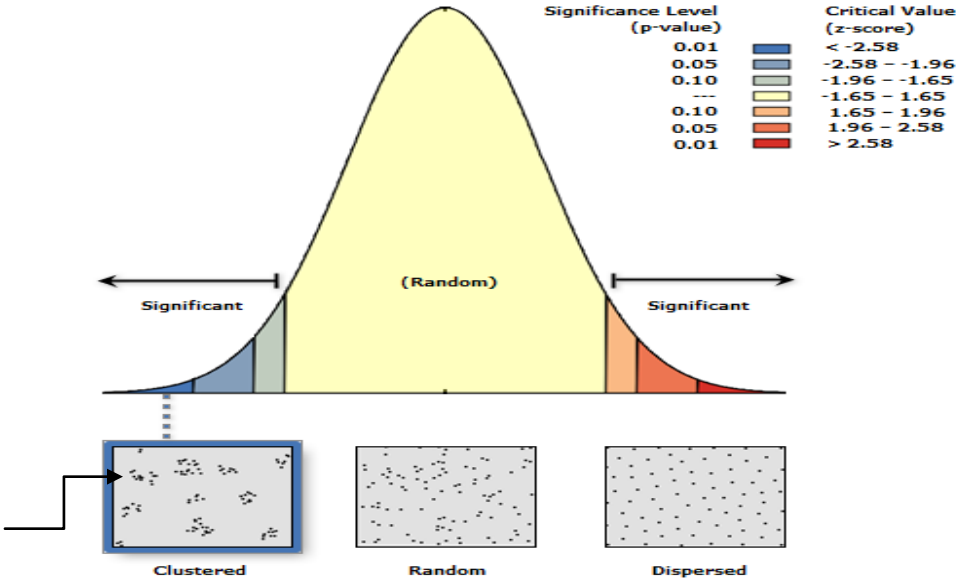



Fig 4.2: Average Nearest Neighbor Report

The result shows that the nearest neighbor ratio is **0.612568** (observed mean distance divided by the expected mean distance), with a critical value of <-2.58 and a test of significant: P-value of 0.0000 as shown in Table 4.2. The result of the breakdown shows that the spatial pattern of distribution of telecommunication masts in Kano metropolis was clustered (Figure 4.2) and there is less than 1% likelihood that this clustered pattern could be the result of random chance.

The degree of clustering was measured using the Getis-Ord General G statistical tools and a result was generated Figure 4.3.

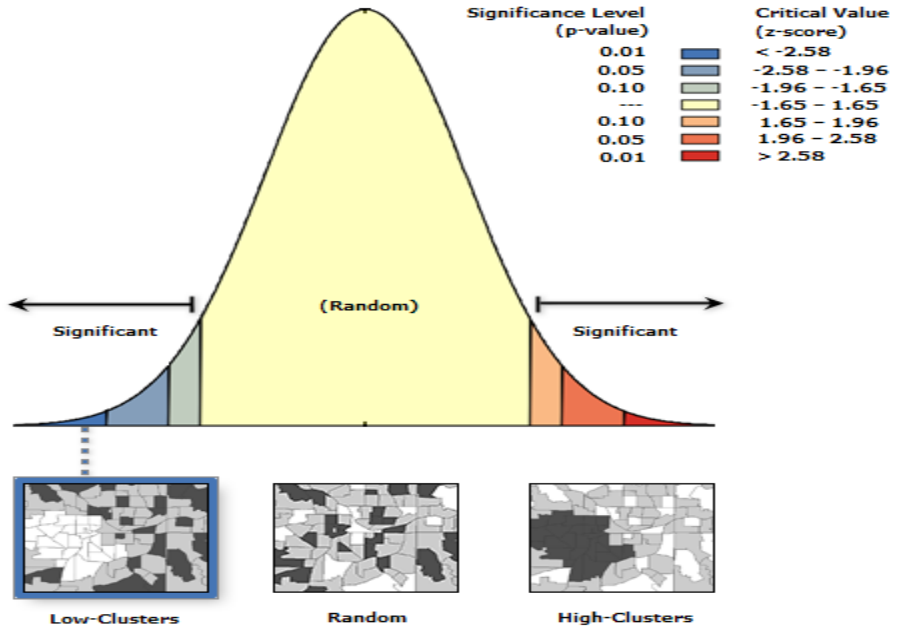



Fig 4.3: Gestis-Ord General G. Result

Source: Author's GIS Report

Result generated from the Figure 4.3 shows that the observe General G value was 0.000701 while the expected General G was 0.001094 with a test of statistic; P-value of 0.000026 which shows that the clustering pattern is low in the study area. This low-clustered pattern could be the result of random chance.

The clustering pattern shows that the masts are not evenly distributed over space, they are situated closely due to the fact that they have same goal to achieve at a particular area probably due to the competitive market among the service providers. These observed clustering further confirms the absence of a definite spatial planning and technical standard to guide the location of mast. The results can be compared to other studies conducted in other part of the country on the spatial pattern of telecommunication mast. In the Federal Capital City, Abuja, the spatial distribution pattern of telecommunication masts were observed to be clustered (Musa *et al*, 2016) so also the spatial pattern of distribution in Ile-Ife were observed to be clustered (Badru *et al*, 2016). Mohammed and Abdurrahman (2014) also reported that the spatial distribution pattern of telecommunication mast in Jimeta, Yola is clustered in the central part of the city and dispersed in the outer area and that of Lagos metropolis as at 2011 was found to be neither clustered nor dispersed but random in nature. All these reports shows that as at present the spatial distribution patterns are clustered in major places and only a few are dispersed and random but as population continues to grow so will the number of subscribers and more masts are going to be required to meet their demand for reliable coverage. This simply indicates that those places that are presently dispersed and random will tend towards clustering as time goes on.

## 4.3 THE LEVEL OF COMPLIANCE TO SET STANDARDS

A minimum regulatory setback distance of seven meter (7m) was used in the research as agreed upon by both NCC and NESREA (2014). The analysis was carried out to determine if the regulatory setback distance of mast to the nearest residents in the study area was complied with. Since the database created consists of distances from each mast to its nearest resident, the query tool analysis was used. The system was queried of those masts that are greater than or equal to seven meters from the nearest resident (≥7m) as shown in Figure 4.4.

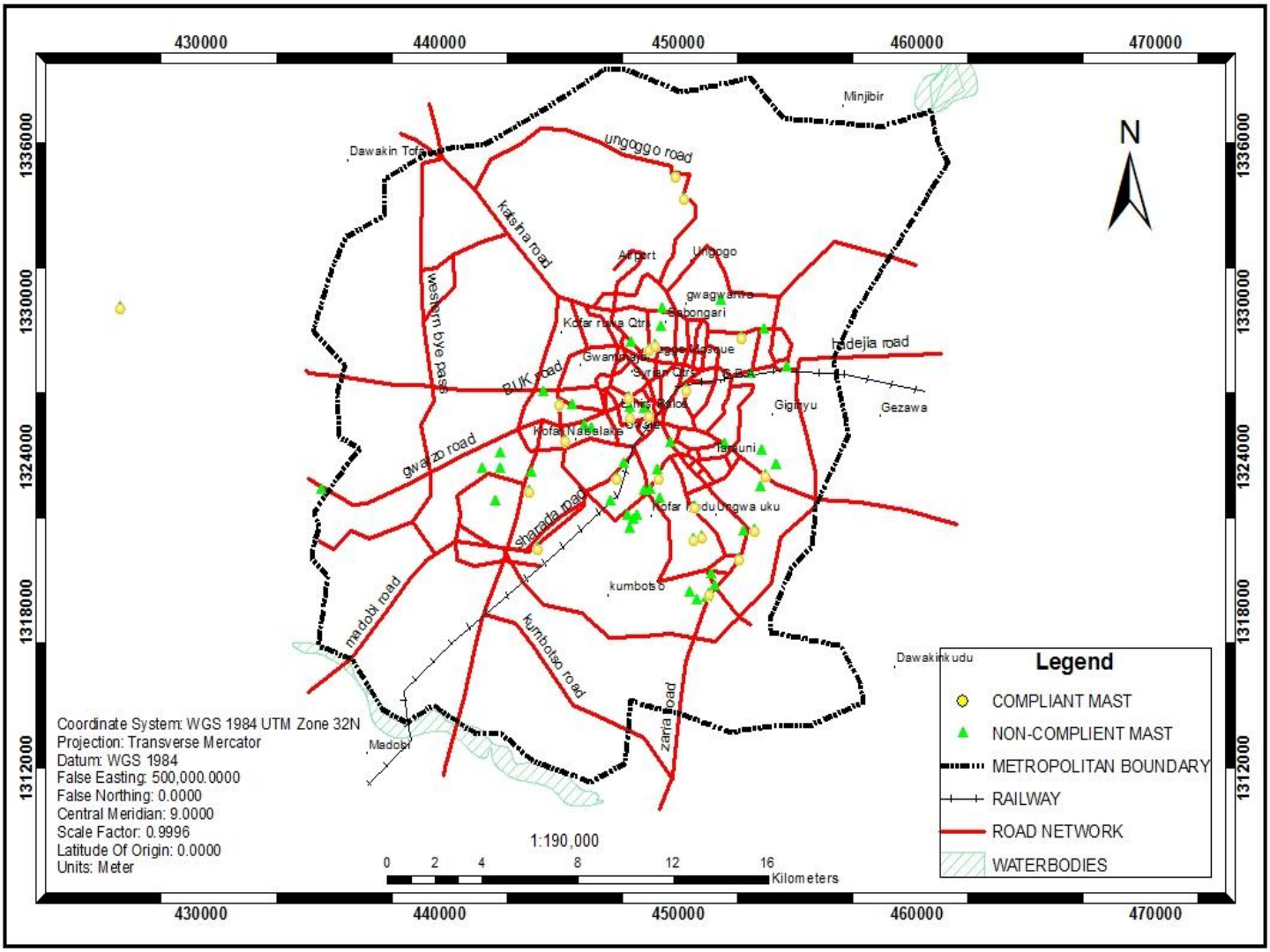



**Fig 4.4: Map showing both Compliance and Non-compliance Mast**

**Source: Authors GIS analysis (2016)**

The query result generated a total of 38 masts (depicted with yellow symbol in Figure 4.4 Table 4.3) from the database that were in compliance out of a total of 82 masts which implies that the remaining 44 masts (depicted with green symbol in Figure 4.4) have violated the regulatory setback.

Table 4.3: Level of Compliance

| LGA | Complied Masts | Non-complied Masts |
|---|---|---|
| Fagge | 3 | 5 |
| Dala | 5 | 7 |
| Gwale | 4 | 5 |
| Kano Municipal | 10 | 6 |
| Tarauni | 4 | 6 |
| Nassarawa | 9 | 9 |
| Kumbotso | 3 | 6 |
| Total | 38 | 44 |

Source: Authors Compilation

Overall, only 46% of the total masts captured are in compliance with NCC/NESREA regulatory standard and from Table 4.3 it could be seen that Kano Municipal has the highest number of compliant mast while Fagge and Kumbotso has the lowest number of compliant masts. Also, 54% of the masts are non-compliant with Kano Municipal having the lowest number of non-compliant mast. It was observed that the 44 non-compliant masts are both faults from either the service providers or the landowner. Some of the non compliant masts were in compliance as the time of construction and some were not. Further results were obtained on those masts that were constructed before and after the residential properties.

Among the 44 masts that violated the setback distance, only 17 were installed before construction of the residential properties which means that at time the masts were installed the standards were adhered to but the residential properties constructed encroaches on the set back

distance thus violating the setback standards. The database was also queried for such masts as shown in Figure 4.5 and Table 4.4.

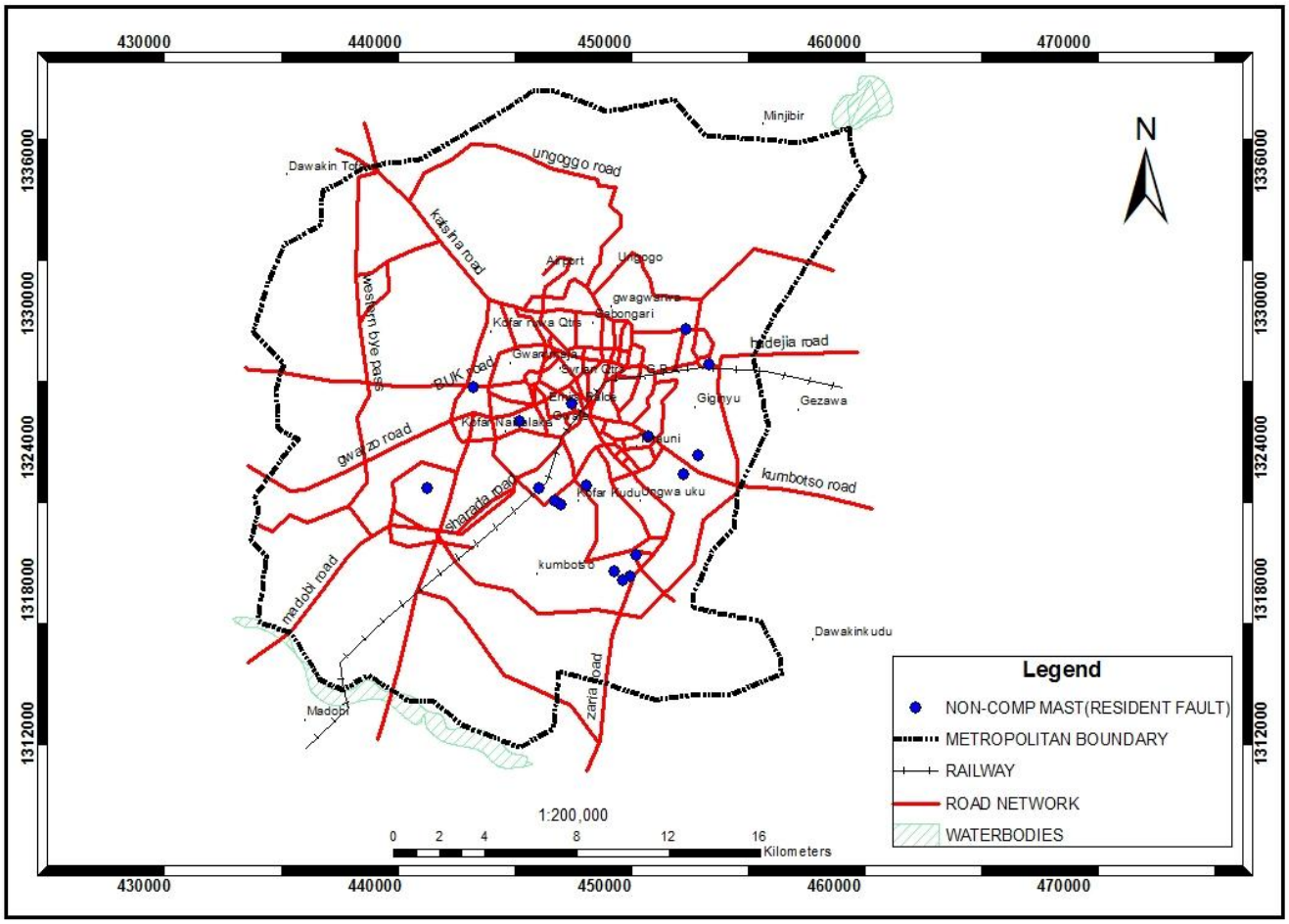



Fig 4.5: Distribution of non-compliant masts (residence fault)

Source: Authors GIS analysis (2016)

Table 4.4: Non-Compliant Masts (residential fault)

| S/N | MAST_ID | SITE LOCATION | SETBACK DIST. |
|---|---|---|---|
| 1 | Mast 1 | Dakata area | 2.4 |
| 2 | Mast 17 | Sharada industrial area | 3.5 |
| 3 | Mast 25 | Daurayi Babba | 4.75 |
| 4 | Mast 33 | Rimi market | 4.4 |
| 5 | Mast 35 | YanAlewa road Gwale | 6.3 |
| 6 | Mast 40 | Jakara Goron Dutse | 6.0 |
| 7 | Mast 44 | Lautai rd by Wudil | 4.4 |
| 8 | Mast 46 | Yankaba Hadejia Road | 6.5 |
| 9 | Mast 54 | Sheka Arewa | 6.6 |
| 10 | Mast 56 | Shagari Quarters | 5.3 |
| 11 | Mast 59 | Shagari Quarters | 4.3 |
| 12 | Mast 71 | Behind Tasha Naibawa | 6.4 |
| 13 | Mast 72 | Faruk Street,U/Uku | 3.4 |
| 14 | Mast 74 | Limawa U/Uku | 4.8 |
| 15 | Mast 76 | LayinAdogano,Y/Lemo | 6.81 |
| 16 | Mast 79 | Maikalwa off Zaria Rd | 3.6 |
| 17 | Mast 80 | Maikalwa Layout | 6.4 |
| **TOTAL** | **17** | | |

Source: Field survey (2016)

These distributions (Figure 4.5) can be attributed to a number of factors which include ignorance of the setback standard set by both the NCC and NESREA, lack of adequate knowledge/awareness on the imminent danger and hazards associated with siting residence close to the telecommunication mast, increase in population leading to increased in demand for land which makes land owner to extend their landed properties, probably no evidence of acquisition of land before construction and possible transfer of land from buyers to buyers among others.

Also, 27 masts out of the 44 non-compliant were installed after the residential building, which implies that the setback was violated by the service provider. The masts are shown in Figure 4.6. and Table 4.5.

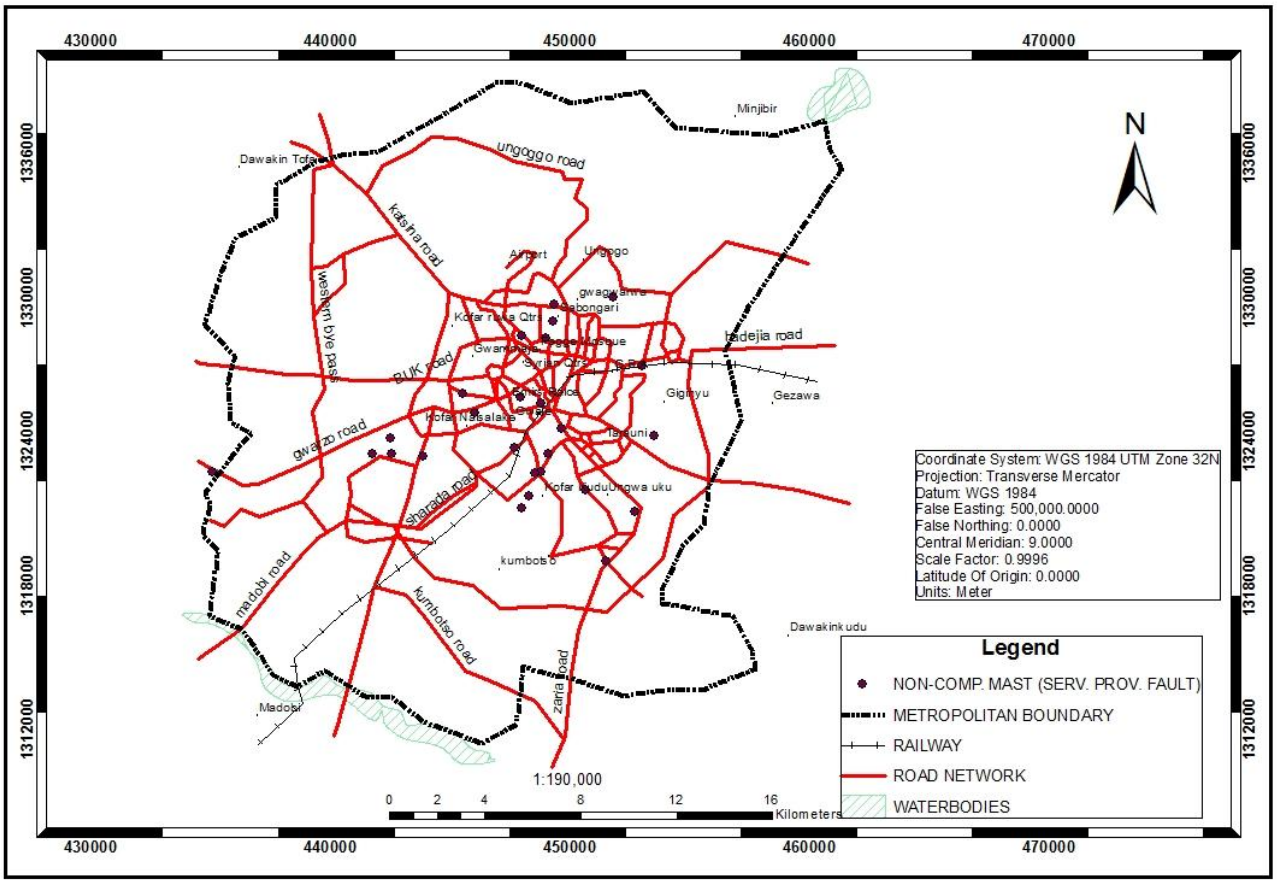



Fig 4.6: Distribution of Non-compliant Mast (service providers fault)

Source: Authors GIS analysis

The above distribution (Figure 4.6) can be attributed to some factors among which are; greed of some land owners that sold the land, transfer of properties from buyer to buyer leading to the eventual sale to the services providers, presence of a competitive market to cover more area. The absence of a city-wide plan for the provision and location of telecommunication infrastructure is also considered as a factor and due to the fact that most of the service providers prefer to approach residential owners to lease part of their properties for the purpose of their masts and the shared properties hardly conform with the town planning and also for security purpose.

Table 4.5: Non-Compliant Masts (Service Provider fault)

| S/N | MAST_ID | SITE LOCATION | SETBACK DIST. |
|---|---|---|---|
| 1 | Mast 3 | TudunWada Brigade | 5.2 |
| 2 | Mast 7 | Zanguru Airport Road | 3.4 |
| 3 | Mast 10 | Sabongari Rumfa Col. | 3.3 |
| 4 | Mast 11 | Sabongari Bello Road | 5.5 |
| 5 | Mast 14 | Sabongari Sanusi Street | 3.8 |
| 6 | Mast 19 | Sharada phase 1 | 2.85 |
| 7 | Mast 21 | Daurayi | 3.75 |
| 8 | Mast 23 | Daurayi Babba | 3.13 |
| 9 | Mast 24 | Daurayi Babba | 2.9 |
| 10 | Mast 29 | Rimi Market | 6.3 |
| 11 | Mast 30 | Rimi Market, K/N | 5.5 |
| 12 | Mast 34 | Sani Mai Nagee | 6.2 |
| 13 | Mast 36 | Murtala Mhd Way | 6.4 |
| 14 | Mast 39 | SaniBuhari StreetGwale | 6.0 |
| 15 | Mast 43 | Unguwan Hotoro | 6.2 |
| 16 | Mast 45 | Batawa Hadejia road | 5.5 |
| 17 | Mast 50 | Gidan Danasabe Zoo rd | 4.4 |
| 18 | Mast 53 | Hausawa Tudun Fulani | 5.5 |
| 19 | Mast 57 | Shagari Quarters | 5.5 |
| 20 | Mast 58 | Ungwan Goje, Shagari | 4.4 |
| 21 | Mast 60 | Zoological Garden | 3.9 |
| 22 | Mast 61 | Bhd Mortgagebank zoo | 6.6 |
| 23 | Mast 62 | Karkasara | 4.1 |
| 24 | Mast 65 | Naibawa Motor Park | 4.8 |
| 25 | Mast 70 | Conoil Gyadi-gyadi | 6.5 |
| 26 | Mast 77 | Kabuga Janbulo 1st gate | 2.28 |
| 27 | Mast 78 | Kabuga Dukawiya | 5.6 |
| **TOTAL** | **27** | | |

Source: Field survey (2016)

In conclusion, only 46% of the telecommunication masts in the study area complied with the regulatory setback distance and 54% of the masts are non-compliant (32% are the service providers' faults and 22% are the residence fault).

## 4.4 REPORTED ENVIRONMENTAL EFFECT OF TELECOMMUNICATION MAST

The relationship between telecommunication masts to reported series of suspected effects (headache, dizziness/nausea, fatigue, memory loss, mental uneasiness, cancer, pollution, accident, inability to concentrate and fear/shock) were analysed based on the response of residents in

distances away from the masts in this section. This was carried out with the information gathered from the questionnaire. Table 4.6 shows the locations where the questionnaires were administered and the number retrieved from each location. The locations are non-compliant to the setback.

Table 4.6: Selected Locations for Questionnaire

| **LGAs** | **MAST ID** | **LOCATION** | **SETBACK DISTANCE** | **NO OF RETRIEVED QUESTIONNAIRE** |
|---|---|---|---|---|
| Fagge | Mast 14 | Sanusi strt (S/gari) | 3.8 | 15 |
| | Mast 10 | Close Rumfa college | 3.3 | 15 |
| Dala | Mast 40 | Jakara goron dutse | 6.0 | 31 |
| | Mast 36 | Aminu kano road | 6.4 | 30 |
| Gwale | Mast 34 | SaniMai nagee Gwale | 6.2 | 25 |
| | Mast 35 | Yan-alewa Gwale | 6.3 | 23 |
| Kano M. | *Mast 33* | Rimi market way | 4.4 | 27 |
| | Mast 29 | Kofar Nassarawa | 6.3 | 29 |
| Tarauni | Mast 44 | Lautai road/wudil rd | 4.4 | 17 |
| | Mast 43 | Hotoro avenue | 6.2 | 17 |
| Nasaarawa | Mast 45 | Hadejia road Batawa | 5.5 | 43 |
| | Mast 46 | Yankaba Hadejia | 6.5 | 43 |
| Kumbotso | Mast 80 | Maikalwa Layout | 6.4 | 21 |
| | Mast 71 | Behind tasha Naibawa | 6.4 | 19 |
| **Total** | **14** | | | **355** |

*Source:* Author's compilation (2016)

### 4.4.1 Socio-economic Characteristics of Respondents

The characteristics of respondents were analysed using parameters such as age, gender, educational status, and places of exposure. Percentages were calculated based on the frequency as shown in Table 4.7.

**Table 4.7: Socio-Economic Characteristics**

| **Age (years)** | **frequency** | **percentage (%)** |
|---|---|---|
| <20 | 21 | 5.92 |
| 21-30 | 70 | 19.72 |
| 31-40 | 110 | 30.99 |
| 41-50 | 70 | 19.72 |
| ≥51 | 84 | 23.66 |
| **Total** | **355** | **100** |
| **Educational level** | | |
| Primary | 15 | 4.23 |
| Secondary | 144 | 40.56 |
| Tertiary | 136 | 38.31 |
| Others | 60 | 16.90 |
| **Total** | **355** | **100** |
| **Sex** | | |
| Males | 230 | 64.79 |
| Females | 125 | 35.21 |
| **Total** | 355 | 100 |
| **Place of Exposure** | | |
| Residential | 288 | 81.13 |
| School | 43 | 12.11 |
| Workplace | 15 | 4.23 |
| Others | 9 | 2.53 |
| **Total** | **355** | **100** |

Source: Field survey (2016)

Table 4.7 shows the socioeconomic characteristic of respondents. Respondents with age ranging from 1-20 accounted for 5.92% followed by 19.72% ranging from 20-30. Age range of 31-40 accounted for 30.99% and those with age greater and equal to 50 accounted for 23.66%. Male and female accounted for 64.79% and 35.21% respectively.

Based on the educational qualification, 40.56% of the respondents only attended secondary school. These are mostly group of people that were found in their respective business centers, few from schools and residential apartment while 38.31% of the respondents attended tertiary institutions, which include those found majorly at their residential apartments. Respondents with only Islamic/Quranic education are categorised as others with a percentage of 16.90 followed by those with only primary school qualification with 4.23%; both group of respondents are found in their business places and some in Islamic education centers and few from residential properties. Respondents whose place of exposure to the effects was their residence are having a very high percentage of 81.13%. They are majorly considered because the effects will be relatively high compared to other place due to the fact that they are more exposed during the day and night and these are the group having majorly secondary to tertiary level of education. Those whose place of exposure are residential properties used as schools and workplace (business) have a percentage of 12.11% and 4.23% respectively followed by residential properties (2.53%) used as centers for Islamic and Quranic learning during the evening hour which are categories as others. It is important to note that those with respondents with primary/ Quranic level of education were interviewed using the questionnaire.

### 4.4.2 Observed Effect Reported By Residents at Distances Away From Masts

Distance from telecommunication mast to resident vis-à-vis cases of observed effects with increasing distance away from the mast were observed. The reported effects experienced by residents for each of the randomly selected locations in each of the LGA are presented as distances increases and at the end of this subsection, all the reported effects cases in the study area were added up for correlation analysis to test the hypothesis. The questionnaire administered is of multiple responses with each questionnaire having a field for each of the suspected effects.

*4.4.2.1 Distance from Masts to Respondents at Fagge*

A total of 30 copies of questionnaire was retrieved for analysis at Fagge LGA (Table 4.8). The Table 4.4 shows the number of respondents experiencing the identified forms of medical and psychological effects suspected to be related to the mast in Fagge LGA at 5m, 10m, 15m and 20m distances away from mast.

Table 4.8: Results on Observed Effects as Reported by Respondents in Fagge LGA

| S/N | Effects | 5m | 10m | 15m | 20m |
|---|---|---|---|---|---|
| | **Health** | | | | |
| 1 | Headache | 8 | 7 | 5 | 4 |
| 2 | Dizziness/Nausea | 7 | 7 | 3 | 3 |
| 3 | Fatigue | 5 | 4 | 2 | 1 |
| 4 | Memory loss | 3 | 3 | 1 | - |
| 5 | Nose bleeding | 3 | 2 | 1 | 1 |
| 6 | Mental uneasiness | 3 | 1 | 1 | - |
| 7 | Cancer (leukaemia) | - | - | 2 | 1 |
| 8 | Sleeping disorder | 7 | 6 | 5 | 4 |
| | **Psychological** | | | | |
| 1 | Noise/vibration | 8 | 6 | 5 | 3 |
| 2 | Pollution | 7 | 6 | 4 | 1 |
| 3 | Accident | 1 | - | - | - |
| 4 | Inability to concentrate | 3 | 2 | 1 | 1 |
| 5 | Fear/shock | 6 | 5 | 3 | 2 |
| | **Total** | 61 | 49 | 33 | 21 |

Source: Field survey (2016)

The major health effects in Fagge LGA are headache, dizziness and fatigue especially from 5-10 metres away from the mast due to continues vibration and noise, which are highly reported at close distance from the mast. The psychological effects among which are noise/vibration and pollution cases are relatively high at 10 metres distance away from the masts. It is only at 15 metres away for both the health and environmental hazards that the reported cases

are low, which implies that as distances increases, the number of cases will reduce. This means that the 7 metres agreed by NCC and NESREA may still need to be reviewed. Also, headache has the highest number of respondents followed by sleeping disorder. The inability to concentrate due to noise and vibration is the least number of respondents suffering from effect. Only one case of accident was reported and it's important to note that the cancer cases are not clinically tested.

*4.4.2.2 Distance from masts to Respondents at Dala LGA*

A total of 61 copies of questionnaire were retrieved for analysis at Dala LGA. Table 4.9 shows the number of respondents experiencing the various forms of medical and environmental effects suspected to be related to the mast in Dala LGA.

Table 4.9: Observed Effects as Reported by Respondents at Dala LGA

| S/N | Effects | 5m | 10m | 15m | 20m |
|---|---|---|---|---|---|
| | **Health** | | | | |
| 1 | Headache | 15 | 12 | 10 | 7 |
| 2 | Dizziness/Nausea | 14 | 12 | 8 | 6 |
| 3 | Fatigue | 14 | 12 | 11 | 7 |
| 4 | Memory loss | 6 | 4 | 3 | 3 |
| 5 | Nose bleeding | 8 | 5 | 3 | - |
| 6 | Mental uneasiness | 4 | 2 | 2 | 5 |
| 7 | Cancer (leukaemia) | - | - | 3 | 2 |
| 8 | Sleeping disorder | 11 | 9 | 5 | 1 |
| | **Psychological** | | | | |
| 1 | Noise/vibration | 14 | 11 | 10 | 8 |
| 2 | Pollution | 13 | 10 | 8 | 2 |
| 3 | Accident | 1 | - | - | - |
| 4 | Inability to concentrate | 14 | 5 | 5 | - |
| 5 | Fear/shock | 13 | 10 | 7 | - |
| | **Total** | **127** | 92 | 75 | 41 |

Source: Field survey (2016)

At Dala LGA, it can be seen from Table 4.5 that the effects are more experienced at 5-10 metres away from the masts, while at 15 metres and above, the reported cases are quite low. Only one case of accident was reported and cases like mental uneasiness, inability to concentrate, fear/shock and cancer are very low compared to the other effects. Noise/vibration, Fatigue and headache have the highest number of respondents and cancer cases (not clinically tested) with the lowest respondents. In general it can be seen that as distances increases the number reported cases decreases and even at distances greater than the set standards cases are still quite high therefore there is need for the set back distance to be reviewed.

*4.4.2.3 Distance from Mast to Respondents at Gwale LGA*

Also at Gwale, 48 questionnaire was retrieved for analysis out of the 58 administered. Table 4.10 shows the number of respondents experiencing various forms of effects suspected to be related to the mast in Gwale LGA.

Among the common effects in Gwale LGA includes headache, dizziness, fatigue, noise, sleeping disorder and pollution at a distance of 5-10 metres away from the masts. This is as a result of continuous noise and vibration which is highly reported at close distance to the mast. Even at 10 metre distance, it is clear that the health and environmental effects reported are high and it is only at 15- 20 metres that the reported cases are quite low.

Table 4.10: Observed Effects as Reported by Respondents in Gwale LGA

| S/N | Effects | 5m | 10m | 15m | 20m |
|---|---|---|---|---|---|
| | **Health** | | | | |
| 1 | Headache | 12 | 10 | 5 | 5 |
| 2 | Dizziness/Nausea | 9 | 9 | 6 | 6 |
| 3 | Fatigue | 10 | 9 | 7 | 2 |
| 4 | Memory loss | 9 | 2 | 1 | 1 |
| 5 | Nose bleeding | 7 | 3 | 3 | 1 |
| 6 | Mental uneasiness | 8 | 6 | 5 | 3 |
| 7 | Cancer (leukaemia) | - | 3 | 2 | 3 |
| 8 | Sleeping disorder | 11 | 11 | 8 | 1 |
| | **Psychological** | | | | |
| 1 | Noise/vibration | 12 | 11 | 5 | - |
| 2 | Pollution | 12 | 10 | 2 | 1 |
| 3 | Accident | - | - | - | - |
| 4 | Inability to concentrate | 10 | 5 | 2 | 2 |
| 5 | Fear/shock | 11 | 9 | 1 | - |
| | **Total** | 111 | 88 | 47 | 25 |

Source: Field survey (2016)

Other cases such as nose bleeding, cancer, shock/fear and inability to concentrate are reported very low even at close distance but decreases drastically as distance increases away from the mast. No cases of accident reported and respondents suffers headache (66%) more than any other hazards even at far distance followed by nausea/dizziness and sleeping disorder.

*4.5.2.4 Distance from Mast to Respondents at Kano Municipal LGA*

Table 4.11 shows the number of respondents experiencing the identified forms of effects suspected to be related to the mast in Kano Municipal LGA. A total of 56 copies of questionnaire were retrieved for analysis of the 61 administered.

Table 4.11: Observed Effects as Reported by Respondents in at Kano Municipal LGA

| S/N | Effects | 5m | 10m | 15m | 20m |
|---|---|---|---|---|---|
| | **Health** | | | | |
| 1 | Headache | 14 | 12 | 8 | 8 |
| 2 | Dizziness/Nausea | 11 | 10 | 9 | 7 |
| 3 | Fatigue | 12 | 10 | 9 | 7 |
| 4 | Memory loss | 4 | 3 | 2 | 2 |
| 5 | Nose bleeding | 6 | 3 | 3 | 3 |
| 6 | Mental uneasiness | 4 | 4 | 2 | 2 |
| 7 | Cancer (leukaemia) | - | 1 | 4 | 4 |
| 8 | Sleeping disorder | 11 | 8 | 6 | 1 |
| | **Psychological** | | | | |
| 1 | Noise/vibration | 15 | 9 | 5 | 1 |
| 2 | Pollution | 9 | 7 | 1 | 1 |
| 3 | Accident | 1 | - | - | - |
| 4 | Inability to concentrate | 10 | 5 | 1 | - |
| 5 | Fear/shock | 11 | 8 | - | - |
| | Total | 108 | 80 | 50 | 36 |

Source: Field survey (2016)

Common hazard cases like headache, dizziness, fatigue, noise/vibration sleeping disorder and pollution are very high especially at 5-10 metres away from the mast due to continuous vibration and noise from the base station and it is only at 15 metres distance away that the reported cases are quite low. Report shows that other like nose bleeding, mental uneasiness, accident and fear/shock are low even at close distance. Headache, dizziness and fatigue are experienced more in Kano municipal compared to other LGA, one case of accident was reported and it can be seen that cancer are more experienced from 10metres and above though not clinically tested.

*4.4.2.5 Distance from mast to Respondents at Tarauni LGA*

The number of respondents experiencing various forms of effect suspected to be related to the mast as distance increases in Tarauni LGA is shown in Table 4.12. A total number of 34 questionnaire were retrieved for analysis out of the 36 administered.

Table 4.12: Observed Effects as Reported by Respondents in Tarauni LGA

| S/N | Effects | 5m | 10m | 15m | 20m |
|---|---|---|---|---|---|
| | **Health** | | | | |
| 1 | Headache | 9 | 8 | 8 | 3 |
| 2 | Dizziness/Nausea | 8 | 8 | 7 | 4 |
| 3 | Fatigue | 9 | 5 | 4 | 1 |
| 4 | Memory loss | 3 | 3 | 2 | - |
| 5 | Nose bleeding | 2 | 3 | 2 | 2 |
| 6 | Mental uneasiness | 5 | 4 | 4 | 2 |
| 7 | Cancer (leukaemia) | - | 1 | 3 | 2 |
| 8 | Sleeping disorder | 8 | 7 | 3 | - |
| | **Psychological** | | | | |
| 1 | Noise/vibration | 9 | 7 | 2 | 2 |
| 3 | Pollution | 9 | 8 | 2 | - |
| 4 | Accident | - | - | - | - |
| 5 | Inability to concentrate | 5 | 3 | 1 | 1 |
| 6 | Fear/shock | 8 | 6 | 1 | 1 |
| | Total | 75 | 65 | 39 | 18 |

Source: Field survey (2016)

It can be seen that among the hazards cases like headache, dizziness, fatigue, noise/vibration and pollution are reported very high especially at 5-10 metres away from the mast. This can be attributed to the continuous noise and vibration from the station which is reportedly high at close distance. Also, the overall total cases of effects at distances away from the mast for both types of effect shows that even a 10 metres distance the effect are still high and it is only at 15 metres and above that reported cases are quite low. No cases of accident were reported with headache having the highest number of respondents.

*4.4.2.6 Distance from Mast to Respondents at Nassarawa LGA*

A total number of 86 questionnaire were administered and 97 retrieved for analysis. The numbers of respondents experiencing various forms of effects suspected to be related to the mast in Nassarawa LGA are shown in Table 4.13.

Table 4.13: Observed Effects as Reported by Respondents in Nassarawa LGA

| S/N | Effects | 5m | 10m | 15m | 20m |
|---|---|---|---|---|---|
| | **Health** | | | | |
| 1 | Headache | 19 | 20 | 11 | 10 |
| 2 | Dizziness/Nausea | 17 | 15 | 12 | 8 |
| 3 | Fatigue | 12 | 11 | 11 | 7 |
| 4 | Memory loss | 11 | 9 | 5 | 3 |
| 5 | Nose bleeding | 8 | 7 | 4 | 2 |
| 6 | Mental uneasiness | 11 | 8 | 6 | 1 |
| 7 | Cancer (leukaemia) | 1 | 5 | 4 | 4 |
| 8 | Sleeping disorder | 16 | 15 | 7 | 1 |
| | **Psychological** | | | | |
| 1 | Noise/vibration | 20 | 12 | 9 | 1 |
| 2 | Pollution | 18 | 9 | 5 | 1 |
| 3 | Accident | 1 | - | - | - |
| 4 | Inability to concentrate | 19 | 10 | 6 | 1 |
| 5 | Fear/shock | 21 | 18 | 5 | 1 |
| | **Total** | 174 | 139 | 85 | 40 |

Source: Field survey (2016)

Even at Nassarawa, the common reported effect cases are the same as other LGAs. Cases of headache, dizziness, fatigue for the health effects and noise/vibration, sleeping disorder and pollution for the environment effects are still high even at 10 metres distance away from the mast but the reported cases quite low at 15 -20 metres. Headache has the highest number of respondents followed by dizziness/nausea and fear/shock, only one case of accident and memory loss has the lowest number of respondents.

*4.4.2.7 Distance from mast to Respondent at Kumbotso LGA*

Table 4.14 shows the number of respondents experiencing the identified various forms of medical and environmental effects suspected to be related to the mast in Kumbotso LGA. A total of 48 questionnaire were administered and 40 retrieved for analysis.

Table 4.14: Observed Effects as Reported by Respondents in Kumbotso LGA

| S/N | Effects | 5m | 10m | 15m | 20m |
|---|---|---|---|---|---|
| | **Health** | | | | |
| 1 | Headache | 11 | 9 | 9 | 5 |
| 2 | Dizziness/Nausea | 10 | 9 | 3 | 1 |
| 3 | Fatigue | 8 | 5 | 3 | 1 |
| 4 | Memory loss | 7 | 6 | 3 | 3 |
| 5 | Nose bleeding | 3 | 3 | 1 | 1 |
| 6 | Mental uneasiness | 3 | 5 | 4 | 4 |
| 7 | Cancer (leukaemia) | - | 2 | 1 | - |
| 8 | Sleeping disorder | 10 | 10 | 6 | 2 |
| | **Psychological** | 11 | 9 | 5 | 1 |
| 1 | Noise/vibration | 9 | 4 | 7 | 1 |
| 2 | Pollution | - | 1 | - | - |
| 3 | Accident | 9 | 4 | 1 | 1 |
| 4 | Inability to concentrate | 11 | 9 | 4 | - |
| 5 | Fear/shock | | | | |
| | **Total** | 92 | 7 | | |

Source: Field survey (2016)

It can be seen that the environmental effects like noise/vibration and fear/shock are reported at close distance of 5-10 metres distance than some of the health effects compare to the other local government earlier discussed. Also, the cases are quite high even at 15metres away and very low at 20 metres. Headache, dizziness, fear/shock and noise/vibration are mostly reported. Only a few cases of cancer (which are not clinically proven) and accident were recorded in Kumbotso.

*4.4.2.8 Scale of Effects Across the Study Area*

The observed effects cases reported by respondents in all the LGAs at each distance away from the mast were summed up as shown in Table 4.15. An overall total of 355 questionnaire were retrieved across the study area out of the 400 administered.

Table 4.15: Overall Total Observed Effects by Respondents in the Metropolis

| S/N | Reported Hazards | 5m | 10m | 15m | 20m |
|---|---|---|---|---|---|
| | **Health** | | | | |
| 1 | Headache | 88 | 78 | 56 | 42 |
| 2 | Dizziness/Nausea | 76 | 70 | 48 | 35 |
| 3 | Fatigue | 70 | 56 | 47 | 26 |
| **4** | Memory loss | 43 | 31 | 17 | 12 |
| 5 | Nose bleeding | 40 | 23 | 17 | 10 |
| 6 | Mental uneasiness | 38 | 30 | 24 | 17 |
| 7 | Cancer (leukaemia) | 1 | 12 | 19 | 14 |
| 8 | Sleeping disorder | 77 | 66 | 40 | 10 |
| | **Psychological** | | | | |
| 1 | Noise/vibration | 89 | 65 | 41 | 16 |
| 2 | Pollution | 77 | 54 | 29 | 7 |
| 3 | Accident | 3 | 1 | - | - |
| 4 | Inability to concentrate | 70 | 34 | 17 | 6 |
| 5 | Fear/shock | 79 | 65 | 21 | 4 |

Source: Field survey (2016)

From Table 4.13, it can be seen that the effect cases are high at 5-10 metres from the masts across the metropolis owing to continuous vibration and noise from the mast. In general, reported cases decreases as the distance increases away from the masts for all the medical/health effects except in the case of cancer claimed respondents which show that cancer cases are more experienced from distances 10 metres away the mast (though not clinically tested). Also, the same trend of decrease in effects as distance increases goes for the environmental related cases and few cases of accident were reported.

The reported cases are found to be more severe in landed properties closer to the mast compared to areas away. This is similar to the findings of Akindele and Adeniji (2008) in Ogbomoso, Oyo state of Nigeria where the severity of suspected health problems is found to be higher in the zone closest to the mast and the problems were observed to decrease outwards. It can be concluded that there is tendency that the closeness to mast is a strong enabling factor for the suspected problems in the area. This similarity can be attributed to the fact that GSM masts are universally produced using similar technology hence the effect may not be spatially different owing to location.

### 4.4.3 Relationship between telecommunication masts and Effect Cases

The data in Table 4.15 were subjected to correlation analysis. The range of relationship using correlation analysis is $-1 \leq r \leq 1$, negative correlation indicate weak relationship and positive correlation indicate strong relationship. The correlation for each of the effect cases were calculated using the distances/zones (5m, 10m, 15m and 20m) to number of respondents that experienced each effect in each zone.

The result presented in Table 4.16 shows that the coefficient of correlation (r) between distances from mast and reported cases of health effect revealed that headache gives an r-value of -0.991, -0.979 for dizziness/nausea, -0.987 for fatigue, -0.999 for nose bleeding, -0.9986 for mental uneasiness followed by cancer with an r-value of 0.782. It implies that there exists a strong negative linear relationship between the distances from the mast to all the health effects except for cancer, which shows a strong positive correlation though the cases are not clinically proven. Also, the coefficient of correlation (r) for the reported case of psychological effects shows that noise/vibration reveals an r-value of -1.000, -0.974 for sleeping disorder, -0.997 for pollution, -

0.964 for inability to concentrate followed by fear/shock with an r-value of -0.97 which implies that there exist a relationship between telecommunication mast and the reported cases.

**Table 4.16: Relationship between Masts and Reported Cases of Effects**

| S/N | Effects reported at various distance from mast | Correlation Value (r) |
|---|---|---|
| | **Health** | |
| 1 | Distances from mast and reported cases of headache | -0.991 |
| 2 | Distances from mast and reported cases of dizziness/nausea | -0.979 |
| 3 | Distances from mast and reported cases of fatigue | -0.987 |
| 4 | Distances from mast and reported cases of memory loss | -0.984 |
| 5 | Distances from mast and reported cases of nose bleeding | -0.999 |
| 6 | Distances from mast and reported cases of mental uneasiness | -0.998 |
| 7 | Distances from mast and reported cases of cancer | 0.782 |
| 8 | Distances from mast and reported cases of sleeping disorder | -0.974 |
| | **Psychological** | |
| 1 | Distances from mast and reported cases of noise/vibration | -1.000 |
| 2 | Distances from mast and reported cases of pollution | -0.997 |
| 3 | Distances from mast and reported case of inability to concentrate | -0.964 |
| 4 | Distances from mast and reported cases of fear/shock | -0.978 |

Source: Author's computation (2016)

The results obtained in the study are compared to other empirical studies carried out by researchers using various statistical approaches. Akindele and Adeniji (2014) used bi-variate correlation analysis (Pearson moment) to show that there exist a significant relationship between distances from mast and to hazards like headache, insomnia, nausea, cancer and ear impairment except in case of respiratory disease. Linear regression was used to test the relationship between residents' health and distance to mast. The medical and physiological effects such as headache,

fatigue, dizziness, stomach pain and eating disorder were found to be statistically significant while the psychological health effect like inability to speak in low tone, emotional instability, irritation that leads to anger are not statistically significant (Odunola *et al*, 2015). Also, similar to the findings is the study reported by Akintowa *et al* (2008) that used chi-square test of statistical significance to show that there is a statistical significant association between level of exposure to telecommunication mast in terms of proximity and the enormity of health hazards. It was also shown that adverse effect decreases with increase in distance and vice versa.

The closeness of mast in residential properties were all taken into consideration in all the findings and due to the fact that all telecommunication mast are produced and installed with the same technological approach, therefore, the relationship and association to reported cases of environmental effects may not be different irrespective of location. Many of the effects will manifest more in the future and therefore, there is need for precautionary measures to be adopted, which deals with the management of scientific risk relating to environmental protection. It should be used to address the potential harm of mast location within built-up areas because the authorities are yet to be equipped with technological capacity to determine the exact harmful effect in time. Also, apart from the regulatory setback there is need for a standard limit to be imposed around the telecommunication mast to serve as a precautionary consideration.

As a conclusion to this chapter, it is important to state a major limitation of the result which is the inability of the researcher to physiologically establish the relationship between reported health hazards and distance from masts. This is obviously owing to the inability to access medical records or collect physical samples from the respondents to ascertain the veracity of their claims. This is a limitation which future research should try to overcome.

# CHAPTER FIVE

# SUMMARY, CONCLUSION AND RECOMMENDATIONS

## 5.1 INTRODUCTION

This chapter presents the summary, conclusions and recommendations of the study. The summary captures the various explanation of the results obtained. The conclusion and recommendations were based on the findings. Recommendations are made for further studies as well.

## 5.2 SUMMARY OF FINDINGS

The study analysed spatial distribution and the different environmental effects experienced due to proximity to telecommunication mast. The positions (coordinate) of masts were plotted on the map of the study area; a database was created containing the attribute of each mast and imported into the map. The regulatory setback distance agreed upon by both NCC and NESREA was used in the study (7m) to examine the fulfillment by the network providers. A total of 82 masts were captured across the metropolis, 46% were in compliance and 54% are not in compliance with the regulatory standards (which 27 were the providers fault and 17 are the residents fault). The distribution pattern of mast was analysed using the nearest neighborhood tool in the ArcGIS software. The nearest neighbor ratio (NNR) of 0.612568 with a Z-score (critical value) of -6.752520 was observed which signifies that the masts are clustered in the metropolis while, the Gestis ord General G shows that the degree of clustering is low. It was also found that there is a strong negative relationship between the reported cases and location of masts except for cancer which shows strong positive correlation though the cancer cases are clinically proven and

that the cases are more severe in areas closer to the mast compared to other areas away from the mast.

## 5.3 CONCLUSION

The preceding chapter shows that about 57.3% of the masts in the metropolis are close to residential properties, which implies that the regulatory setback on distance away from residential properties has been violated. The study found that among those masts that violate the regulation distance, 17 of the masts setback distance were violated by the residents that is to say the setback distance were encroached by the resident. There is a relatively low degree of clustering of mast in the metropolis with a Z-value of -0.675 which implies that there is less than 1% likelihood that the clustering is as a result of random chance.

The effects experienced are found to be more severe in areas closer to the mast and decreases as the distance increases away from the masts. Results also shows that there is an association between location of the telecommunication masts to cases of effect. This further implies that there is a tendency that the closeness to telecommunication mast is a factor for the identified effects in the study area However, a major limitation of this study is the reliance on survey method to get information on reported health effects rather than a medical certification or authentication of medical records of such hazards. This is because the study does not have a paramedical approach.

## 5.4 RECOMMENDATIONS

Bearing in mind the analysis and findings, the following measures should be followed to ensure safety in the environment from the mast. Thus:

i. There is need for awareness and sensitization to the general public by relevant regulatory bodies (NCC and NESREA) through the land owners union or community based associations on the risk involved with residing in close proximity to a telecommunication mast. These programs should be carried out through land owners union or community based association to improve the knowledge of the general public about hazards involved with these practices and to curb future lease of land properties to telecommunication companies without investigating the purpose the land is intended for.

ii. There is need for the minimum regulatory setback distance policy to be reviewed by both the NCC and NESREA since many health/environmental hazards are still reported at 15 metres distance. Also, laws and guidelines should be set for landowners on criteria for leasing out their land to telecommunication companies. This is to ensure adherence or non-violation of the regulatory setback distance.

iii. Service providers should embrace the idea of co-location of telecommunication infrastructures as advised by the regulatory bodies (NCC and NESREA) which reduce operational cost due to duplication of same facilities and to avoid clustering of mast in the environment. This means several telecommunication providers can use same mast which ultimately reduces the number of masts over space.

## 5.5 RECOMMENDATION FOR FURTHER STUDIES

Further research/studies of this nature may in addition to survey design use medical assessment of residents who have reported exposure to some effects. Such collaboration will generate more reliable and valid data on the subjects concerned.

## REFERENCES


Abdel –Rassoul, G., Abou El-Fatech, O., Abou Salem, M., Michael, A., Farahat, F., El-Batanouny, M., Salem, E. (2006): Neurobehavioral Effect Among Inhabitant Around Mobile Phone base Station. *Neurotoxicology*. DOI: 10.1016/j.neuro.2006.7.012

Adang, D., Camp, B. and Vorst, A. (2009): Pulse Exposure Effect on the Memory Related Behaviour of Rats. The 9th European Conference on Wireless Technology, UK.

Adzandeh, E. A., Fabiyi, O. O. and Bello, Y. A. (2014): Statistical Analysis of Urban Growth in Kano Metropolis, Nigeria. *International Journal of Environmental Monitoring and Analysis*. 2(1): 50-56. doi: 10.11648/j.ijema.20140201.16

Ahmad, K. (2003): Kano and its Environment. A Publication of Kano Forum. Kano State Ministry of Information.

Ahmad, M. (2010): *Creating a GIS Application for Local Health Care Planning in Kano Metropolis.* An Unpublished Post Graduate GIS/RS Thesis submitted to Geography Dept, ABU Zaria.

Ajala, I. (2005): *GIS and GSM Network Quality Monitoring: A Nigerian Case Study*. Retrieved fromhttp://ads.directionmag.com on July 15, 2015

Akindele, O.A. and Adeniyi, M. (2014): Location Adequacy of Telecommunication Masts and Residents livability in Osogbo, Nigeria. *International Journal of Research in Applied, Natural and Social science*. 2, (11): 7-16 Retrieved from www.impactjournal.us on 23/7/2015.

Akintowa, A., Busari, A.A., Adewole, O., Olayemi, S.O. (2009): The Hazard of Non-Ionisation Radiation of Telecommunication Mast in Urban Area of Lagos, Nigeria. *Africa Journal of Biomedical Research* 2. 12(1):21-35

Akwule, R. (2009): Global Telecommunication: The Technology Administration and Policies

Alenoghena, D.,Emagbetere, T and Aibinu, J. (2014). Developed a comprehensive city structure data base system (CSDS) for the placement of base stations in Minna, Niger state of Nigeria. *Covenant Journal of Informatics and Communication Technology (*CJICT) Vol. 2, No. 1, June, 2014.

Alfonso, B. (2009): Electromagnetic Pollutions from Phone Mast; Effect on Wildlife. *Journal of Pathophysiology*3(16): 191-199

Andorno, R. (2004): The Precautionary Principle; A New Legal Standard for a Technological Age. *Journal of international Law* 1:11-19

Ayinmode, B. (2010): *Estimation of Radio Frequency Power Density Around GSM Base Station in Western Part of Ibadan, Nigeria.* Msc Thesis, Dept of Physics, University of Ibadan, Nigeria.

Badru, R. A., Alwadood, J.A., Atisan, A. O., Oloko-Oba, M. A., Babalogbon, B. A., Jesuleye, I. A., Alaga, T. A. and Shaba, H. A. (2016): Evaluation of Geo-spatial Proximity of Mobile Communication Base Tranceiver Station to Building in Ile-Ife, Nigeria. International *Journal of Scientific and Technological Research.* Vol5(2). ISSN 2277-8616

Beaglehole, R., Bonita, R. and Kjellstrom (1993): *Basic Epidemiology*. World Health Organisation : Geneva, Switzerland.

Bello, M. O. (2010): Effect of the location of GSM Base Station on Satisfaction of Occupier Rental Value of Proximate Residential Property. *Journal of Computer and Information Science*, 3(4):159-170

Biebuna, J.J., Esekhagbe, E. (2011): Assessment of Radiatio Hazard from Mobile Phone Base Station. *Journal of innovative Research in Engineering and Science*, Global Research Publishing 2(1):1-9

Bond, S., SiYeoul, M., and MacMahon, N. (2003): The impact of Cellular Phone Base Station On Property Value. *Ninth Pacific-Rim Real Estate Society Conference Bristone*, Australia.

Bond, S. and Wang, K. (2005): The Impact of Cell PhoneTowers On House Prices in Residential Neighbourhood. *Appraisal Journal*

Bortkiewicz, A., Zmysony, M., Szyjkowska, A., Gadzicka, E. (2004): Subjective Symptom Reported by People Living in the Vicinity of Cellular Phone Base Station. Med. Pr.55:345-351

Brandt, S. & Maennig, W. (2012). Perceived Externalities Of Cell Phone Base Stations: Housing Prices In Hamburg. Contemporary Economic Discussion. Environment and Planning Unit of University of Hamburg, Germany 44(2), 396–410

Burroughs P.A (1986): *Principle of Geographical Information System*: *Principles and Application*. London. Longman publishers

Chang, k. (2010): *Introduction To Geographic Information System*. NewYork: McGraw Hill.

Cherry, N. (2002): *Propable Health Effects Associated with Mobile Base Station in Comminunities: TheNeed for Health Studies. 8th Edition*. Lincoln University: Canterbury, New Zealand.

Coggen, D. (2006): Health risk for mobile phone stations. *Journal on MRC, Epidemiology Resource Center*, Southamptom SO166YD, Southamptom General Hospital, UK.

COMEST (World Commission on the Ethics of Scientific Knowlegde and Technology) *'The Precautionary Principle (2005)*. Paris, France. Accessed on 3/15/2016 available at unesco.unesco.org/images/0013/001395/e.pdf

Cole, D. (2005): *Precautionary Principle*. (Online) access on 4/15/16

Daily independent Newspaper (2014, December 17): NCC and NESREA Agrees on 7meter Setback for Base Station. Retrieve from http://dailyindependentnig.com on 8/5/2015.

Danraka A.M. (2010).Distribution of Zain base stations in Kano metropolis, Kano state, Nigeria. Unpublished project, geography department Ahmadu Bello University, Zaria

Danyaro, M. (2009).*Kano State: 40 Years of Statehood 49th Anniversary Publication*, kano State Environmental Agency. Ministry of Information Kano state.

Demers, M. M. (1997): *Fundamental of Geographical Information System*. ESRI Press, London. Longmam Publishers.

Diaz-Bordenave, J.E. (1977): *Communication and Rural Development*. UNESCO, Paris

Duggal, S. K. (2004): *Surveying Vol II*. Allahadad University New Delhi. Tata McGraw Hills

Editorial (2012): Dangers of Telecommunication Mast. *The Leadership Newspaper Publications*, Abuja. Accessd on 21st january, 2016.

Eger, H., Hagen, K.U., Lucas, B., Vogel, P., Voit, H. (2004): Influence of the Spatial Proximity of Mobile Phone Base-Station on Cancer Rate. German Article.. *umwelt-Medizin-Gaselli*

Elieen, O. C. (2006): Mobile Phone Mast and Health Concern. Electromagnetic Radiation Research Trust. Retrieved from www.radiationresearch.org/pdf/2006

Ezeh, D. N. (2005): *What to Write and How to Write; A Step-by-Step Guide to Education Research Proposal and Report*. Enugu. Pearls and Gold Publisher, Nigeria

Fernie, K.J. and Reynolds, S.J. (2005): The Effect of Electromagnetic Field from Power Line on Avian Reproductive Biology and physiology: A Review. *J-toxicology Journal*. Environ. Health.B. Critical. Rev.8:127-140

Firstenberg, A. (1997): Microwaving Our Planet; the Enviromental Impact of the Wireless resolution. Cellular Phone Taskforce, Brooklyn, New York

Ford, D. (2005): *The Effect of Microwave Radiation from Telecommunication Mast*. Available at www.tetrawatch.net/paper/ford-tower/pdf

Franz, W.L., Ledner, R. and Walcher, N. (1998): Advances in Built-up Area 3D GIS Data for Telecommunication. *Journal for Society of Photogrammetry and Remote Sensing*2:1-12

Galati, R. S. (2006): *Geographical Information System Demystified*. Artech House Publishers. USA.

Godin, L (2001): *GIS in telecommunication*, ESRI Press, California USA

GSM Association (2012): *Impact of Exclusion zone Policies on Siting Base Station, Australian Case Study Analysis*. (online). Available at www.gsma.com/publicpolicy/wp-content

Hamblin, C., and Wood, R. (2002): Increase Incidence of Cancer and Related Effect near Cell phone Transmitter Station. *International Journal of Cancer Prevention*. 1(2):1-9

Hart, L., Jackson, K.P., and Moka, E.C. (2012): Land Use Planning and Telecommunication facilities Location in PortHarcourt, River State. *Research Journal In Engineering and Applied Science*. Pg 184-189. Emergingresource.org, access on May 22,2015.

Hutter, H.P., Moshammer, H., Wallner, P., and Kundi, M. (2006): Subjective Symptoms, Sleeping problem, and Cognitive Performance in Subject Living near Mobile Base Stations. Occup. Environ. Med. 63 pg. 307-313.

Jones, N. V. (2005): *Telecommunication Management System*. Colorado Readers Limited. USA

Kauppi, M. (2000): *No Place to Hide.* Resolution at International Conference on Cell Tower Siting, Salzburg Austria.

Lerner, E. B., Fairbanks, R. and Shah, M. N. (2005): Identification of out-of-hospital Cardiac Arrest Cluster Using GIS. Academic Emergency Medicine Publications 12(1), pp18-84

Longley, P. A. and Goodchild, M., Maguire, D and Rhind, D. (1999): *GIS, Principle, Techniques, Application and Management.* 2nd Edition. John Wiley publishers

Magras, I. and Xenos, T. (1997): Radiation-Induced Changes in the Prenatal Development of Mice. Bioelctromagnetic (18), pp455-461

Mann, S.S., Cooper, T.G., Allen, S.G., Blackwell R.P. and Lowe, A.J (2000*): Exposure to Radio Wave Near Mobile Stations*. National Radiological Protection Board. Oxford, U.K

McLafferty, S. L (2003): GIS and Health Care. Annual Review of Public Health Conference, New York (24), pp25-42

Michael, A.O., Nnaemeka, B.E., Mathew, T.O. (2013): Locational Effect of GSM Mast on Neighbouring Residential Properties' Rental Value in Akure, Nigeria. *Academic Journal of Interdisciplinary Studies,* MCSEA Publishing, Rome-Italy.2(3):147-155.DOI:10.5901/ajis.2013.v2n3p147.

Miclaus, S., Bechet, P. (2007): Estimated and Measured values of Radiofrequency Radiation Power Density Around Cellular Base Station. *Romanian journal of Physics*. 52:429-440

Mobile Operators Association (2015): 'Base Station and Mast. Available at www.mobile mastinfo.com/. Retrieved on 10/1/17

Mohammed A. H. and Abdurrahman B. I. (2014): the Incorporation of Precautionary Principle in the Planning of Global System for Mobile Communications Mast Location in Built-up Areas: Proposal for Jimeta, Nigeria. *Journal of Earth Science and Engineering*.4 (2). 284-294. David Publishing

Mohammed, H.I. (2011): *Spatial Analysis of MTN Base Station Masts and Its Implication on Health Through The Use of GIS in Kaduna North*. An Unpublished thesis submitted to Geography dept ABU, Zaria.

Moore S. M., Pritsky N.T., and Southwick P.V. (2002): *Telecommunication: A Beginner Guide*, McGraw Hill, USA

Mouly, M.and Pautet, M. B. (1992): GSM, A System for Mobile Communication. *IEE Journal on Personal Communication* 2(5), pg 9-19

Moss, M. (1990): "The New urban Telecommunication Infrastructure'. Originally published in the *Computer/Law Journal*, Vol.6(2), 1985. Retrieve 4/4/16, from www.mitchellmoss.com

Musa, D., 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

National Bureau of Statistics (2016): *Nigeria Telecommunication sector; State of Disaggregated Data*. First Quarter Summary Report. Federal Government of Nigeria.

National Population Commission (2006): Census Figure 2006. Retrieved from www.population.gov.ng. Accessed on 16th August, 2016

Nicola, G. (1996): Staying Online In Italy. GIS Europe 5(3). Telecommunication Magazine Online, Milan.

Nigeria Communication Commission, (NCC, 2009): *Guidelines on Technical Specification for the Installation of Telecommunication Masts and Tower* (online). Accessed on 8th August, 2015. Retrieved from ncc.com.ng

Odunola, O. O., Jelili, M. O., and Asani, M. A. (2015): Telecommunication Mast Location and Its Health Implication for Residents in Ogbomoso, Nigeria. Journal of Civil Environmental Research. Vol7(9). ISSN 2224-5790 (paper)

Ogboru, T. (2015): NESREA and NCC Regulation on Telecommunication Mast; Implementing the Precautionary Principle. *Journal of sustainable developmental law and policy* 5.

Ojo, S.O., Ologe, K.O., and Ezedukur, I. (2013): *Count Down to WASSCE/SSCE, NECO and UTME, Geography*. 2nd Edition, Evans Brokers (Nigeria Publishers) Limited. Ibadan-Nigeria

Olofin, E.A. and Tanko, A.I. (2002): *Aspect of Physical Geography of Kano Region and Related Human Resources.* Handbook for Student Field Trip, Geography department Bayero University Kano.

Oluocha A. H. And Ogbale, A.W. (2007). The Distribution and Analysis of Secondary Schools in Makurdi Metropolis. Final year project, Department of geomatics Engineering, A.B.U. Zaria (unpublished)

Omogunloye, O.G., Qaadri, J.A., Omogunloye, H.B., and Oladiboye, E.O. (2013): Analysis of Mast Management Distribution and Telecommunication Services using Geospatial Technique. *IOSR Journal of Environment Science, Toxicology and Food Technology.* l(3)3: 58-75available atwww.iosrjournal.org

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).

Otubu, A.K. (2012): Mass Mast in Planning And Environment Law Maze: Need to Regulate. Available at SSRN:http://ssm.com accessed on 3/7/2015

Pereira, A., Niggerbrugge, A. and Powel, L. (2007): Potential Generation of Geographical Inequities for Management of a Segment Elevation Myocardial Infarction. *International Journal of Health Geographics 6(43)*

Pearsson, B. R. (1997): *Blood Brain Barrier in Rat Exposed EMF Used in Wireless Communication and Wireless Network*. Hingham MA, USA. Kluwer Academic Publishers,

Petkovic M.S., Djordjevic –Kajan S., Stojanovic D.H., and Stoimenov L.V (2008): *The Role of GIS in Telecommunication Network Maintenance*. Computer Graphics and GIS Laboratory, University of Nis Beogradska, Yugoslavia

Petkovic, M. S. (2002): The *Role of GIS in Telecommunication network maintenance*. California, Longman Publishers

Prashant, P. and Sunil, K.K. (2015): Telecommunication Utility Analysis Using GIS and GPS Techniques. *Journal of Indian Society of Geomatics 9(2)*

Prince, O. and Laide, A. (2012, April 12): NCC and NESREA Fight Over MTN Mast Base Station. *The Vanguard Newspaper*, pg 10. Retrieved from http://vanguardngr.comon 8/5/2015

Rajeshkumar, J. and Shashikant, P. (2014): design and Development of GIS/GPS Utility Management System for DOS Housing Colony, Ahmadadad. *Journal of Engineering Research and Applications.*4(9):56-73

Rappaport, T. S. and Prentical-Hall, N. J. (1996): *Wireless Communication: principle and Practice*. Chichester. John Wiley and Son Publishers

Rogers, S. and Vivas, P. (2014): *A study on the Use of GIS for Creation of Addressing System.* Berne. Universal Postal Union Publications, Germany

Santini, R., Santini P., Danze, J.M., LeRuz, P., Siegne, M. (2002): Study of the Health of People Living in the Vicinity of Mobile Phone base Station: I. Influences of distance and sex. Pathol. Biol. 50:369-373

Schuuman, N., Bell, N. and L'Henreux, R. (2009): Modelling Optimal Location For Pre-hospital Helicopter Emergency Medical services. BMC Emergency Medicine. *Journal of Trauma infection and Critical Care 65(1)*

Shalangwa, D. A. (2010): Measurement of Exposure To Radiofrequency Field Radiation From GSM Masts. *Journal of electrical and electronics engineering*. Vol 2(3) pp75-84. Available online at www.academicjournal.org/jeer ISSN 2367

Shu, Z.,Hong, L. and Guodong, L. (2011*): Application of GIS in Telecommunication Information Resource Management System*.International Conference on Information Management, Innovation and Industrial Engineering. IEEE Computer Society. Pp401-404

Steiniger, S.and Weibel, R. (2009): GIS Software, A Description in 100 Words. *Encyclopedia of Geography.* Online

Surendra, K. Y. (2013): GIS in Power Sector. *International Journal of Engineering Research and Technology*6:759-766. International Research Publication House. Available at www.irphouse.com. Retrieved on 3/8/16.

Twigg, L. (1990): Health-based GIS and the Potential in the Light of Existing Data. *Social science Medical Journal,* 30(1):143-155. Available at Researchgate.net accessed on 10/13/16

Ubabudu, M. C. (2013): The Effectiveness Of Global System Mobile Providers Servives On Communication In Nigeria. *International Journal Of Business And Public Administration*. Vol 10(2) Pg58-79

United Nation (1992): Rio Declaration on Environment and Development. (online). http://www.ujus.uio.no//environmental.development.rio.declaration access on 14/3/16

Vijay, S., Kumar, H., and Chandra A. (2001): *Role of Geographical Information Systems in Distribution Management*. Available at www.gisdevelopment.net/application/urban/overview accessed on 3/5/2015

Wale, A., Hakeem, B., and Oluwafemi, O. (2011): Locational Analysis of Telecommunication Infrastructure in Residential Neighbourhoods of Lagos Metropolis. *Preceedings Real Corp, Tangungsband.* Available at http://www.corp.at accessed on 2/8/2015.

Wager, P.A., Eugster, A., Hilty, L.M., Som, C. (2005): Smart Label in Municipal Solid Waste-A Case for Precautionary Principle. *Journal of Environmental Impact Assessing*. Review25: 569-586.

Warden, C. R., Daya, M. and LeGrady, L. A. (2007): Using GIS to Evaluate Cardiac Arrest Survival. Prehospital Emergency Care Publication, 11(1). pp19-24

Wolf, R., Wolf, D. (2004): Increase Incidence of Cancer near Cellphone Transmitter Station. *International journal on cancer Prevention* 1:123-128

World Health Organisation (2000): Electromagnetic Field and Public Health; Mobile Telephone and Their Base Station. Retrieve on 8th August 2015 from www.who.int/mediacentre/factsheets/

Zain (2015): Information, Tools, Product and Services for Zain Telecommunication Network. Available at www.zain.com accessed on 10/1/17

# APPENDICES

## APPENDIX 1

## DEPARTMENT OF GEOGRAPHY

## AHMADU BELLO UNIVERSITY, ZARIA

Dear Respondent,

This questionnaire is designed as part of M.Sc. research on Spatial Distribution of Telecommunication Mast and Their environmental effects in Kano Metropolis. This work is purely academic and so any information given will be used for such purpose and confidential.

SECTION A: SOCIO-ECONOMIC CHARACTERISTIC OF RESPONDENT

1. Location: a. LGA……b. Street Name…….……c. Distance from mast…….
2. Age: a.≤ 20 ( ) b. 21-30 ( ) c. 31-40 ( ) d. 41-50 ( ) e. ≥51
3. Gender:
   A. male b. Female ( )
4. Marital status:
   a.Single ( ) b. married ( ) c. divorced ( ) d.widowed ( )
5. Educational qualification:
   a.Primary ( ) b. secondary ( ) c. tertiary ( ) d. others ( )
6. Occupation:
   a. Civil/public servant ( ) b. farmer ( ) c. student ( ) d.selfemployed e. others ( )
7. Duration of stay in the area:
   a. ≤5years b. ≤10years c. ≤ 20years d. since birth
8. Place of exposure to the mast: a. house ( ) b. school ( ) c. work place ( ) d. others, specify ……
9. Are you aware of the hazards experience staying close to telecommunication mast?
   (a) YES (b) NO

SECTION B: INFORMATION ON HAZARD PROBLEMS

The following are some series of hazard that might be experienced by staying close to telecommunication mast. Please tick as appropriate if experiencing or you have experienced or any member of your family have been diagnose or experiencing any of the hazards.

| | **ENVIRONMENTAL EFFECTS** | **Yes** | **No** |
|---|---|---|---|
| **S/N** | **Health** | | |
| 1 | Headache | | |
| 2 | Dizziness/Nausea | | |
| 3 | Fatigue | | |
| 4 | Memory loss | | |
| 5 | Nose bleeding | | |
| 6 | Mental uneasiness | | |
| 7 | Cancer (leukaemia) | | |
| 8 | Sleeping Disorder | | |
| | **Psychological** | | |
| 1 | Noise/vibration | | |
| 2 | Pollution (Fumes) | | |
| 3 | Causes accident | | |
| 4 | Inability to concentrate | | |
| 5 | Fear/Shock | | |

SECTION D: PREVENTION AND MANAGEMENT OF HAZARD ISSUE

1. What have you spent on managing the effect due to proximity to telecommunication masts?

   .....

2. What steps have to you taken to control or seek redress from appropriate quarters and authority.

   .....

   .....

APPENDIX II

**SAMPLES DATABASE**

| MASTS I.D | SITE LOCATION | SETBACK DIST(m) | X | Y |
|---|---|---|---|---|
| MAST 1 | Dakata Area | 2.4 | 453603 | 1328956 |
| MAST 2 | Roman/New road | 8.3 | 450569 | 1329459 |
| MAST 3 | Tudun wada brigade | 5.2 | 451825 | 1330046 |
| MAST 4 | AlongTudun MurtalaWay | 9.7 | 452769 | 1329459 |
| MAST 5 | Zanguru Airport road | 12 | 426596 | 1329811 |
| MAST 6 | Dakata Area | 10.3 | 452636 | 1328632 |
| MAST 7 | Zanguru Airport road | 3.4 | 425766 | 1342305 |
| MAST 8 | Zanguru Airport road | 16 | 425103 | 1342307 |
| MAST 9 | Sabongari Area | 5.5 | 449882 | 1329289 |
| MAST 10 | Sabongari Close Rumfa College | 3.3 | 449311 | 1329038 |
| MAST 11 | Sabongari Area bello road | 5.5 | 449356 | 1329736 |
| MAST 12 | Abuja Rd Sabongari | 22 | 448775 | 1328186 |
| MAST 13 | Sabongari Niger street | 7 | 449441 | 1328271 |
| MAST 14 | sabongari sanusi street | 3.8 | 449020 | 1328322 |
| MAST 15 | No mans land | 14 | 449046 | 1328322 |
| MAST 16 | Sharada Phase 1 | 11 | 447449 | 1323219 |
| MAST 17 | Sharada industrial road | 3.5 | 447164 | 1322301 |
| MAST 18 | sharada area | 3.5 | 446497 | 1322770 |
| MAST 19 | Sharada Phase 1 | 2.85 | 447715 | 1323772 |
| MAST 20 | Daurayi Panshekara Rd | 10.1 | 443774 | 1322725 |
| MAST 21 | Daurayi | 3.75 | 443880 | 1323405 |
| MAST 22 | Daurayi | 9.3 | 444148 | 1322899 |
| MAST 23 | Daurayi babba | 3.13 | 442556 | 1323537 |
| MAST 24 | Daurayi babba | 2.9 | 441775 | 1323537 |
| MAST 25 | Daurayi babba | 4.75 | 442337 | 1322326 |
| MAST 26 | Daurayi babba | 9.8 | 440898 | 1321528 |
| MAST 27 | Sharada housing Estate | 21 | 444126 | 1320480 |
| MAST 28 | Emir palaceKofar Nassarawa | 10.1 | 447964 | 1325573 |
| MAST 29 | Rimi marketKofar nassarawa | 6.3 | 447965 | 1325901 |
| MAST 30 | Emir palaceKofar Nassarawa | 5.5 | 448805 | 1325608 |
| MAST 31 | Emir palaceKofar Nassarawa | 11.1 | 448801 | 1325602 |
| MAST 32 | Emir palaceKofar Nassarawa | 12 | 448804 | 1325607 |
| MAST 33 | Rimi market road | 4.4 | 448604 | 1325850 |
| MAST 34 | sani mai nagee Gwale | 6.2 | 446046 | 1325235 |
| MAST 35 | Yan alewa Road Gwale | 6.3 | 446360 | 1325123 |
| MAST 36 | Murtal mhd way | 6.4 | 448027 | 1328448 |
| MAST 37 | Aminu Kano Way | 11.2 | 445026 | 1326065 |
| MAST 38 | Yargaya Street | 14.2 | 445274 | 1324689 |
| MAST 39 | SaniBuhari street Gwale | 6 | 445543 | 1326009 |

| | | | | |
|---|---|---|---|---|
| MAST 40 | Jakaragorondutse road | 6 | 444336 | 1326515 |
| MAST 41 | REDCROSS | 13 | 450327 | 1326642 |
| MAST 42 | Adamu Marshal road | 13.2 | 453690 | 1323303 |
| MAST 43 | Ungwan Hotoro Avenue | 6.2 | 453522 | 1324262 |
| MAST 44 | Lautai road by wudil road | 4.4 | 451975 | 1324493 |
| MAST 45 | Batawa Hadejia Road | 5.5 | 453043 | 1327209 |
| MAST 46 | Yankaba Hadejia Road | 6.5 | 454582 | 1327465 |
| MAST 47 | Danbazau off JakaraRoad | 8.6 | 446624 | 1326833 |
| MAST 48 | Bank of the North Zaria road | 25 | 447930 | 1326307 |
| MAST 49 | Sharif Plaza off Zaria Road | 9 | 449648 | 1324480 |
| MAST 50 | Gidan danasabe Zoo Road | 4.4 | 449140 | 1323501 |
| MAST 51 | Hausawa Ribadu Road | 10 | 449192 | 1323195 |
| MAST 52 | Hausawa Tudun Fulani | 8.4 | 448916 | 1322675 |
| MAST 53 | Hausawa Tudun Fulani | 5.5 | 448824 | 1322775 |
| MAST 54 | Sheka Arewa | 6.6 | 449251 | 1322420 |
| MAST 55 | Sheka Behind LEA School | 9.2 | 449491 | 1321278 |
| MAST 56 | Shagari Quarters | 5.3 | 448136 | 1321613 |
| MAST 57 | Shagari Quarters | 5.5 | 448288 | 1321752 |
| MAST 58 | Ungwan Goje Shagari Qtrs | 4.4 | 448001 | 1321228 |
| MAST 59 | Shagari Quarters | 4.3 | 447886 | 1321762 |
| MAST 60 | Zoological Garden, Kano | 3.9 | 448572 | 1322714 |
| MAST 61 | Bhd Mortgage Bank Zoo road | 6.6 | 449690 | 1324563 |
| MAST 62 | Karkasara | 4.1 | 450687 | 1322030 |
| MAST 63 | Darmanawa | 23 | 450667 | 1320853 |
| MAST 64 | Darmanawa | 16 | 451011 | 1320945 |
| MAST 65 | naibawa Motor Park | 4.8 | 452741 | 1321124 |
| MAST 66 | Along Zaria road | 15 | 451281 | 1318719 |
| MAST 67 | Conoil Naibawa, Zaria road | 7.5 | 450698 | 1322098 |
| MAST 68 | Naibawa zaria road | 11 | 452542 | 1320068 |
| MAST 69 | Unguwa Uku | 14 | 453202 | 1321185 |
| MAST 70 | Conoil Gyadi-Gyadi, Zaria road | 6.5 | 451549 | 1319038 |
| MAST 71 | Behind Tasha Naibawa | 6.4 | 451428 | 1319475 |
| MAST 72 | Faruk Street Unguwa Uku | 3.4 | 454140 | 1323690 |
| MAST 73 | Unguwa Uku Layout | 9.8 | 451713 | 1320783 |
| MAST 74 | Limawa Unguwa Uku | 4.8 | 453469 | 1322874 |
| MAST 75 | Layin Kuka Unguwa Uku | 7.8 | 453195 | 1322064 |
| MAST 76 | Layin AdoganoYanlemo | 6.81 | 451180 | 1318569 |
| MAST 77 | Kabuga Janbulo 1ST Gate | 2.28 | 442551 | 1324173 |
| MAST 78 | Kabuga Dukawiya | 5.6 | 435078 | 1322739 |
| MAST 79 | Maikalwa off Zaria Road | 3.6 | 450815 | 1318461 |
| MAST 80 | Maikalwa Layout | 6.4 | 450483 | 1318791 |
| MAST 81 | Along Ungogo road | 15 | 450244 | 1334012 |
| MAST 82 | Jatau offpanisau ungogo | 25 | 449884 | 1334900 |

# APPENDIX III

## Complaint Masts

| S/N | MAST_ID | SITE /LOCATION | SETBACK DIST. |
|---|---|---|---|
| 1 | Mast 2 | Roman/New road | 8.3 |
| 2 | Mast 4 | Along Tudun Murtala | 9.7 |
| 3 | Mast 5 | Zanguru Airpt road | 12.0 |
| 4 | Mast 6 | Dakata Area | 10.2 |
| 5 | Mast 8 | Airport road | 16.0 |
| 6 | Mast 9 | Sabongari | 7.5 |
| 7 | Mast 12 | Abuja Rd Sabongari | 22.0 |
| 8 | Mast 13 | Niger street | 7.0 |
| 9 | Mast 15 | No man's land | 14.0 |
| 10 | Mast 16 | Sharada phase 1 | 11.0 |
| 11 | Mast 18 | Sharada area | 7.5 |
| 12 | Mast 20 | Panshekara road | 10.1 |
| 13 | Mast 22 | Daurayi | 9.3 |
| 14 | Mast 26 | Daurayi Babba | 9.8 |
| 15 | Mast 27 | Sharada housing | 21.0 |
| 16 | Mast 28 | Emir palace K/N | 10.1 |
| 17 | Mast 31 | Kofar Nassarawa | 11.1 |
| 18 | Mast 32 | Kofar Nassarawa | 12.0 |
| 19 | Mast 37 | Aminu Kano way | 11.2 |
| 20 | Mast 38 | Yargaya street | 14.2 |
| 21 | Mast 41 | REDCROSS | 13.0 |
| 22 | Mast 42 | Adamu Marshal close | 13.2 |
| 23 | Mast 47 | Danbazau off Jakara | 8.6 |
| 24 | Mast 48 | Bank of North Zaria Rd | 25.0 |
| 25 | Mast 49 | Sharif plaza | 9.0 |
| 26 | Mast 51 | Hausawa Ribadu rd | 10.0 |
| 27 | Mast 52 | Hausawa Tudunfulani | 8.4 |
| 28 | Mast 55 | Sheka behind LEA sch | 9.2 |
| 29 | Mast 63 | Darmanawa | 23.0 |
| 30 | Mast 64 | Darmanawa | 16.0 |
| 31 | Mast 66 | Along Zaria road | 15.0 |
| 32 | Mast 67 | Conoil Gyadigyadi | 7.5 |
| 33 | Mast 68 | Naibawa Zaria road | 11.0 |
| 34 | Mast 69 | Unguwa uku | 14.0 |
| 35 | Mast 73 | Unguwa uku layout | 9.8 |
| 36 | Mast 75 | Layin kuka Unguwa uku | 7.8 |
| 37 | Mast 81 | Along Ungogo road | 15.0 |
| 38 | Mast 82 | Jatau road Panisau | 25.0 |
| | **Total** | **38** | |