SPATIAL ANALYSIS OF PHYSICAL ACCESSIBILITY TO HEALTH CARE FACILITIES IN FUNTUA LOCAL GOVERNMENT AREA OF KATSINA STATE, NIGERIA

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JULY, 2017

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P13SCGS8203

A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES AHMADU BELLO UNIVERSITY, ZARIA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OFMASTER OF SCIENCE DEGREE IN REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

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DECLARATION

I declare that this dissertation entitled **"Spatial Analysis of Accessibility to Health Care Facilities in Funtua Local Government Area of Katsina State, Nigeria**" has been performed by me in the Department of Geography and Environmental Management,Faculty of Physical Sciences, Ahmadu Bello University, Zaria, under the supervision of Dr. J. O. Adefila and Dr. A. K. Usman.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 other Institution.

Aminat Yemi OYEWOLE _____ _____
Signature Date

CERTIFICATION

This dissertation entitled **"Spatial Analysis of Accessibility to Health Care Facilities in Funtua Local Government Area of Katsina State, Nigeria"** by Aminat Yemi OYEWOLE meets the regulations governing the award of Master of Science degree inRemote Sensing and Geographic Information System of the Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

Dr. J.O. Adefila Chairman, Supervisory Committee	_____ (Signature)	_____ Date
Dr. A.K. Usman Member, Supervisory Committee	_____ (Signature)	_____ Date
Dr. A.K. Usman Head of Department, Geography	_____ (Signature)	_____ Date
Prof. A.Z. Abubakar Dean, School of Postgraduate Studies	_____ (Signature)	_____ Date

DEDICATION

This dissertation is dedicated to my beloved mother and my loving children namely, Kazeem Akintayo Akintola, Maryam Omowumi Oyewole and Sarat Motunrayo Oyewole.

ACKNOWLEDGEMENTS

My profound gratitude and appreciation goes to Dr. J. O. Adefila, the Chairman supervisory committee for his encouragement and immense contribution to the success of this work. I am also grateful to Dr. A.K. Usman, member supervisory committee and Head of Geography Department, A.B.U. Zaria for his tireless contributions to the completion of this work.

My special appreciation goes to all staff of Geography Department, A.B.U. Zaria especially Dr. Y.Y. Obadaki, Dr. R.O.Yusuf,Prof. E.O. Iguisi and Dr. B. Akpu for their encouragement and pieces of advice. I want to specially acknowledge my course mate for their constructive criticisms during the seminar presentation most especially Adebayo Olatubosun and Daniel Okere. I sincerely appreciate Yusuf Suleiman, Abdulfattah Bello and Corper David Okorochukwu for their assistance in the field work. My thanks also go to the staff of PHC at Head office Funtua, most especially Mallam Ibrahim Danjuma Karama and Mallam Yasha'u Nuhu for giving me relevant and current information on Health Care facilities in Funtua LGA.

Special thanks to my mother, children and all my friends in NASFAT Zaria, no words can express how deeply grateful I am for your prayers, love and support. Finally, all adorations, praises, glory and gratitude belongs to Almighty Allah (SWT) who spares my life to attain this height. ALHAMDULILLAH

ABSTRACT

Accessibility to healthcare facilities has been identified as a major indicator of development. The importance of adequate healthcare facilities in providing sustainable rural development can therefore not be over-emphasized. The study analyzed the spatial accessibility to healthcare facilities in Funtua Local Government Area of Katsina State. Record on the number of healthcare facilities (HCFs) from the Ministry of Health was obtained. Global Positioning System (GPS) receiver was used to obtain geographic coordinates of the HCFs. Nearest neighbour analysis (NNA) technique was used to determine the spatial pattern of the physical healthcare facilities, Origin-Destination (O-D) cost matrix analytical tool in ArcGIS 10.3 was used to determine the distance and travel time from designated settlement (ward) to the various physical healthcare facilities. Out of the 59 physical healthcare facilities distributed in the study area, 89.8% were owned by the government while the remaining 10.2% were privately owned. The distribution showed that Dukke ward had the highest percentage (25%) of HCFs. The Primary Health Care (PHC) facilities constituted 88.1% while the remaining were Secondary Health Care (SHC) facilities. The result further indicated that the minimum distance from the communities to the nearest facility was 0.64 km while the maximum distance was 34.80 km with Dandutse ward having the highest access to the nearest healthcare facility with a minimum distance of 0.64Km andMaska ward the least access. TheNNA showed critical value of (-0.142957) at 0.88 significance level indicating the distribution pattern of HCFs in Funtua LGA to be random. The study concluded that the wards in the study area have physical access to HCFs but the service delivery leaves much to be desired given the deficiency of facilities and medical personnels. The study therefore recommends that medical personnels should be employed and posted to HCFs, rehabilitation of the HCF buildings and the medical facilities in the study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

A health care facility is defined as all units ownedby public and private authorities as well as voluntary organizations and whichprovides health care services,hospitals, and health and maternity centers. Consequently, Onokerhoroye (1999) defined health care facility as all units owned by public and private authorities as well as voluntary organizations and which provides health care services including hospitals, health and maternity centres.

Healthy population and access to healthcare services are significant factors influencing economic development and prosperity. Thus, accessibility to healthcare facilities has generally been identified as a major indicator of development, and the existing spatial pattern of distribution of healthcare facilities play very prominent role in gauging the level of efficiency or otherwise of the existing level of provision of these facilities within any region (Sanni, 2010).Accessibility to Health Care is a multi-dimensional concept and can be defined as the ability of a population to access healthcare services. It varies across space because neither health professionals nor residents are uniformly distributed (Lou and Wang 2003).Accessibility is also defined by Paecz, (2004) as the potential for interaction between locations in space.Since geographic access is an essential feature of an overall health system, it is important for health service stakeholders to develop accurate measures of physical access to health(McLafferty, 2003).

The geographic inventory of healthcare comprises the analysis of spatial organization (number, sizes, types, and locations) of health services, how and why spatial features changes over time and how people gain access to health services (Fortney, Rost,

Zhang and Warren, 1999). Khan (1992) identified five varied dimensions of access which were classified into spatial components namely; accessibility, availability, affordability, accommodation and acceptability. Thus, access to healthcare can be grouped into potential and realized delivery of services based on whether actual utilization data of the services is incorporated (realized) or based solely on the characteristics of the services offered (potential) (Delamater, Messina, Shortridge and Grady, 2012). In whatever area, the motive behind accessibility studies is geared towards good assessment and evaluation thereby accelerating opportunities for fruitful decision-making and planning, helping policy makers to arrive at a rationaldecision to ensure equitable distribution of resources and effective service delivery.

Access describes people's ability to use health services when and where they are needed. Healthcare decisions are strongly influenced by the type and quality of services available in the local area and the distance, time, cost, and ease of traveling to reach those services (Haynes, Bentham, Lovett and Gale, 1999). For medical conditions that require regular contact with service providers, travel time and distance can create barriers to effective service use (Fortney *et al.*, 1999). GIS is being used to create better measures of geographical access and to analyze geographical inequalities in access as well as those patterned along social and economic lines.

Some concepts that have frequently been used to measure health services remain extremely relevant and are part of the key characteristics. For example, terms such as access, availability, utilization and coverage have often been used interchangeably to reveal whether people are receiving the services they need (Bamford, *et al.*, 1999).Access is a broad term with varied dimensions: the comprehensive measurement of access requires a systematic assessment of the physical, economic, and socio-psychological aspects of people's ability to make use of health services.Availabilityis an aspect of

comprehensivenessand refers to the physical presence or delivery of services that meet a minimum standard. Utilizationis often defined as the quantity of healthcare services used. Coverageof intervention is defined as the proportion of people who receive a specific intervention or service among those who need it. Access to medical services is one of the basic necessities of any human community. It is a major complement to a strong, dynamic and progressive society.

Thus, the provision of health services should therefore be a shared responsibility between the private and public sectors. The main goal of health service delivery is to provide equitable utilization and access to healthcare services. An important factor in obtaining quality care is physical access to healthcare as lack of spatial access can result in delayed treatment and poor health outcome. Fundamental to addressing the issues of equity and equitable access to healthcare is the issue of geographical distribution (Oliver and Mossialos, 2004). Adequate, equitable and easy access to healthcare facilities by local communities in specified geographical areas is an important issue of human service provision to the individuals living in that area. It is also a challenging issue for both public policy makers and urban planners (Geertman and Van Eck 1995; Hewko 2001; Wang and Lou 2005; Burns and Inglis 2007).

It is essential to ensure that the population, healthcare facilities and transportation infrastructure are spatially located where accessibility frictions are lessto ensure equal and easy access. There are many different conceptualizations of accessibility to healthcare facilities, and many different measures of accessibility have been proposed and used in literature (Talen andAnselin 1998; and Hewko 2001). Facilitating access is concerned with helping people to command appropriate healthcare resources in order to preserve or improve their health. If services are available and there is an adequate supply of services, then the opportunity to obtain healthcare exists, and a population may 'have access' to

services. The extent to which a population gains access also depends on financial, organizational and social or cultural barriers that limit the utilization of services. Thus, access measured in terms of utilization is dependent on the affordability, physical accessibility and acceptability of services and not merely adequacy of supply. Services available must be relevant and effective if the population is to 'gain access to satisfactory health outcomes'. The availability of services, and barriers to access, have to be considered in the context of the differing perspectives, health needs and material and cultural settings of diverse groups in society. Equity of access may be measured in terms of the availability, utilization or outcomes of services. Both horizontal and vertical dimensions of equity require consideration.

In Nigeria, healthcare provision is a concurrent responsibility of the three tiers of government in the country. However, because Nigeria operates a mixed economy, private healthcare providers also have a visible role to play in healthcare delivery. The federal government's role is mostly limited to coordinating the affairs of the University Teaching Hospitals and Federal Medical Centers while the State government manages the various general hospitals and the local government focuses on dispensaries (Primary Health Care) which are regulated by the federal government through the National Primary Health Care Development Authority (NPHCDA). Varying spatial distribution of the population, healthcare facilities and transportation infrastructure in an area often lead to spatial variations in accessibility to healthcare facilities, which in turn would result in disadvantaged location and communities having poor spatial accessibility to needed healthcare facilities (Ahmad, 2012).

Due to the rapid growth in population in Funtua local government area in the recent years, the demand for health care services has tremendously increased with accessibility difficulty due to bad roads leading to some of the health care centres.

Previous studies of this type have faced a number of problems due to paucity nature of data. However, with the introduction of Geographic Information Systems (GIS) and Remote Sensing techniques, data is now available for effective study particularly on accessibility and distribution pattern in any geographic location.Currently, the increasing availability of Geographical Information Systems (GIS) in health organizations, together with the proliferation of spatially disaggregate data, has led to a number of studies that have been concerned with developing measures of access to healthcare services (Higgs, 2009). Moreover, with the advancement of GIS and sophisticated computer technology, decision and policy making in facility site selection can be enhanced into a larger dataset with more complicated data structures, more accurate spatial measurement, spatial analysis and spatial modeling. GIS capability to represent spatial objects as points, lines, or polygons has increased the flexibility of entity representations in facility location modeling (Indriasari, *et al*. 2010). Thus, geographically based healthcare research commonly utilizes methodologies and measurements attainable using GIS which include networkmodel (vector representation) and raster model (raster representation). These methods are used to measure distances and travel time between the locations of health facilities and people (Jones, Ashby, and Naidoo 2010; Delamater, *et al.,* 2012).

Problems with accessibility to healthcare include evaluation of the adequacy of the numbers of healthcare facilities and the proper distribution of these facilities to ensure easy and immediateaccess to a health facility for every patient who needs one, the affordability, and therefore the accessibility of quality healthcare to all patients, etc (Nwangwu, 2013).

1.2 STATEMENT OF THE RESEARCH PROBLEM

The rural populace in Nigeria has very low access to health facilities when compared with their urban counterparts, yet they constitute about 51.4% of the population (Central Intelligence Agency {CIA}, 2015). Many people in Nigeria encounter a range of service delivery and health problems when they try to access healthcare. Such problem ranges from drugs stock-out to poor infection prevention practices to shortage of health staff and this can lead to unnecessary suffering by patients or in the worst cases, death. Some communities usually lack the means of confronting these challenges, leading to poor accessibility to healthcare services (Health Partners International, 2014).

In the year 1987, the federal government of Nigeria launched the Primary Health Care(PHC) system as the bedrock of the health policy, with optimism that the system will reduce substantially the morbidity and mortality afflicted in our population by frequent outbreaks of preventable diseases. Several strategies were put in place to achieve this laudable dream, they include: health education and health promotion programmes, provision of infrastructure to healthcare centers; provision of adequate staff through training and recruitment, implement the rollback malaria through the promotion and use of insecticide treated nets (ITNs) especially to children and pregnant women; improved nutritional status of children and increase the rate of immunization coverage; raise awareness on HIV/AIDS pandemic and tuberculosis control programme and reduction of the present rate of infant and maternal mortality through the management of childhood illness and reproductive health programme. Tragically, two decades since the introduction of the PHC, the provision of the PHC centres have not been without accessibility difficulties (Laah and Mamman, 2002).

Funtua Local Government Area has experienced a rapid population growth with a population figure of 304,343 when it was together with Dandume LGA in 1999 and now

for Funtua LGA only 303,149 in 2006 (National Population Commission, 2006). Considering the landmass of Funtua LGA \which is (448Km square) static and a dynamic population with an ever increasing demand for health care services; one would wonder how health care facilities are spatially distributed across space to meet the demand of growing population and their physical accessibility to these facilities. In addition, the density of the road network is an important factor in accessibility to health care facilities (Law, 2007). It would be of interest to investigate the spatial distribution of health care facilities along with its physical accessibility through the application of Geographic Information System technique in the management of urban and rural health infrastructure in achieving sustainable development in Funtua LGA. Studies have shown that with increase in population and rapid urbanization health facilities are increasingly becoming inadequate with difficulty in accessibility.

In Katsina State, like in every other State in Nigeria, the general hospitals which are avenues for healthcare delivery are located very far away in the LGA headquarters. Consequently, the primary healthcares (PHC) that are available for the inhabitants are disgusting, ill-equipped and under-staffed. The primary healthcare services in Funtua LGA are under severe economic constraints and insufficient manpower resources to meet the healthcare needs of the inhabitants. It is interesting to note that most communities in Funtua LGA live in scattered farmsteads, hamlets and village settlements. Most of these communities are cut-off from the basic service centers by lack of good roads or transport facilities especially in the rainy season.(Hewko, 2001).

Musa and Abdulhamed (2012) also explained how accessibility problems affect the level of utilization of the healthcare facilities in Jigawa state, Nigeria. Findings revealed that the health care facilities are unevenly distributed and the reason includes political policy and the desire to locate the facilities in urban areas. Reasons like cost of

transportation and low income level. Distance user fees, cost and non-availability of drugs were considered as factors of poor accessibility and utilization. So construction of more roads and improvement in the location and distribution of new health facilities in the state were the recommendations.

Kibon and Ahmed (2013) created a database that analyzes the type and pattern of primary healthcare facilities in Kano Metropolis, Kano state, Nigeria. The result showed that the distribution of PHC Facilities is uneven; the western part is not well served. Most of the facilities were clustered, meaning that some areas were underserved. Consequently, it was recommended that the current situation should be examined with a view of addressing the inequity in the distribution of PHC facilities and manpower. Abbas (2009) examinedaccessibility and utilization of health care facilities in Kaduna State, focusing on Kachia Local Government Area of Kaduna State. The researcher used the universally accepted standards set by WHO to determine the level of compliance or departure in terms of provision of health care facilities in the area. The Spearman's rank correlation co-efficient was used to analyze hospital patients-origin survey. The result showed that the number of patients visiting the two state hospitals in the local government area decrease inversely as the square of the distance travelled away from them, thus confirming the effect of location on accessibility and utilization of health facilities in the area. The result for the research confirmed that a good number of people in the study area find it difficult to access healthcare facilities, as the ones provided fall far too short of the standards recommended by WHO.

Onamade (2014) examined access and utilization of antenatal care services among womenin Funtua Local Government Area of Katsina State. The researcher obtained data throughthe administration of semi-structured questionnaire. The study revealed that 86 percent of the respondents had knowledge of antenatal facilities existing in tertiary health

care centers. The distance of antenatal facility revealed that 29 % of respondents were less than 2km away from their destination. According to the author's analysis, the demand for antenatal care from modern health care providers appears,significantly determined by economic factors such as the householdliving standard, the costs for the antenatal care and in particular the costs related to thedistance to health care facilities.

Even though the study by Onamade (2014) was carried out in Funtua LGA, the author did not consider all the health care centres in the study area, the focuswas basically on pregnant women and antenatal care only. However, other research works mentioned above looked at accessibility to health care facilities and how health care facilities are distributed across space, none of these studies above has attempted to analyze the spatial accessibility to health care facilitiesin Funtua LGA using GIS technique, this is the gap in knowledge this study attempts to fill and is set out to answer the following research questions:

1. What are the categories of healthcare facilities available in the study area?
2. Howthe health care facilities spatially distributed in the study area?
3. What is the level of accessibility to healthcare facilities in the study area?
4. What are the available facilities and personnel in the health care centres?

1.3 AIM AND OBJECTIVES OF THE STUDY

The aim of this study is to analyze the spatial accessibility to healthcare facilities in Funtua Local Government Area of Katsina State using Geographic Information System (GIS) technique. However, the specific objectives of the study are to:-

i. identify, characterizeand map the healthcare facilities in Funtua LGA
ii. analyze the distribution of healthcare facilitiesin Funtua LGA
iii. determine the spatial accessibility of healthcare facilities in Funtua
iv. examine the available facilities and personnel in the health care centres

1.4 SCOPE OF THE STUDY

This study is concerned with the spatial analysis of accessibility to health care facilities in Funtua Local Government Area of Katsina State. The study covered the entire eleven wards in the study area. Both public and private healthcare facilitieswere considered. The content scope of the study covered mapping, assessing the distribution pattern of the healthcare facilities, determine the accessibility level to the health care facilities and examine the facilities in the health centres in the study area. The temporal frame covered all the healthcare facilities registered with the State Ministry of Health as at year 2016.

1.5 SIGNIFICANCE OF THE STUDY

Health is paramount to the well-being of man, its availability and accessibility is equally important hence the need to have an overview of the distribution of healthcare facilities which influence its utilization in a particular area. Funtua today as in most parts of Nigeria towns is equally faced with increase population growth, high poverty level accompanied by illiteracy and ignorance, poor nutrition and other related health risk and problems such as inadequate sanitation, unsafe drinking water and high rate of environmental pollution. These conditions have encouraged high prevalence cases of both infant and adult diseases such as measles, diarrhea, tuberculosis, cardio-vascular diseases and other respiratory infections. Even though the state government have tried in the provision of healthcare facilities but often the utilization of these facilities has not been without accessibility difficulties which the findings of this study intends to reveal. Moreover, this study attempts to explore the use of GIS with the intention of generating data that would be useful for planning, policy formulationand management of healthcare delivery system in Nigeria and Funtua LGA in particular.

CHAPTER TWO

CONCEPTS, THEORIES AND LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents general concepts and review of relevant literature relating to the spatial accessibility to healthcare facilities. The conceptual issues encompass the concepts of spatial accessibility and location. Relevant literatures reviewed include types of healthcare facilities in Nigeria, historical perspective of public health and hospitals as well as antiquity of healthcare infrastructure in Nigeria, GIS-Based measures to accessibility and Katsina State Strategic Health Development Plan Policy.

2.2 CONCEPTUAL FRAMEWORK

2.2.1 Concept of SpatialAccessibility

Access to healthcare services means timely use of personal health services to achieve the best health outcomes. Furthermore, access to healthcare influences overall physical, social and mental health status; prevention of disease and disability; detection and treatment of health conditions; quality of life; preventable death and life expectancy (Healthy People 2020.gov, 2012). Barriers to access result in unmet healthcare needs, delays in receiving appropriate care, inability to get preventive services, and hospitalizations that could have been prevented (Healthy People.gov,2012).

Osotimehin (2009) describe 'access as availability of resources and the ability to reach and use them without constrains.Webster (1993) define access as“permission, liberty or the ability to enter, to approach or communicate with or pass to and from, freedom or ability to obtain or make use of; ability or means to participate in, work in or gain insight or the ability to reach a desired need when and if available. Accessibility is an important feature where people have a need to reach destinations situated away from their residence. It can be the ability to go shopping, get to school, to reach jobs or

hospitals (Oliver and Mossiales, 2004). Accessibility can also affect the quality of life for instance, being able to visit friends and family, go on vacations and tours (Guagliardo, 2004). Conceptually, accessibility to healthcare services includes the degree of approachability to the healthcare, acceptability, availability; affordability and appropriateness of the services render (Whitehead, 1992; Haddad and Mohindra, 2002; Shengelia, Murray and Adams, 2003; Harris, Harris and Roland, 2004).

Approachability relates to the fact that people facing health needs identify that some form of services exists, can be reached, and have an impact on the health of the individual (Harris, Harris, and Roland, 2004). Services can make themselves more or less known among various social or geographical population groups. Various elements such as transparency, information regarding available treatments and services and outreach activities could contribute to make the services more or less approachable. Complementary to this notion of approachability of services, the notion of ability to perceive need for care among population is crucial and determined by such factors such as health literacy, knowledge about health and beliefs related to health and sickness (Haddad and Mohindra, 2002).

Acceptability relates to cultural and social factors determining the possibility for people to accept the aspects of the service (the sex or social group of providers, the beliefs associated to systems of medicine) and the judged appropriateness for the persons to seek care. For example, a society forbidding casual physical contact between unmarried men and women would reduce acceptability of care and acceptability to seek care for women if health service providers are mostly men. It may be that some services are inequitable in the way they are organized, making them unacceptable to some sections of the community that they are intended to serve (Whitehead, 1992).

Ability to seek healthcare relates to the concepts of personal autonomy and capacity to choose to seek care, knowledge about healthcare options and individual rights that would determine expressing the intention to obtain healthcare. A good example would be female discrimination regarding the initiation of care or abuse and neglect discouraging ethnic minorities to seek care. This relates to the challenge of ensuring that care meets the needs of different cultural, socio-economically disadvantaged and vulnerable population. Because different groups may judge appropriateness and quality differently, this is an important challenge (Harris, Harris, and Roland, 2004).

Availability and accommodation refers to the fact that health services (either the physical space or those working in Health Care roles) can be reached both physically and in a timely manner. Availability constitutes the physical existence of health resources with sufficient capacity to produce services (existence of productive facilities) (Frenk, 2010). It results from characteristics of facilities (example, density, concentration, distribution, building accessibility), of urban contexts (decentralization, urban spread, and transportation system) and of individuals (duration and flexibility of working hours for instance). It also relates to characteristics of providers (presence of the health professional, qualification) and modes of provision of services (example, contact procedure and possibility of virtual consultations).

Access is restricted if available resources are unevenly distributed around a country, or across levels of care (with specialty care developed at the expense of primary care) (Whitehead, 1992). Ability to reach healthcare relates to the notion of personal mobility and availability of transportation, occupational flexibility, and knowledge about health services that would enable one person to physically reach service providers. Restricted mobility of the aged and handicapped, or the inability of casual workers to be

absent from work to consult medical providers would be examples of these (Harris, Harris, and Roland, 2004).

Affordability reflects the economic capacity for people to spend resources and time to use appropriate services (Haddad and Mohindra, 2002). It results from direct prices of services and related expenses in addition to opportunity costs related to loss of income (Haddad and Mohindra, 2002). Furthermore it can vary by type of services and depends on the capacity to generate the resources to pay for care (e.g. mode of payment, mobilization of resources). Economic studies of utilization models demand using variables such as price of care, travel time and the opportunity costs linked to it, patient's income, perceived quality of care, provider behavior, etc. These models give useful information about elasticity of demand for different types of health services (Shengelia, Murray and Adams, 2003).

Ability to pay for healthcare is a widely used concept within the health services and health economics literature (Frenk, 2010). It describes the capacity to generate economic resources - through income, savings, borrowing or loans - to pay for healthcare services without catastrophic expenditure of resources required for basic necessities (e.g. sale of home). Poverty, social isolation, or indebtedness would be examples of factors restricting the capacity of people to pay for needed care (Haddad and Mohindra, 2002).

Appropriateness denotes the fit between services and clients need, its timeliness, the amount of care spent in assessing health problems and determining the correct treatment and the technical and interpersonal quality of the services provided (Shengelia, Murray and Adams, 2003). Adequacy relates to the appropriateness (what services are provided) and quality (the way in which they are provided) of health services and its integrated and continuous nature (Haddad and Mohindra, 2002; Shengelia, Murray and Adams, 2003). Clearly, the content and effectiveness of health services and goods has the

opportunity to utilize matters (Frenk, 2010; Shengelia, Murray and Adams, 2003). Opportunity to utilize only services of poor quality in this sense is seen as restriction of access to healthcare (Frenk, 1992; Haddad and Mohindra, 2002).

When taking everything into account however, healthcare services access means that healthcare facilities are unrestricted by spatial/physical, economic, social, organizational, or linguistic barriers (Osotimehin, 2009).Economic access refers to the affordability of products and services for clients. Social or cultural access relates to service acceptability within the context of the client's cultural values, beliefs, and attitudes (Osotimehin, 2009 and Frenk, 2010). Organizational access refers to the extent to which services are conveniently organized for prospective clients, and encompasses issues such as clinic hours and appointment systems, waiting time, and the mode of service delivery (Osotimehin, 2009 and Frenk, 2010). Linguistic access means that the services are available in the local language or a dialect in which the client is fluent (Lori, Lynne, Nadwa and Theresa, 1992).

Economic access refers to the affordability of products and services for clients. Social or cultural access relates to service acceptability within the context of the client's cultural values, beliefs, and attitudes. For example, family planning services may not be accepted if they are offered in a way that is inconsistent with the local culture. Organizational access refers to the extent to which services are conveniently organized for prospective clients, and encompasses issues such as clinic hours and appointment systems, waiting time, and the mode of service delivery. Linguistic access means that the services are available in the local language or a dialect in which the client is fluent (Lori, Lynne, Nadwa and Theresa, 1992; Osotimehin, 2009 and Frenk, 2010).

Spatial accessibility often referred to as geographic or physical accessibility, is concerned with the relationship between population distribution and the supply of

healthcare facilities, it thus has a strong underlying geographic component, although it is intuitive that the level of public health of a population may be affected negatively by the distance to healthcare services, there remains limited quantitative information regarding this impact (Guagliardo 2004). Spatial access may be measured by modes of transportation, distance, travel time, and any other physical barriers that could keep the client from receiving care (Guagliardo 2004).

Black *et al.* (2008) pointed that concept of spatial accessibility identifies the different dimensions of patient to service provider relationships as it puts into consideration the concept of geographical and physical barriers to healthcare accessibility. Moreover, Adetunji (2010) noted that, spatial accessibility is often quantified using the concept of cost of reaching the service where cost is defined in a number of ways such as distance, time or economic cost. If accessibility is measured by distance, then Euclidean distance is often used, but Dahlgren (2008) pointed that, Euclidean distance does not normally give a realistic value of the accessibility as in most cases, it is impossible to travel along a straight line between two points; therefore it is more common to measure distance along road network.

Osotimehin(2009) opined that physical accessibility largely depends on quantity and quality of connectivity which determines the travelling time, travelling distance, speed determined by the road and its surface condition, sinuosity, matter of choice for travelling as per road condition. Healthcare is a fundamental prerequisite to realizing individual potential and equal opportunity for all and because where the facilities are located matters, it is best to locate them in central places that possess a higher degree of convenience (Osotimehin, 2009). Hence, spatial access to healthcare facilities stresses the importance ofdistance and location (Abbas, 2009).

2.2.2 Concept of Spatial Location

The term location refers to position on earth used to identify a point or an area on earth surface or elsewhere (Rushton, 1991). Generally it could be a room, factory, house, school, a town or a city, hospital etc. For instance, each house in a street or road has its own location but together the houses are distributed across space to form a pattern (Rushton, 1991). However, distribution is seen as the arrangement of objects viewed at a variety of scales, these may be at or near the earth, or beyond. Distribution may vary from ordered patterns to apparent randomness (Skupin and Fabrikant, 2007).

2.2.2.1 Primitive Concept of Location

Spatial pattern can be derived from the primitive concept of location but are themselves not considered primitive (Golledge, 1995). In contrast, work by the French Geographer Brunet (1980) considers a limited number of spatial patterns themselves (or, to be more precise, the processes that lead to specific spatial patterns) as being primitive to a language of space. In the light of the latter, the analysis of spatial patterns becomes particularly intricate if we look not only at spatial patterns created by the location that entities have in space, but at the combination of spatial and attribute values. From a quantitative perspective, this theoretical construct is most famously summarized by Tobler's (1970) first law of geography (TFL) everything is related to everything else, but near things are more related than distant things.

As Miller (1991) noted, the concept of TFL is implicit in the practice of spatial analysis. In similarly strong terms O'Sullivan and Unwin (2003) parroted that "If spatial autocorrelation (as a way to formalize TFL) were not commonplace, geographic analysis would be of little interest, and geography would be irrelevant. But if geography is worth studying at all, it must be because phenomena do not vary randomly through space. Because the relationship between distance and similarity has additionally been

extendedinto the realm of using space (distance) to represent semantic similarity, a concept also referred to as spatialization (Montello *et al*., 2003; Skupin and Fabrikant 2007). Montello and colleagues named their studies “The first law of cognitive geography”, stressing the fact that distance ubiquitously is associated with similarity (or dissimilarity). It has to be noted though that several factors, such as connectedness contribute to distance estimations in map-like displays (Fabrikant, Montello, and Mark 2006).

2.2.2.2 Quantitative Perspective of Location

To approach spatial patterns from the perspective of quantitative analysis, spatial analysts have established a framework that allows for grounding the characterization of spatial patterns on the mathematically established principle of randomness. This is considered a pre-requisite to establish statistical significance, which is, comparing observed patterns to a set of patterns that could be the result of a random process (complete spatial randomness/independent random process) (O'Sullivan and Unwin 2003).

However, the problems of understanding randomness is a research topic in many disciplines, and this is rather astonishing, as the difficulty of understanding random spatial processes is pronounced in case visual representations are involved; humans tend to see patterns in maps and readily interpret patterns ignoring the possibility that they might be the outcome of a chance process (O'Sullivan and Unwin 2003).Hence, several theories have been propounded to explain the relationship between spatial arrangement and access to services, among such include: location and central place theories.

2.2.3 Concept of Spatial Pattern

In geography, "spatial patterns" refers to the organization and placement of people and objects in the human world. It may refer to the distances between them or the

regularity of distribution among them. In other words, refers to how resources, activities, human demographics or features of the landscape are distributed across the surface of the Earth (Golledge, 1995). Spatial patterns are everywhere. They include naturally occurring patterns, such as the concentration of plant life in a certain area as well as man-made patterns, such as those found in towns, cities and communities. In fact, everything that has a location in geographic space inevitably creates or contributes to a spatial pattern (Skupin and Fabrikant, 2007).

2.2.4 Concept of Health

The world health organization (WHO) defined health as a condition that exists when an individual or group is able to realize aspirations and safety needs and to change or cope with the environment, (Dines and Cribb, 1993).The WHO also defined health in its broader sense in 1946 as a state of complete physica, mental and social wellbeing and not merely the absence of disease or infirmity (WHO, 2006).These definitionsaffirmed that health plays an important role in the wellbeing of man and therefore must be given utmost attention at all times.

2.2.5 Concept of Health Care Facilities

A health care facility is defined as all units ownedby public and private authorities as well as voluntary organizations and whichprovides health care services, hospitals, health and maternity centers. (https://wikipedia.org/wiki/community-health)

Health care facility according to Onokerhoraye (1999) is defined as all units owned by public and private authorities as well as voluntary organizations and which provides health care services including hospitals, health and maternity centres. In other words these are organizations or decision making units whose mission and resources are devoted to improving patient's health through health intervention measures and services

such as curative, preventive, protective and health promotion activities, i.e.hospitals and health care centres.

2.2.6 Concept of Health Care

Health careis the maintenance or improvement of health via the diagnosis, treatment, and prevention of disease, illness, injury, and other physical and mental impairments in human beings. Health care is delivered by health professionals (providers or practitioners) in allied health professions, chiropractic, physicians, physician associates, dentistry, midwifery, nursing, medicine, optometry, pharmacy, psychology, and other health professions. It includes the work done in providing primary care, secondary care, and tertiary care, as well as in public health (https://wikipedia.org/wiki/community-health).

In many countries, the system of healthcare delivery comprises a range of institutions which are classified on the basis of their specialization, sophistication and the level of care they can provide. Basically, there are three main levels identified, these are: Primary, Secondary and Tertiary healthcare delivery systems (Pavignani, 2007 and Adamu, 2001). Primary Health Care by policy arrangements is within the purview of LGA, based on the residual operation of Local Government Authority.

Primary health structures are unarguably the first points of call for the sick and injured persons. They undertake mild healthcare cases like treatment for malaria, fever, cold, nutrition disorder, among others. They are mainly for milder health problems and health education. They also handle infant, maternal and pregnancy matters.Other health issues in their care are family planning and immunization (Badru, 2003). They emphasize healthcare and are involved in record-keeping, case reporting and patients' referral to higher tiers. Primary health centres are known within the system by content of health centre, maternity home/clinic and dispensaries (Pavignani, 2007, Adamu, 2001 and

WHO, 1997). These categories of medical care refer complicated cases to secondary general hospitals. According to Medical and Dental Council of Nigeria (MDCN) in Badru (2003), PHC facilities are also to undertake such functions as health education, diagnosis and treatment of common ailments, through the use of appropriate technology, infrastructure and essential drug list.

The Secondary level care more commonly called General hospitals, to which Patients from wide surrounding area or district are referred when necessary by the primary care units for more serious diagnosis or treatment. Hospitals are usually located in urban and some few rural areas. Apart from out-patient services, they offer surgical and emergency services. In many cases, the out-patient component (mainly providing first contact care) is quite large.General hospitals have provisions for accident and emergency unit and diagnosis unit (including X-ray, scan machines and other pathological services) among other services(Badru, 2003).

The status of being a second layer of health institutions imposes certain acceptable standards and level of infrastructure. Furthermore, general hospital incorporates the facilities of the PHC into its own to play its role as a second tier health institution. As a matter of fact, to be so qualified, it should provide simple surgical services, supported by beds and bedding for minimum of 30 patients. There should also be ancillary facilities for proper diagnosis and treatment of common ailments. General hospitals are often within the control of state governments and private individuals or group of individuals (WHO, 1997).

Finally, the large specialization teaching hospitals (tertiary), usually located in the main towns and often only in the capital city. They are equipped with higher technology and mainly devoted to in-patient care. This is usually larger than the general hospitals and has a greater emphasis on teaching, particularly of doctors (Pavignani, 2007, Adamu,

2001 and WHO, 1997). This category of medical institution handles complex health problems/cases either as referrals from general hospitals or on direct admission to its own. It has such features as accident and emergency unit, diagnostic unit, wards units, treatment unit and out-patient consultation unit. All these units are to be equipped with the necessary facilities and staffed by skilled personnel.

Teaching hospitals also conduct researches and provide outcomes to the government as a way of influencing health policies. This explains why this type of health institution is often a university-based; Examples are Lagos University Teaching Hospital (LUTH), University College Hospital (UCH), Ibadan, Aminu Kano Teaching Hospital (AKTH), in Kano State, Ahmadu Bello University Teaching Hospital (ABUTH) in Zaria, Kaduna State, The National Orthopedic Hospital Igbobi Yaba, Psychiatric Hospitals in Aro, Abeokuta and Yaba in Lagos. Others are National Hospital in Abuja, University of Nigeria Teaching Hospital, Enugu (Badru, 2003).

2.2.6.1 Katsina State Strategic Health Development Plan Policy (2010 – 2015)

Health services provision in Katsina State is organized like in other parts of the country- into three levels of tertiary, secondary and primary levels. The federal government is responsible for the provision oftertiary services in Federal Medical centre, Katsina, while the state runs the secondary Health Carecenters through the hospital services management board, while the LGAs have the mandate of providing PHC services to the communities, where the State's Primary Health Care Development Agency (SPHCDA) helps with coordination and technical support of PHC activities and partners' activities (bridging the gap between PHC and secondary level) KatsinaState Ministry of Health (KSMOH),2010).

Important health indices related to the state are Neonatal Mortality Rate55/1,000 live births; IMR 114/1,000 live births; U5MR 269/1,000 live births; MMR 1,000/100,000

livebirths; total fertility rate of 7. The fully immunized child (FIC) is below 5% from the 2006 NICS, andvaccine preventable diseases remain major causes of childhood morbidity and mortality. The state hasone of the highest MMR in the country and efforts are directed at addressing this problem. It has 1,427health facilities as at the year 2010: 21 general hospitals and 22 CHC. ANC attendance is about 55% but delivery in HF by skilled attendants is about 10%. There were 480 midwives and 981 nurses in the state with one each insome LGAs (KSMOH, 2010).

The state's administration has provided visionary leadership and shown a lot of political commitmentto ensuring all indigenes of the State benefit from quality health services e.g. frees medical care, mobileambulance services to the hard to reach rural areas. A lot has been achieved, however there are still constraints.The priority constraints to delivery of health services in the State have been stratified along thefollowing coverage determinants:Availability of commodity (Weak procurement process, inadequate funds, and Lengthy bureaucratic processes); Availability of human resources, (Poor recruitment policy, and Low institutional capacity for training and Re-training of personnel); Accessibility (Several routine distribution health facilities are not well maintained/not functional).Initial and continuous utilization (very low awareness level, poor IPC skills and attitude) and effective coverage **(**poor health seeking behaviour and low awareness level).The SSDHP has provided a State wide framework for streamlining all health activities in Katsina State) (KSMOH, 2010).

It has however found it imperative to identify among these activities, certain priority, low cost and highimpact interventions that are particularly targeted at meeting the 7 point Agenda and MillenniumDevelopment Goals. They have been categorized under three main service delivery modes they included: Family/Community Oriented Services, Population Oriented/Outreaches/Schedulable Services and Individual/Clinical

Oriented Services (KSMOH, 2010). The following strategies have been identified as imperative to redress the constraints in the healthdelivery process. They are stratified along the coverage determinants stated below:

i. Availability of Commodity: Advocacy to FMOH, state, LGAs for increased budgetaryallocation and timely release of funds for the purchase of commodities, Strengthening the budgetary Implementation Monitoring Mechanism, Shortening the length of commodity procurement systems

ii. Availability of Human Resources: Revision of recruitment policy, Institutionalize a periodicmerit based recruitment mechanism that is based on need, Strengthening institutionalcapacity in the State for training/retraining (upgrade training institutions)

iii. Accessibility: Strengthening the Supervision, Monitoring and Evaluation mechanism,Strengthening of reward/incentive system to motivate workers, Strengthening / Privatizing maintenance of health infrastructure

iv. Initial Utilization: Defining a Communication Strategy. Subjecting IEC materials to theproper message development process, Conduct a State wide Awareness Campaign as defined in the Communication Strategy

v. Continuous Utilization Community participation and ownership of health campaign activities through the involvement of Development Committees

vi. Effective Coverage: Commissioning a major LLIN distribution campaign, Sustained Health Awareness Campaign, Training and retraining of distribution and health awareness personnel

The challenges in health provision are related to system failures and include:

i. Inadequate personnel especially Doctors and Mid-wives

ii. Inadequate Tutors in schools of The College of Health Sciences

iii. Low level of awareness among the rural populace among services and their benefits

iv. Low literacy level especially among women

v. Poor health seeking behavior among the majority of the people

vi. Occasional outbreak of some diseases e.g. malaria, gastroenteritis, CSM, measles and Pertussis

vii. Limited funding at lower level

viii. Weak supervision due to inadequate capacity, logistic support and funding especially at LGA level.

2.2.7 Geographic Information Systems

According to Burrogh (2001) Geographic Information Systems (GIS) is the science and technology related to powerful set of tools for collecting, storing, and retrieving at will, transforming and displaying spatially referenced data.

A Geographic Information System is designed to accept large volmes of spatial data derived from a variety of sources including remote sensing and to efficiently store, retrieve, manipulate, analyze and display these data according to user-defined specifications (Marble and Pequet, 1983).

Even though there have been so many attempts to define GIS, it is difficult to select one definitive definition. Thus, there is no absolutely agreed upon definition of GIS. However, the world health organization (2004) describes GIS as an excellent tool of analyzing epidemiological data, revealing trends, dependencies and interrelationships that would be more difficult to discover using traditional tabular approach. The spatial modeling capacity offered by GIS has greatpotentials and has been used in different fields which include: education, government, military, planning, law enforcement, agriculture,health et cetera.

In essence, the application of GIS in this study includes geodatabase creation for relevant queries; explore spatial pattern and the spatial dimensions of access. Since health care decisions are stongly influenced by the type and quality of services available in the area, and the travel distance, time, cost and ease of reaching those services. Therefore, mapping and visualization of health disparities and their relationship to the geographical location of Health Care services can allow for better resources allocations to contasting and underserved populations (Parker and Campbell, 1998).

2.2.71 Database Design

At its most basic level, an ArcGIS geodatabase is a collection of geographic datasets of various types held in a common file system folder, a Microsoft Access database, or a multiuser relational DBMS (such as Oracle, Microsoft SQL Server, PostgreSQL, Informix, or IBM DB2). Geodatabases come in many sizes, have varying numbers of users and can scale from small, single-user databases built on files up to larger workgroup, department, and enterprise geodatabases accessed by many users.But a geodatabase is more than a collection of datasets; the term geodatabase has multiple meanings in ArcGIS:

- The geodatabase is the native data structure for ArcGIS and is the primary data format used for editing and data management. While ArcGIS works with geographic information in numerous geographic information system (GIS) file formats, it is designed to work with and leverage the capabilities of the geodatabase.
- It is the physical store of geographic information, primarily using a database management system (DBMS) or file system. You can access and work with this physical instance of your collection of datasets either through ArcGIS or through a database management system using SQL.

- Geodatabases have a comprehensive information model for representing and managing geographic information. This comprehensive information model is implemented as a series of tables holding feature classes, raster datasets, and attributes. In addition, advanced GIS data objects add GIS behavior; rules for managing spatial integrity; and tools for working with numerous spatial relationships of the core features, rasters, and attributes.
- Geodatabase software logic provides the common application logic used throughout ArcGIS for accessing and working with all geographic data in a variety of files and formats. This supports working with the geodatabase, and it includes working with shapefiles, computer-aided drafting (CAD) files, triangulated irregular networks (TINs), grids, CAD data, imagery, Geography Markup Language (GML) files, and numerous other GIS data sources.
- Geodatabases have a transaction model for managing GIS data workflows.

(http://desktop.arcgis.com/en/arcmap/10.3/manage-data/geodatabases/what-is-a-geodatabase.htm)

The nerve centre of any GIS is data model, which is a set of constructs for representing objects and processes in the digital environment of the computer (Luo and Wang, 2003). The GIS users interact with the operational GIS so as to carry out a number of tasks such as making maps, querying databases, facility site location and proximity analysis among others (Higgs, 2005).Since the analysis to be perform in order to understanding the real worldvaries, the decision and choice of a given data model is influence by the nature of the real world phenomena being investigated (Amer, 2007).Because these phenomena have different characteristics, there is no single type of all-encompassing GIS data model that is best for all circumstances (Luo and Wang, 2003).

Ryan and Ronald (2001) defined database as a collection of logical related data, designed to meet the information needs of an organization. It is a large repository of data used simultaneously by departments, institutions and even individual and group users (More, *et al.*, 2005). Instead of disconnected files with redundant data, all data items are integrated with a minimum amount of duplication (Fiebig and Moerkotte, 2000). The objects that comprise a database include: Database schema (conceptual and physical models as well as application interface), Schema objects (that resides within a schema.), tables, fields and columns, records and rows, keys, relationships and data types (alphanumeric, numeric and date/time) (More, *et al.*, 2005).

A spatial database system according to Ryan and Ronald (2001) is a database system that offers spatial data types in its data model and query language and supports spatial data types in its implementation, providing at least spatial indexing and spatial join methods. Brinkhoff Kriegel and Schneider (1993) parroted that, spatial database systems offer the underlying database technology for geographic information systems and other applications. Ryan and Ronald (2001) added that, in various fields there is a need to manage geometric, geographic, or spatial data, which means data related to space. The space of interest can be, for example, the two-dimensional abstraction of (parts of) the surface of the earth that is, geographic space (Ryan and Ronald, 2001). Most prominent example is: a man-madespace like HCF.

Hence, according to Ryan and Ronald (2001), database design is the process of converting objects/models into Tables and views, where model components such as entities and attributes are converted into Tables and columns. They opined that, constraints are added to columns where necessary in order to enforce data and referential integrity, views of Tables might be created in order to filter the data that a user sees, or to simplify the query process.After the database itself is designed, an application for the end

user must be designed because the user cannot be expected to fully understand the structure of the database (Becker and Güting, 1992).With a basic understanding of databases and the different types of database environments, then a database model that is best for a certain organization is chosen, which could be either: Flat-file database model, Hierarchical database model, Network database model, Relational database model, Object-oriented (OO) database model or Object-relational (OR) database model (Ryan and Ronald, 2001).

The Flat-file database required data to be stored in readable files on the host operating system, with the hierarchical model, information was stored in tables using parent/child relationships, but with many limitations compared to later models, the networkmodel improved on the hierarchical model in the area of parent/child relationships (Ryan and Ronald, 2001).Relationships are easier to manage, and it is much easier to navigate to different tables within the database (Aref and Samet, 1991a).Nearly all problems with previous data models were solved with the developmentof the relational model (Ryan and Ronald, 2001).

The relational model improved on parent and child table relationships and proved a way to reduce the amount of redundant data stored (Aref and Samet, 1991a). The goal of the object-oriented model was to makedata storage more compatible with object-oriented programming tools, which has yet to berefined (Aref and Samet, 1991a). Finally, the object-relational model displayed an attempt to combine the concepts ofobject-oriented programming with the relational database, which also needs much improvement (Aref and Samet, 1991b).

A general-purpose database management system (DBMS) on the other hand, is a software system designed to allow the definition, creation, querying, update, and administration of databases (Abel, 1989 and More, *et al.*, 2005). Well-known DBMSs

include MySQL, PostgreSQL, SOLiteM, Microsoft SQL Server, Microsoft Access, Oracle, Sybase, dBASE, FoxPro, and IBM D2 (More, *et al.*, 2005). A database is not generally portable across different DBMS, but different DBMSs can inter-operate by using standards such as SQL and ODBC or JDBC to allow a single application to work with more than one database (Fiebig and Moerkotte, 2000).Databases and DBMSs can be categorized according to the database model(s) that they support (such as relational or XML), the type(s) of computer they run on, the query language(s) used to access the database (such as SQL or XQuery), and their internal engineering, which affects performance, scalability, resilience, and security(Fiebig and Moerkotte, 2000).

In the relational model, related records are linked together with a key, the relational model also allowed the content of the database to evolve without constant rewriting of links and pointers (Becker and Güting, 1992).Brinkhoff, Kriegel and Schneider (1993) added that, the relational part comes from entities referencing other entities in what is known as one-to-many relationship, like a traditional hierarchical model, and many-to-many relationship, like a navigational (network) model.Thus, a relational model can express both hierarchical and navigational models, as well as its native tabular model, allowing for pure or combined modeling in terms of these three models, as the application requires (Ryan and Ronald, 2001).For instance, a common use of a database system is to track information about Health Care infrastructures, their names, types, quantity, quality, capacity, various hospital addresses where they are distributed at and so on. In the navigational approach all of these data would be placed in a single record, and unused items would simply not be placed in the database. In the relational approach, the data would be normalized into a name table, an address table and a quantity table (for instance). Records would be created in these optional tables only if

the variables were actually provided (Ryan and Ronald, 2001, and Becker and Güting, 1992).

Structured Query Language, more commonly referred to as SQL, is the standard language used to issue commands to and communicate with a relational database (Becker and Güting, 1992). With SQL, one caneasily enter data into the database, modify data, delete data, and retrieve data (Becker and Güting, 1992). SQL is a nonprocedurallanguage, which means that user can tell the database what data to access, notnecessarily what methods should be used to access the data (Ryan and Ronald, 2001). SQL therefore, is a standard relational model language supported by allrelational DBMSs; it was one of the first commercial languages for the relational model (Aref and Samet, 1991b).

Most organizations in developed countries today depend on databases for their business operations (Fiebig and Moerkotte, 2000). Databases are not used only to hold administrative information, but are often embedded within applications to hold more specialized data (Fiebig and Moerkotte, 2000; and Ryan and Ronald, 2001): for example engineering data or economic models. Examples of database applications include computerized library systems, flight reservation system and computerized part inventory system (More, *et al.*, 2005). The database application in this study was the distribution of HC facilities and their available equipment which couldaid effectivedecision making processes.

2.2.7.2 ArcGIS Neighbourhood and Network Statistics Functions

The Neighborhood Statistics Functions can be used as point data for the location of Health Care Centers, for spatial demonstration of point-pattern. These methods involved the exploring pattern in locational data by comparing graphically the observed distribution functions of event-to-event or random point-to-event nearest neighbor

distances, either with each other or with those that may be theoretically expected from various hypothesized models, in particular that of spatial randomness (Upton, 1985). The output of this function is more useful for pattern recognition than for the location of individual. Health Care data such as location of facilities can be analyzed by this function to identify their spatial pattern in any area. Health studies can use several GIS based neighborhood statistics functions such as the focal mean, the focal sum or the focal range, which computes the required statistics for either rectangular or circular neighborhood shapes (Black 2003).

The second main GIS tool that is considered to be very useful in Health Care studies is the Network Analyst. It is one of the most frequently used components of a GIS in the utilities and Transportation Planning Fields. It can find answers to questions such as what is the shortest path between locations X and Y. Such analysis is known as Routing. This function can be used in the health studies for defining the shortest path between patient location and health center. The resulted path can be presented to the ambulance driver together with the direction file that describes step by step the best routes for getting fast to such patient. Allocation is another function available in GIS Network analysis that facilitates the modeling of resource distribution through a spatial network and the determination of service zone. This function can be used in health studies in creating health center catchment area (Luo and Wang, 2003).

One of the advanced GIS Network analysis function is the Estimation of travel time between a set of Origins and a set of Destinations (i.e., O–D Travel Time Matrix) through a transportation network. This is a common task, to list a few; spatial interaction modeling uses travel time between any pair of interacting places (Fotheringham andO'Kelly, 1989); traffic demand forecasting relies on an accurate estimation of travel time among locations in various land uses (Black 2003); and accessibility measurement to

certain facilities like health care requires the travel time data between supply and demand locations (Luo and Wang, 2003).

In the absence of data of a transportation network or the computational power of GIS, one has to resort to simple distance measures such as Euclidean distance or Manhattan distance (Wang, 2006). This measures only need the input of geographic coordinates of origins and destinations and use simple mathematical formular to calibrate, but are primitive indices of travel impedance. But, Travel time estimation is based on a transportation network. A transportation network consists of a set of nodes (or vertices) and a set of arcs (or edges or links) that connect the nodes. Travel time estimation is usually performed to find the shortest time or average or minimum/maximum distances along a road network from a specific origin such as settlement to specific destinations like Health Care through a series of nodes and arcs connecting them (route) on the network (Chang, 2004).

2.3 THEORIES OF LOCATION

2.3.1 Hoover Location Theory

According to Hoover (1948), location theory, the spatial pattern of economic activities is explained mainly in terms of transport cost. Therefore, Hoover remarked that the expenses and inconveniences of moving finished goods to distance customers and producing raw materials from distance sources induce producers to locate near their Markets or their sources of raw materials. That is, industrialists tend to locate where aggregate transfer costs are at minimum.Thus, the location that is more likely to minimize travel costs for the user population is those at strategic points in the transport network. In other words, the cost of transport (for people and consumers) rather than the transfer cost (of materials by the supplier) is more important in public facilities, which involves mainly

the movement of people to points where services are located: in our case, patients to Health Care facilities .

In the location of Health Care facilities, therefore the main objective is the maximization of social utility or the minimization of social costs for a given population. At the same time, all patients should have access to medical care. For this reason, the basic issue to note is that a non-monetary criterion is very important in the location of such public facilities. Efficient locations from the user point of view are necessary if societal resources are not to be unduly wasted in overcoming distance. An efficient set of locations can save human effort and monetary resources that can be devoted to many other things (Dahlgren, 2008)

2.3.2 Central Place Theory

The Central Place Theory (CPT), propounded by Christaller (1933) is an attempt to explain the spatial arrangement, size, and number of settlements. Partly about the location and spacing of service centers or central places, where a service centers is a settlement that provides some kind of service for surrounding catchment area. An important issue here is the main objective of the spatial distribution of service centers. From the welfare point of view, optimal distribution is largely determined by accessibility to services at the minimum aggregate travel cost. Such an optimal specification links the welfare problem closely with CPT (Christaller, 1933).

The main principles of the CPT that are relevant to this study are: the range of good, and the principle of least effort. The range of good refers to the average maximum distance people will travel to purchase goods and services. Different goods and services have different threshold range. While the principle of least effort on the other hand, indicates that people generally travel to the nearest location where a good or service is

obtainable. Consumers therefore are guided by the principle of least effort in selecting where they obtain the goods or services they require (Christaller, 1933).

Relating these principles to the present study, Health Care facilities cannot just be located everywhere, even though they are public utilities. Resources cannot be wasted through duplicating similar projects in virtually every locality a single facility can suffice. In a similar manner, a facility may be considered as service center. It would therefore, have an identifiable catchment area. Consequently, Hospitals of different grades would have different catchment areas. The Tertiary Health Care facilities normally have an extensive catchment area (WHO, 1997). Conversely, a village dispensary offers only a limited range of services, which are also offered by its counterparts in other villages. It therefore has small catchment areas which are guided by accessible recommended distance (WHO, 1997).

The principle of least effort is also relevant in this study, since people are more likely to patronize Health Care facilities close to them, due to higher cost of travelling to distant ones. This is true especially with remote areas, where low income and low level of education, may make other alternative sources of medical care, like Traditional medicine being relatively cheaper and without the trouble of overcoming the frictional effect of distance (Onyemelukwe and Ariyo, 1996).

Generally, in the Central Place Theory, movement is recognized by the frequent reference to distance and travel cost. And travel cost affects the range of good or service and the size of the complementary region within which it is offered. The complementary region is the tertiary in which the central place or service center has competitive advantage because of the factor of distance (Morrill, 1970). Travel costs are therefore less for consumers within a center's complementary region than for those outside it. For this reason, demand decreases with increasing distance. This pattern of fall in demand reflects

the effects of distance on movement in general and on the consumption of central goods and services in particular, and is associated with travel costs (Owumi, 2005).Again “these costs occur because of the friction component of space that can be overcome only by expending energy for travel. The effect of this friction component of space is to restrict travel distance in the interest of limiting travel costs (Bush and Gauthier, 1968).

2.4 LITERATURE REVIEW

2.4.1 Historical Perspective of Public Health and Hospitals inNigeria

According to Onokerhoraye (1982) the first medicalcenters in Nigeria were established in the rural areasby Christian mission.This however, was not without surreptitious support from the colonial masters to expand Christianity (Onibonoje, 1985). These medical centers, however, were merely mobile clinics and at mostcommunity dispensary out-posts to treat primary healthproblem, snake bites and minor injuries. It was in later years, when the British rule had been well established thatthe administrators promoted the creation of medical centers in the real sense of hospitals to take care of epidemics,such as sleeping sickness, small pox, malaria andother primary health concerns (Aluko-Arowolo, 2006). However, hospitals were concentrated only in the urbanareas where there was a high concentration of Europeans and government officials. Official residential quarters such as Government Reserved Areas (GRAs) were reserved for government senior workers. Such reserved areas were also called European Quarters. Such quarters existed in Lagos (Ikoyi/VictoriaIsland), Ikeja, Ibadan, Kaduna, Jos, Enugu and other majortowns (Akin-Aina, 1990, Home, 1983).

Two distinct spin-off effects could be deduced immediatelyfrom this particular arrangement, first a total neglect of rural areas in matters of Health Care and second, an established inequality in the urban centres between the colonialists including their black associates and general citizenry. Even in spite of independence, almost fifty years ago,

these residential patterns are still very glaring in Nigerian towns and cities (Mabogunje, 2007 and Home, 1983). Apart from these, there was no emphasis on the traditional Health Care type(s) and a huge vacuum was created that further entrenched inequality between the haves and have-nots and between the rural and urban settlements (Mabogunje, 2007).

The dichotomy brought to the fore, the challenges in the Health Care system and other associated services, in that infrastructure and personnel that are very essential to efficient hospital system like food, roads, pipe-borne water and electricity for storage of drugs and surgical operation etc were not provided for (Aluko-Arowolo, 2005). This later influenced the health policy of subsequent governments in Nigeria and designed a 'roadmap' for health system and sundry services in the country which placed health services specifically on three pedestals: the primary, secondary and tertiary institutions for rural, mixed population, and urban elite respectively (Mabogunje, 2007).

2.4.2 GIS-Based Measures to Accessibility

Increasing advancement in GIS in health organizations, together with the availability of data, has supported studies related with developing measures of access to Health Care services (Black, Ebener, Aguilar, Vidaurre and Morjani, 2004).They also stated that GIS is suitable in measuring spatial accessibility to Health Care as they enable researchers to input, store, manage, manipulate of both spatial and attribute (textual) data, analyze and visualize spatial information. Literatures like Bagheri, Benwell and Holt (2005), Guarlaido (2004), Umar (2016), Mohammed *et al*. (2015) and many more have explained about measuring spatial dimension of access. Measuring straight line distance (Euclidean distance), Origins Destinations Matrix and creating theissen polygons are some simple methods in accessing physical access.

Higgs (2005) employed the use of GIS-based measures in exploring relationships between geographical areas, utilization quality of Health Care service and health

outcomes. These studies explore the facial configuration of Health Care delivery system along with service for different socio-economic class of people and the characteristics of people or the area where they reside, seeking Health Care in measuring access to health care service (Higgs, 2005).

Eda, Susan and Waldorf (2007), demonstrated the utility of the gravity measures as a tool to assess spatial accessibility to Health Care services in Indiana. The gravity measures presented in their study account for three factors: distances between the population and Health Care providers; the capacity of Health Care providers, and the demand for Health Care. The empirical application indicates that access to Health Care varies sharply across Indiana counties, with deep pockets of deprived access. While the population in centrally located and urban areas enjoys better access, rural counties in southern Indiana and along the Illinois border have the poorest access to Health Care. Their result showed that more than one third of Indiana citizens did not have reasonable access to Health Care services, and that rural residents are particularly disadvantaged.

Adamu (2012) measured geographic accessibility to hospital facilities in Sheffield, using two distances measures; Euclidean and Network distance. Geographic Information System (GIS) was used as a tool to analyze the population distribution and to determine the distance and availability of hospital facilities in Sheffield. Distance between population centroids (origin) and hospital postcodes (destination) were calculated using Euclidean and Network distance measures. The researcher used threshold distance of 7 Km as a bench mark to determine level of accessibility in the study area. Result from the study revealed that the population in the city center had better access to hospital facilities due to proximity, as most hospitals are located within the city center. Secondly, the comparison of the distance types based on different age groups shows that Euclidean distance was highly correlated with network distance, with the

values greater than 0.90. However, the young and middle aged category appeared to have better access to hospital facilities in Sheffield than the old age category.

The GIS Software Packages such as ArcGIS which constitutes ArcMap, ArcCatalog ArcInfo, ArcView and ArcScene has many functions and tools designed for Health Care studies. GIS software provide spatial analysis that offer excellent tools for spatial data management and visualization (Amer, 2007). They are crucially important in any health-oriented study as they enable better decision-making by providing health status and needs for an area or region from a spatial point of view (Burrough, 1990). To achieve that, it is enough to have a database and a geographic base (like a map of the area of study), and the GIS is capable of analyzing the data and present a colored map that allows the visualization of the spatial pattern of the phenomenon (Luo and Wang, 2003).

2.4.3 SpatialPattern and Accessibility to Heaalth Care Facilities

A number of studies have attempted to determine the spatial accessibility to Health Care facilities in various communities. Prominent among such investigators are Bindu and Janak (2013), these Reserchers used a geospatial approach to assess and model the spatial accessibility of primary Health Care facilities in the tribal Talukas of the Vadodara District of Gujarat State of India.Findings showed that, the locational pattern of the PHC in the study area was randomly dispersed as obtained by Average Nearest Neighbor analysis and all such PHCs are overburdened, serving large population as per the norms, where 8 PHCs were serving total population of more than 22,000 which goes up to 51,000.In terms of the time and distance, findingsalso convey that, the central and southern villages of the study area were relatively accessible as compared to the eastern and northern villages.The analysis suggest that the population of the study area can optimally be accommodated by allocating only a few new facility but emphasis

has to be given to improving the connectivity especially in the inaccessible area which are rendered as dark zone on the basis of poor road connectivity.

Murad (2011) created a GIS-Based spatial profile for exploring health services supply and demand in Jeddah city, Saudi Arabia.Level of accessibility was identified using accessibility indicators scores. Also a demand based catchment area was created to define the growth and extent of health catchment area. The outputs of his application provides health planners with spatial tools for evaluating the location of health services supply and demand and considered as a spatial decision support system for health planners in the city.

Abdurrahman and Nurünnisa (2013)explored the potential use of GIS for modeling the spatial distribution and accessibility of the health care delivery system in Yola. Several digital and non-digital data sets were collected and transformed into GIS data. Spatial analysis tools, including symbols, overlay operations; Kernel Density Estimations (KDE), buffer operations, and a raster calculator were used for the analysis. All identified public and private facilities were classified as primary, secondary, or tertiary. The majority of these facilities were concentrated in Jimeta. The study also produced the three following accessibility models: (i) the distance to the health facility, (ii) the health facility-to-population ratios, and (iii) the physician-to-population ratios.The findings revealed that there were 56 health care facilities in in Yola, of which 64% were public and 36% were private. However, 71.43% of these health care facilities were located in the southern and western parts of Jimeta which reflects an imbalance of health care facility provisions in the central part of Jimeta and Yola-Town, which had the larger population sizes but a limited supply of health care facilities.Even though 71.43% of the health care facilities were located in Jimeta, Yola-Town had a higher density of physicians. Based on this analysis, it was concluded that a gross inadequacy exists in

terms of health care facilities and physicians. Thus, these results identify the need for urgent improvements in the Yola health care delivery system, including the construction of new facilities, upgrades for existing facilities, increased physician employment, and the adoption of GIS technology by Yola health care planners and policy makers for effective planning and resource allocation

Onokerhoraye (1999) examined access and utilization of modern health care facilities in the petroleum-producing region of Nigeria: a case study of Bayelsa State. The study used both cartographic and geographic information techniques to examine the spatialpattern of health care delivery facilities in one part of the oil producing region of Nigeria which in recent years has been characterized by violence as a result of perceiveddeprivation in the provision of social services by the people. The location oftertiary, secondary and primary health care services in the eight local government areasof Bayelsa state were presented against the background of the pattern of population andsettlement location. The study also examined the utilization pattern of the availableservices by a sample of households in three of the local government areas. Thefindings showed that the available health care facilities in the state were concentrated inthe northern part of the state where the population density is lower largely because it isthe upland part of the state. Conversely the central and southern part of the statewhere population and settlement density are higher, there were limited health carefacilities located in them. The inaccessibility of the available health care facilities had obviously affected the utilization of modern health care services by a vast proportion of the people in the state who still depend on traditional medical care and selfmedication. It was concluded by recommending a policy of deliberate dispersal ofhealth care services to the central and southern parts of the state where there were nofacilities. It was also

suggestedthat the community members should betrained to provide the needed staff in the primary health centers located in the smallersettlements.

Adetunji (2013) examined the spatial distribution pattern and accessibility of urban population to Health Care facilities in Ilesa Southwestern Nigeria. The findings revealed that Health Carefacilities were unevenly distributed. Health trips in Ilesa were therefore skewed towards zones with more health services. The result of the analysis of variance (ANOVA) further showed significant variations in accessibility to the facilities among the sampled population in the area. It was concluded and recommended that some of the public Health Carefacilities in the areashould be upgraded to the status of General Hospitals due to the growing nature of the town.

Michael (2011) assessed the spatial distribution of Health Carefacilities in Lokoja, Kogi State of Nigeria. The study was conducted within five (5) neighborhoods in the study area. "Nearest Neighbor Analysis" (NNA) was applied in analyzing the data to establish the distribution pattern of health centers in the study area. An indication of weak randomness was observed, which is indicative of insignificant accessibility.Ismaila (2011), analyzed the spatial accessibility of Health Care facilities in Yola, Adamawa state, Nigeria. Models of accessibility were built based on distance to Health Care facility in the state. Density of health facilities and Physicians were considered as well as health facility to population ratio. The model was tested using ArcGIS raster calculator operation. The result shows gross in-adequacy both in terms of Physicians and distance to Health Care facilities.

Lekan (2010) examined the distribution of Health Care facilities in the thirty local government areas of Osun State, Nigeria. Twelve indices, representing the totality of Health Care delivery by State and local governments in the state were used for the analysis. Findings indicated existence of gaps in access to Health Care facilities between

local government areas in the state, though the observed gap could not easily be attributed to rural-urban dichotomy. The study concluded that there was an urgent need for serious intervention on the part of the government in the provision of Health Care facilities in the state, focused on equitable distribution and accessibility to enhance regional development.

However, a number of studies have utilized Network and Neighborhood analyses within the ArcGIS software environment to analyze pattern and physical accessibility to Health Care in various parts of the world. A good example is found in the work of Brabyn and Skelly (2002) the study utilized Cost Path Analysis Network Spatial Analyst Tool to estimate the geographical accessibility of Public Hospitals in New Zealand via a road network. In this case, minimum Travel Time and distance to the closest Hospital were determined.

Ejiagha, Ojiako and Eze (2012), employed network analysis to determine the closeness of a facility and shortest route to the Health Care facilities in Enugu Urban Area of south eastern Nigeria. The study also identified areas deprived of healthcare facility within the GIS software environment. Furthermore, Muhammad, *et al*., (2014) employed both Network and Neighborhood GIS analyst tools to analyze the spatial distribution and accessibility to Health Care facilities in Giwa and Tofa LGAs of Nigeria. OD (Origin Destination) matrix was created and the average nearest neighborhood analysis was done. Findings showed that healthcare facilities are grossly inadequate, their distribution is random. Also some people travel a distance of up to 30km to access the nearest healthcare facility.

Umar (2016) analyzed the spatial distribution of PHC facilities in some selected LGAs in Kano South Senatorial Zone, Kano State Nigeria. Data were analyzed using multiple GIS Techniques (Neighborhood and Network Analyst) and descriptive statistics. Results showed variation in the distribution of PHC facilities within the study area, with

Sumaila having the highest percentage (36.03%), Ajingi (26.13%), and Gaya (25.23%) while Rano accounted the least (12.61%). However, there was similar regularity in the spatial pattern of the facilities. Also the communities travels within the minimum range of WHO standard distance (Sumaila, (0.5 – 5.4 km); Gaya, (1 - 3.8 Km); Ajingi, (0.5 – 5.1 Km); and Rano, (0.6 - 3.6 Km)) to access some of the nearest facilities. However, the disparity between what is required of the facilities for the entire population and what is available based on WHO criteria, apparently appeared to be greatly engrossed (with a shortfall of 411 Health Posts, 32 Health Clinics and 6 primary Health Centers), where the existing coverage offers one facility to 8,833 people. Therefore, it is recommended that, more facilities should be provided and located at central places with respect to population sizes within the Senatorial District.

CHAPTER THREE

THE STUDY AREA AND METHODOLOGY

3.1 THE STUDY AREA

3.1.1 Location and Size

Funtua Local Government Area is located between Latitudes 11^0 16' 00" N - 11^0 36' 00" North of the Equator and Longitudes 7^0 08' 00"E - 7^0 24'00" East of the Greenwich Meridian. It is bounded by the following local government areas; to the north by Faskari, to the north-east by Bakori, to the west by Dandume, to the east by Danja and to the south by Giwa local government area of Kaduna State. It has an area of 448 Km^2. Thestudy area has a total of 11 electoral wards namely: Dukke, Dandutse, Goya, Angwan Ibrahim, Maigamji, Makera, Nasarawa, Angwan Musa, Maska, Sabon- Gari and Tudun- Iya wards. (Fig.3.1).

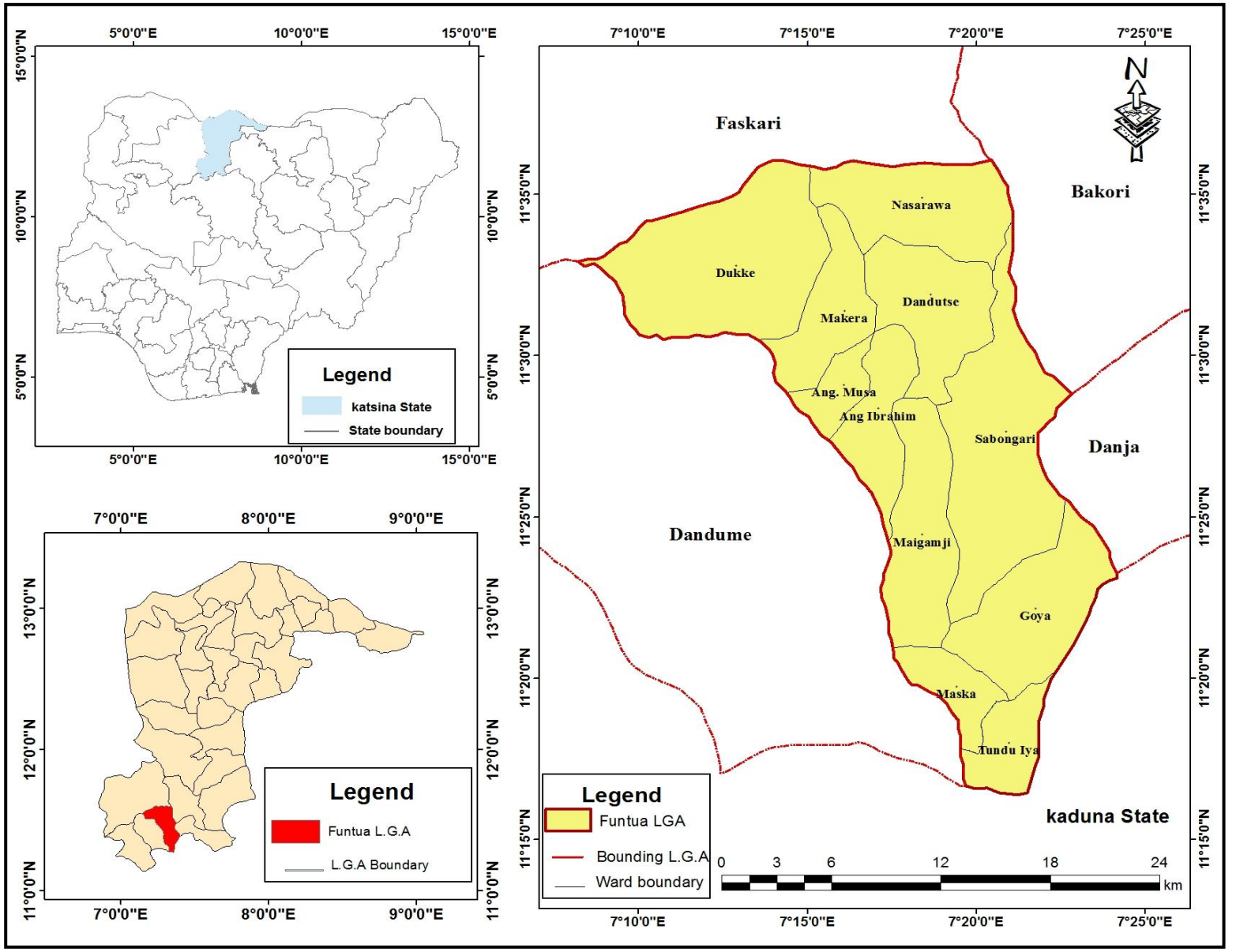

Figure 3.1: The Study Area
Source: Adapted from Administrative Map of Katsina State (2016)

3.1.2 Relief and Drainage

Funtua falls under the high plains of Hausa highlands with a gently rolling terrain. The highest places are due to gneisses and porphyroblastic granites which form a saddleback at the west. The lowlands are underlain by the more easily weathered quartz feldspar-biotite, Schist and Serpentimite of the Basement complex. The streams generally have a north-south alignment. The Ungwaguagwa-Alikeai-Yankara footpath roughly demarcates the streams flowing north from those flowing south and its watershed. Most of the streams are strike controlled (seasonal in nature) notably the River Gauri and its numerous tributaries, while others flow north-west from kondo which is thought to be "fault" controlled (Adamu,2000)

Funtua has very few rivers and lakes, many of those present are either intermittent/seasonal or reduced drastically in volume during the prolonged dry season (Babsal, 1998). However, it appears to be hydrographically active region because of the water resources and most rivers take their sources from the basement complex plains and pediments in the center of the state. For instance, the Gada and Bunsuru rivers take their sources from the plains and flow into Zamfara State to become tributaries to the Rima River. The Sokoto River also takes its source from this region (Babsal, 1998).

3.1.3 Climate

The climate information available in Katsina meteorological station reveal the climate of Funtua is humid-tropical climate characterized by relatively long dry season and smaller duration wet season with a cool dry harmattan season between these two major seasons. The two seasons reflect the influence of the interaction of the warm moist tropical maritime air mass and the hot and dry tropical continental air mass during the respective seasons. The two air masses meet along the Inter-Tropical Convergence Zone (ITCZ) which moves in response to the seasonal disposition of the overhead sun (Adamu, 2000)

Rainfall amounts are generally related to the thickness of the tropical maritime air mass. The tropical maritime air mass is wedged shaped and thins northwards. Consequently, when the ITCZ moves northwards over the study area in May, rainfall becomes progressively heavier and more steady, reaching its peak in August. In September, as the ITCZ moves southwards, rainfall becomes lighter and sporadic rainfall is concentrated in the months of July, August and September with figures generally less than 500mm annually. The area experience average annual rainfall of 193.3mm and a seasonal average temperature of more than 28^0C monthly. Rainfall starts from May and ends in November. However cloud cover is very low and insulation is therefore high. Average daily sunshine hours are about seven months of the year. Solar radiation is 500-550kly per day and between 70-80kly per annum and net radiation is in the region of about 95kly per year (Adamu, 2000).

3.1.4 Population and People

The predominant ethnic groups in Funtua LGA are the Hausa and Fulani. Other ethnic groups found in the area include the Yoruba, Igbo and Nupe.A great majority of the people are settled cultivators and traders. But there is a considersble number ofnomadic cattle Fulanis, whose males rear livestock, while the females hawk locally prepared fermented milk in towns and villages. A sizeable number of migrants from southern Nigeria especially the yorubas and igbos, are found and they dwel mostly in towns. Islam has been the major religion in the area with people enjoying peace and tranquility devoid of ethnic or religious intolerance. (Adamu, 2000). According to the 2006 census figures, Funtua LGA has a population of 303,149. (NPC, Katsina Office, 2009).

3.1.5 Soils and Vegetation

The soils of the areaare largely clayey (locally called "Laka") and about five meters in depth, and fine in texture. In Funtua town and its environs, the soils are more

fertile in nature. The economy crops are cotton, maize, millet, guinea corn and groundnuts. The area falls under the Northern -Guinea Savannah Zone, with a vegetation consisting of broad-leaved species with tall tussocks grasses of guinea affinities mixed up with fine-leaved of thorny trees with continuous short and feathery grass cover. The vegetation has largely been exploited by man for firewood, grazing and cultivation.

3.1.6 Health Care

Health Care services in Funtua includes: promotive (health education, food supply and proper nutrition): preventive (that is routine immunization, supply of portable drinking water, basic sanitation and the control of locally endemic diseases) ; and curative (that is supply of drugs to children and pregnant women, treatment of minor ailments delivery services and child welfare) **(**Funtua LGA PHC, 2016**)**

3.2 METHODOLOGY

3.2.1 Reconnaissance Survey

A reconnaissance survey was carried out in order to identify the healthcare facilities and get a better picture of the study area. The visit assisted the researcher to get acquainted with the research problem under investigation. In addition, one was able to interact with some residents in the study area whereupon some spot assessments were made regarding the healthcare facilities in the study area. Also, the researcher was able to collect auxiliary data through field observation that was useful for the study.

3.2.2 Types and Sources of Data

1. The geographic coordinates of the HCFs were obtainedfrom the field survey using the Global Positioning System (GPS) Garmin GPSmap 76CS receiver.
2. Checklist were used toobtain the attribute data of identified healthcare facilities from the various health facility management.The data includename of HCF,address, electoral ward, and category of healthcare e.g. dispensary, clinic,

maternity etc, and other relevant information such as ownership i.e public or private, year of establishment, availability of pharmacy, bed capacity et cetera were used for creation of geodatabase for the study.

3. Political map of Funtua LGA was obtained from Funtua LGA Secretariat
4. Road network data was generated through Open Street Mapping (OSM).
5. The documented materials from unpublished and published dissertations and thesis, journals, textbooks, internet materials, seminar, conference papers and encyclopedia were used for literature review.
6. Population data of year 2006 of the study area was also gotten from Funtua Local Government Secretariat respectively.

Table 3.1: Population Distribution by Wards

Ward	**Population (2006)**
Dandutse	33284
Dukke	34551
Goya	24982
Maska	24970
Makera	25229
Maigamji	25449
Nasarawa	25442
Sabon gari	34612
Tudun Iya	19261
Unguwar Ibrahim	24766
Unguwar Musa	30603
Total	**303,149**

Source:NPC Katsina(2016)

3.2.3 Techniques of Data Processing

3.2.3.1 Georeferencing

The administrative map of the study areawas scanned and imported into ArcGIS 10.3 version softwarefor georeferencing. Georeferencing enable us to relate space object

or raster object that has not been tied to any geographic reference to a coordinate reference system. Thereby allowing various independent GIS datasets to be brought together as overlay of geographic information. Thus, the scanned map was georeferenced.

3.2.3.2 Digitizing

The georeferenced map was digitized on-screen under the following themes: the Local government area and the political ward as polygon, LGA and ward boundary as lines also road network as lines

3.2.3.3Attribute data table

Attribute data are acquired data resources often organized in a database format, usually in tabular form and stored in a database management system. All attribute data for the health care facilities obtained from the various health care management through inventory using the checklist were typed in Microsoft excel and saved as CSV (comma deliminated) format for analysis.

3.2.4 Method of Data Analysis

Objective (i):identify, characterizeand map the health care facilities in Funtua LGA:An inventory of all the Health Care facilities were taken, this include attributes of name of facility, electoral ward, type of facility, geographic coordinates of the health care facilities obtained from the field were structured into Microsoft Excel. The reqired number of fields (columns) was added to the table and the data for all the health care facilities were entered into their corresponding records (rows).The GPS coordinates were imported into ArcGIS 10.3 interface. As such, all the shapefiles holding the relevant data layers were then spatially overlaid to create a combination of visual map of polygon, line and point feature classes.Consequently, the x and y spontaneously displayed the georeferenced location of each HCF in space, along with road network and electoral wards as reflected in their attribute tables. This aided to visualize the distribution of all the types of HCFs in the study area.

Objective (ii): analyze the distribution pattern of Health Care facilitiesin Funtua LGA: The study further built on the output map of the HCFs distribution to determine the spatial pattern. Hence, the Nearest Neighbor Analysis (NNA) inferential statistical tool in ArcGIS10.3 was used to investigate the spatial pattern in the data. This tool automatically calculated for the LGA the average nearest neighbor ratio by dividing the observed average distance by the expected average distance. NNA is the method of exploring pattern in the location data by comparing mean distance (Do) of a phenomena to the same expected mean distance (De) usually under randomdistribution.

A negative z-score indicates clustering, while a positive z-score means disperse or evenness. Moreover, the z-score usually returns a range of values between -2.58 to 2.58. Therefore, a negative z-score less than -2.58 indicates a significant clustering at 0.01 probability level. On the other hand, a positive z-score greater than 2.58 indicates a significant regularity or dispersal at 0.01 probability level (Getis and Ord 1998).

Objective (iii):determine the spatial accessibility of Health Care facilities in Funtua LGA: The WHO (1997) recommended standard for locating primary health care facilities in developing countries which proposed that the maximum distance people should travel to access primary health care facilities should not be more than 5km or 30 minutes walk along the existing raods was adopted as a criteria for determining the spatial accessibility of the health care facilities in the study area. Thus, each of the electoral ward within the the study area was represented by its geometric centroids, (the centre of the ward) this was generated randomly, and the average distance covers from each ward to each health care facility along the road network was calculated using the network analyst functionality in ArcGIS 10.3. This process involved the use of Origin Destination Matrix (OD) analyst tool. This tool is useful for representing a matrix of distances going from a set of origin locations (wards) to a set of destination locations (HCFs). The output of the OD matrix is a table containing the total distances (km) from each origin to each

destination and a supportive visual model of the cost matrix.The distance between every ward centroid and all the health care facilities were determined; also, the shortes and the farthest health care facilities to a ward in Funtua local government area were shown.

Objective (iv): examine the available facilities and personnel in the health care centres: Based on the information derived from the inventory using checklist, a file geodatabase was created using ArcGIS 10.3 version software. In order to minimize redundant data, tables were created by dividing the collected data into subject-based tables. These tables were created in Microsoft Excel and data for the file geodatabase was entered and saved asXLS format,imported into ArcGIS environment as way points and points layer were created and stored in the geo-database for queries The attributes in the file geodatabase include: name of healthcare, address, ownership, geographic coordinates of HCFs, number of health personnel, number of bed capacity, registered healthcare facilities, year of establishment, type of facility, number of nurses and doctors, availability of pharmacy, midwives, ward attendants and CHEW in public HCFs. Single query operations were performed on the database as follows:

- How many HCFs have at least a doctor?
- How many HCFs have at least a nurse?
- How many public HCFs have at least a midwife?
- How many HCFs have pharmacy?
- What is the bed capacity in the HCFs?

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter is concerned with the analysis of data collected from the fieldand discussion of results on the spatial analysis of health care facilities in the study area. The results offered reflect the spatial pattern of the health care facilities and their physical accessibility. The distribution of the available medical facilities and personnels in the various HCFs in the study area were also presented.Results are displayed with the use of tables, figures and maps according to the objectives of the study.

4.2 PHYSICAL HEALTH CARE FACILITIES IN FUNTUA LGA

The result of the data set for the identified health care facilities in the study area is displayed in Table 4.1; Table 4.2 and Figure 4.1 and Figure 4.2 respectively. The Tables and Figures show both numerical and spatial distribution of the category of health care facilities in the study area.

4.2.1 Categories of Physical Health Care Facilities

There are two categories of healthcare facilities in the study area i.e primary and secondary based on the type of services they offer; Table 4.1.

Table 4.1: Categories of Health care Facilities in Funtua LGA

Category of HCF	Absolute Frequency	Relative Frequency (%)
Primary	52	88.1
Secondary	7	11.9
Total	59	100.0

Source: Author's analysis, 2016

It could be seen from Table 4.1that a total of 59 physical health care facilities are distributed across the study area. The primary health care (PHC) facilities which are mostly provided by by the state or local government constitutes the highest percentage

(88.1%), while the Public SHC constitutes 1.7%,this signified that primary health care facilities are predominant in the study area, and this could be attributed to being the first point of contact to obtain health care services. However, it could also be due to the fact that, it requires little investment, since the hosting community are to provide the house to be used and accommodation for staff that are posted there, which are usually not more than two (Ajala, Sanni and Adeyinka, 2005). Further,disaggregating the PHC, 21 were health posts which provide mostly preventive services with little or no clinical care; 17 health clinics which were to be peripheral health facility; 5 primary health centres which were intermediate health facility and 9 health centres serving as the referral for the health clinics and primary health centres respectively.

According to Abdurrahman and Nurunnisa (2013), Secondary health care (SHC)levelprovides specialised services to patients who are referred from the primary health care level. These services are provided through out-patient and in-patient hospital services, which include general medical, surgical, and paediatric cases and community health services. Adequate supportive services, such as laboratory, diagnostics, blood bank, rehabilitation and physiotherapy are also provided.However, because Nigeria operates a mixed economy, private providers of medical health care have a visible role to play in health care delivery.Thus, the the available SHC facilities in the area are mostly provided by the private individuals and this constitutes 10.2%,this indicates that there is noadequate intervention by the private health care providers.This is similar to the findings of Mohammed *et al.*(2014) which identified only primary and secondary health care facilities in Giwa LGA of Kaduna State.The tertiary health care facilitiesconsists of highly specialised services,such as orthopaedic, eye, psychiatric, and paediatric cases. These services are provided by teaching hospitals and at specialist hospitals. Appropriate support services are incorporated into the development of these tertiary facilities to provide effective referral services. The absence of tertiary health care facilities in the

study area might be attributed toits proximity to Ahmadu Bello University Teaching Hospital (ABUTH), Shika in Kaduna State.

Table 4.2: Distribution of Public and PrivateHCFsbased on wards

Ward	**Public**		**Private**	
	Number of HCFs	Percentage	Number of HCFs	Percentage
Dukke	15	28.3	0	0.0
Ung. Ibrahim	0	0.0	0	0.0
Maigamji	7	13.2	2	33.3
Dandutse	1	1.9	0	0.0
Sabon-Gari	3	5.7	2	33.3
Nasarawa	1	1.9	0	0.0
Maska	4	7.5	0	0.0
Ung. Musa	1	1.9	1	16.7
Goya	5	9.4	0	0.0
Makera	9	17.0	1	16.7
Tudun Iya	7	13.2	0	0.0
TOTAL	**53**	**100.0**	**6**	**100.0**

Source: Author's Analysis, 2016

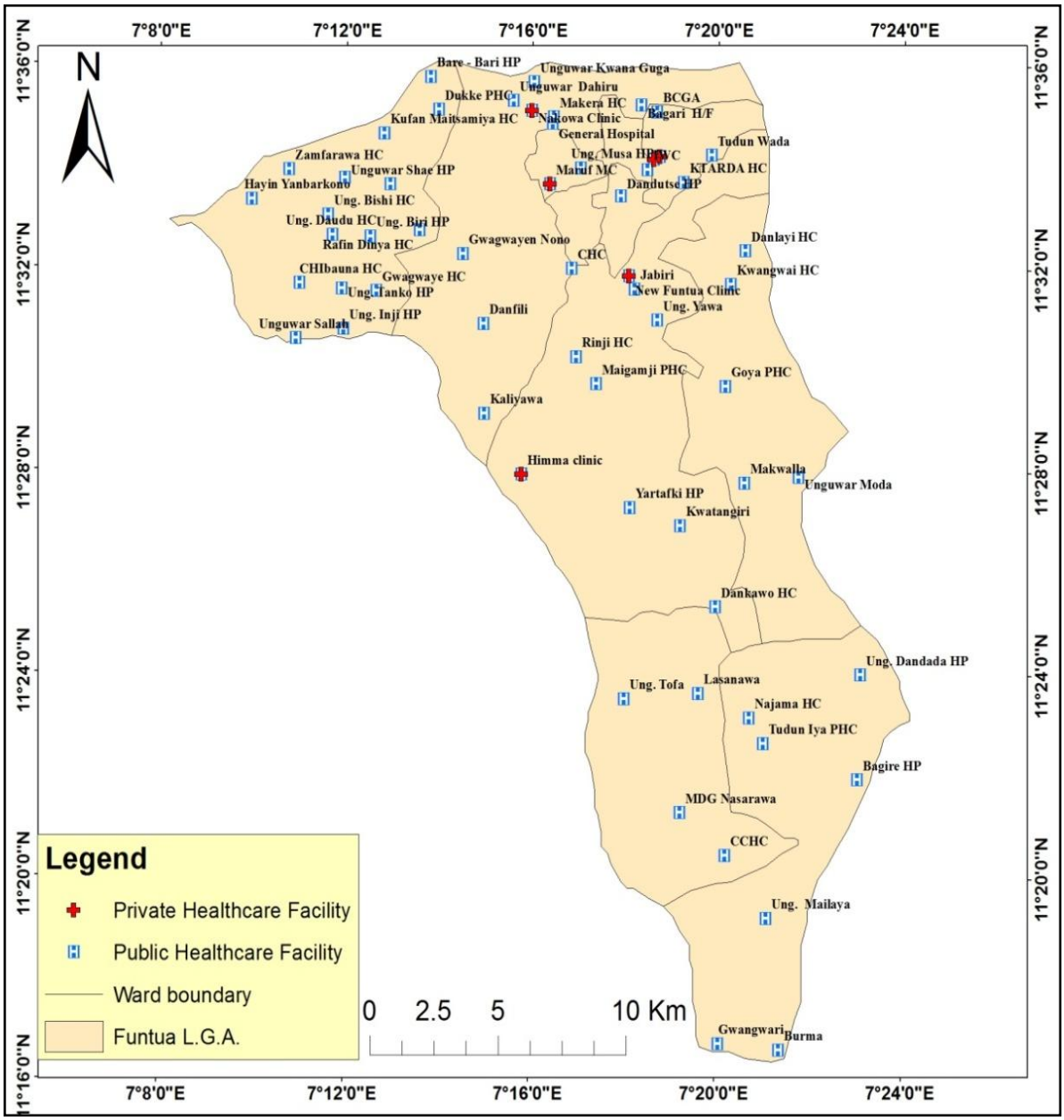

Figure 4.1: Distribution of Private and Public Health Care Facilities
Source: Author's Analysis,2016

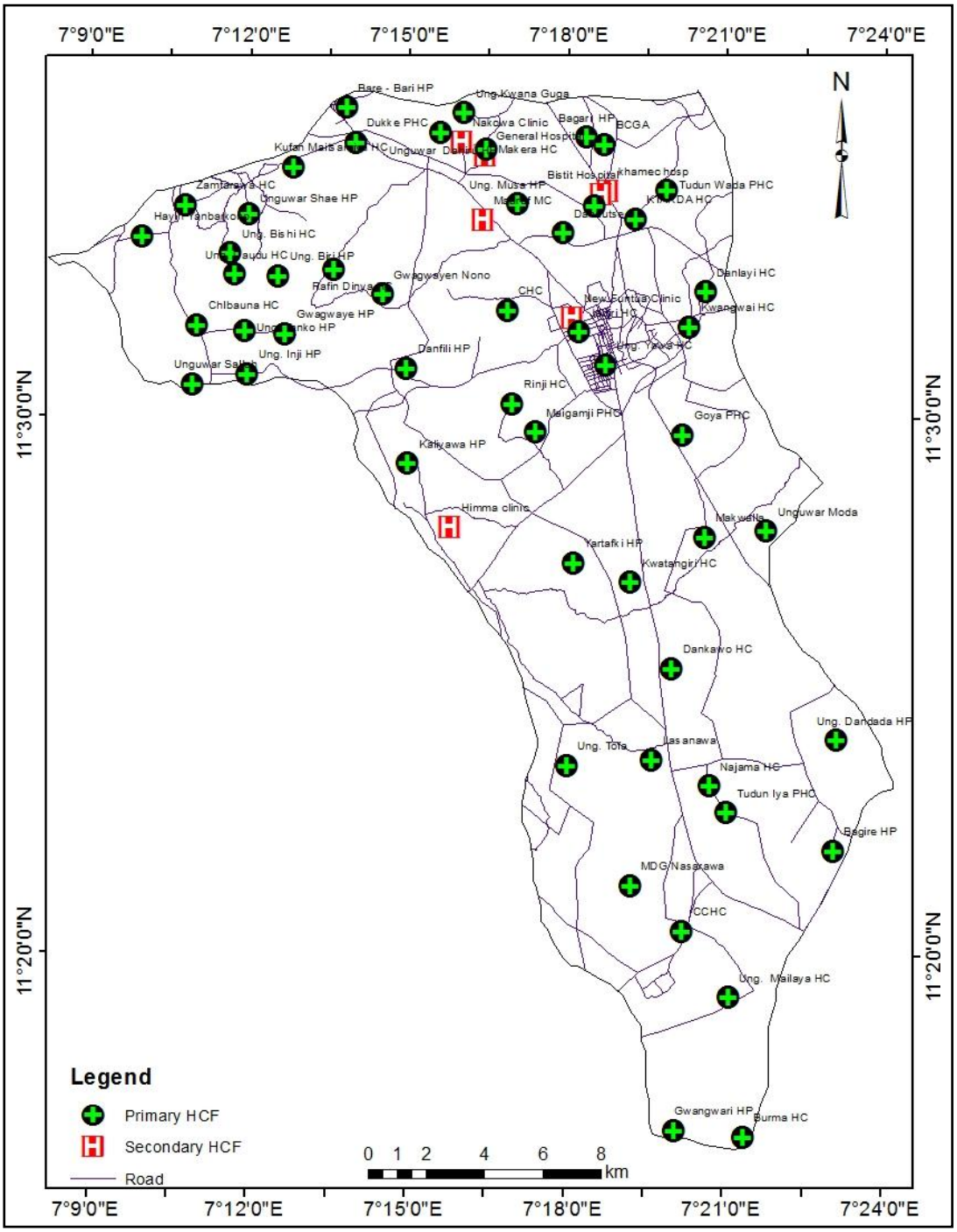

Figure 4.2: Spatial Distribution of Health Care Facilities in Funtua LGA
Source: Author's Analysis, 2016

FromTable 4.2 it could be seen that out of the total 59 HCFs, 53 whichconstitutes 89.8% are public health centers while 6 (10.2%) are privatehealth centres. However, Dukke ward had the highest percentage(28.3%) of the public health care facilities while 0.0% of the private health centrewas foundin this ward, Makera ward constituted9 (17.0%) of the public facilities, Maigamji and Tudun Iya 7 each (13.2%) of the public facilities with 16.7% of private Health Care facilities, Unguwar Ibrahim had the least of HFC at 0.0% both in the public and the private.The situation in the study area is

incontrary with one of the itemized agenda of the Federal Ministry of health (2009) which among its interventions recommended to strengthen the health sector in the country with effective public and private partnerships to provide to synergized efforts for improving the performance of the health system in Nigeria as there is no adequate intervention in health care provision by the private sectors.

However, Figure 4.1 shows the visual distribution of HCFs in Funtua LGA.ThePrimary health care centres are unevenly distributed across the study area with clustered distribution of these facilities inthe northen part of the area, this might be attributed to the denser population and urbanized of that area.This goes in line with Lou and Wang (2009)that said series of locational factors may be responsible for the distribution of Health Care facilities in an area, the factors may include : population size, easy access to facility from other nearby settlements,availability of approachable roads, mode of transport or impediment like water bodies, forest and rugged terrain etc.A look at the distribution suggests that health care facilities are not evenly distributed in Funtua LGA.This agrees with the findings of Abbas, Auta and Na'iya(2012) which revealed that there was inequality in the distribution of Health Care facilities in Chikun LGA of Kaduna State,the public health centreswere found to be clustered along the Eastern part ofChikun LGA inKamazou, Kujama, Kakau, Sabon Gayadistricts while 6 (33.4%)of the public health centres werefound at the southern part of the study area in Chikunand Gwagwada districts and none existed at the northwestern part of the study area. A similarity can be drawn with a study conducted by Muhammed*et al.,* (2014) that revealed inconsistency in the distribution of health facilties in Giwa LGA of Kaduna state.

4.3 SPATIAL PATTERN OF HEALTH CARE FACILITIES IN FUNTUA LGA

The distribution pattern of health care facilities in the study area was determined by average nearest neighbor in ArcGIS 10.3 software interface. The average nearest

neighbor analysis calculates the nearest neighbor index, which is a measure of the distance between each facility centroids and its nearest neighbor‘s centroid location; it then averages all these nearest neighbor distances. These parameters were used as the basis for the determining whether the distribution is random, dispersed or clustered. The spatial pattern of the health care facilities in the study area is shown in Figure 4.3while the average nearest neighbor statistics is shown in Table 4.3.

The result presented in Figure 4.2 shows the average nearestneighbor summary for the study area; the significant level and the critical level which indicates a random distribution pattern of health care facilities in the area. Furthermore, Table 4.2 shows that the nearest neighbor ratio for the spatial pattern of health care facilities in the area is 0.990271 with critical value (z-score) of -0.142957 at 0.886324 level of significance (p-value). According to Getis and Ord (1998), the z-score usually returns a range of values between -2.58 to 2.58; therefore, a negative z-score less than -2.58 indicates a significant clustering at 0.01 probability level. A range of scores between both 2.58 to -1.96 at 0.05 significant level and -1.96 to -1.65 at 0.10 probability level shows that there is tendency towards a clustered pattern. A range of z-scores between -1.65 to 1.65 indicates a random distribution. Again, if the z-score lies between both 1.65 to 1.95 at 0.10 significance level and 1.96 to 2.58 at 0.05 probability level then it is obvious that there is tendency towards a regular pattern . Therefore, since the z-score is approximately -0.14 which is is less than the standard critical value of 2.58 as measured by Getis and Ord (1998), then the pattern is significantly even with greater than 1% (0.01 level of significance), this affirms that the locational pattern of Health Care facilities in the study area is statistically random.

Table 4.3: Summary of Average Nearest Neighbour Statistics

Average Nearest Neighbour Summary

Observed Mean Distance:	1635.8415 Meters
Expected Mean Distance:	1651.9123 Meters
Nearest Neighbor Ratio:	0.990271
z-score:	-0.142957
p-value:	0.886324

Source: Author's Analysis, 2016

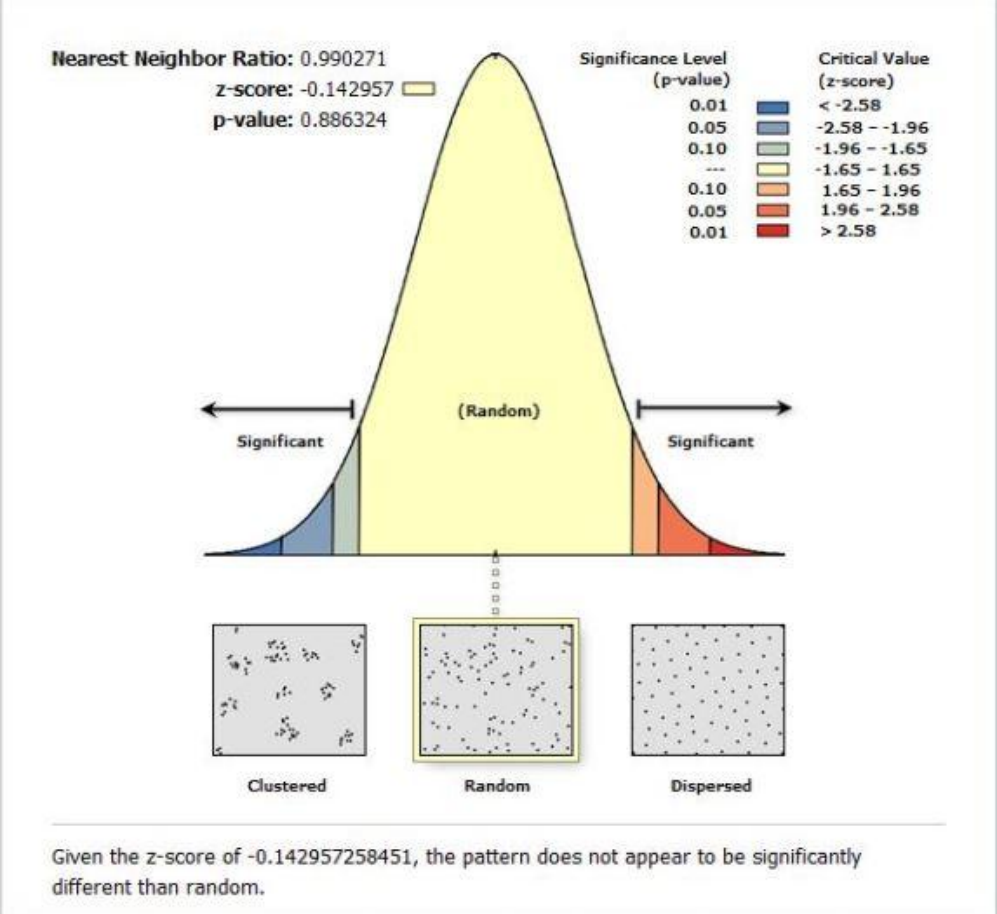

Figure 4.3: Pattern of Health Care Distribution in Funtua LGA
Source: Author's Analysis, 2016

In the contrary, the result further differs with many research findings, including among the other, the work of Kibon and Ahmed (2012) who discovered that pattern of

health care facilities in Kano metropolis, Kano State of Nigeria was clustered and haphazardly distributed. Likewise, Musa and Abdulhamed (2012) findings revealed that the health care facilities in Jigawa State, Nigeria were unevenlydistributed. Also, Umar (2016) in his study of spatial distribution of health care facilities in Kano South senatorial zone revealed that the locational pattern of primary health care facilities in the area was dispersed as shown by the Average Neares Neighbour analysis.

4.3 SPATIAL ACCESSIBILITY TO HEALTH CARE FACILITIESIN FUNTUA L.G.A

Accessibility can be assessed by either measuring the distance from residence to the Health Care facility (linear distance or road distance) or by estimating travel time. Analyses performed in this section were based on the measurement of the accessibility of people residing within the boundaries of the LGA to the Health Care facilities. Therefore, analyses rest upon the spatial relationship between the centers of settlement and Health Care facilities. In this regard, with ArcGIS Network Analyst, an origin-destination (OD) cost matrix was created for each political ward; this was to identify areas where Health Care facilities are located at points that command a high degree of centrality and vice-versa.

4.3.1 Spatial Analysis of Origin-Destination (O-D) Cost Matrix in Funtua LGA

The Table showing results of spatial Analysis of Origin-Destination cost matrix in Funtua LGA is shown in Appendices IV-XIV. The spatial pattern in Figure 4.4 is the supportive visual map of the O-D cost matrix showing the accessibility of Health Care facilities in the area. The figure presents all the cost mediums inform of lines which connects the origins as wards and the destinations as Health Care facilities via transport network. The built up road network dataset in the edges and vertices in ArcCatalog assisted in establishing the efficiency of the road network within ArcGIS 10.3 software

interface. Thus, the accessibility matrixes presented the spatial connectivity of each node in the transport network.

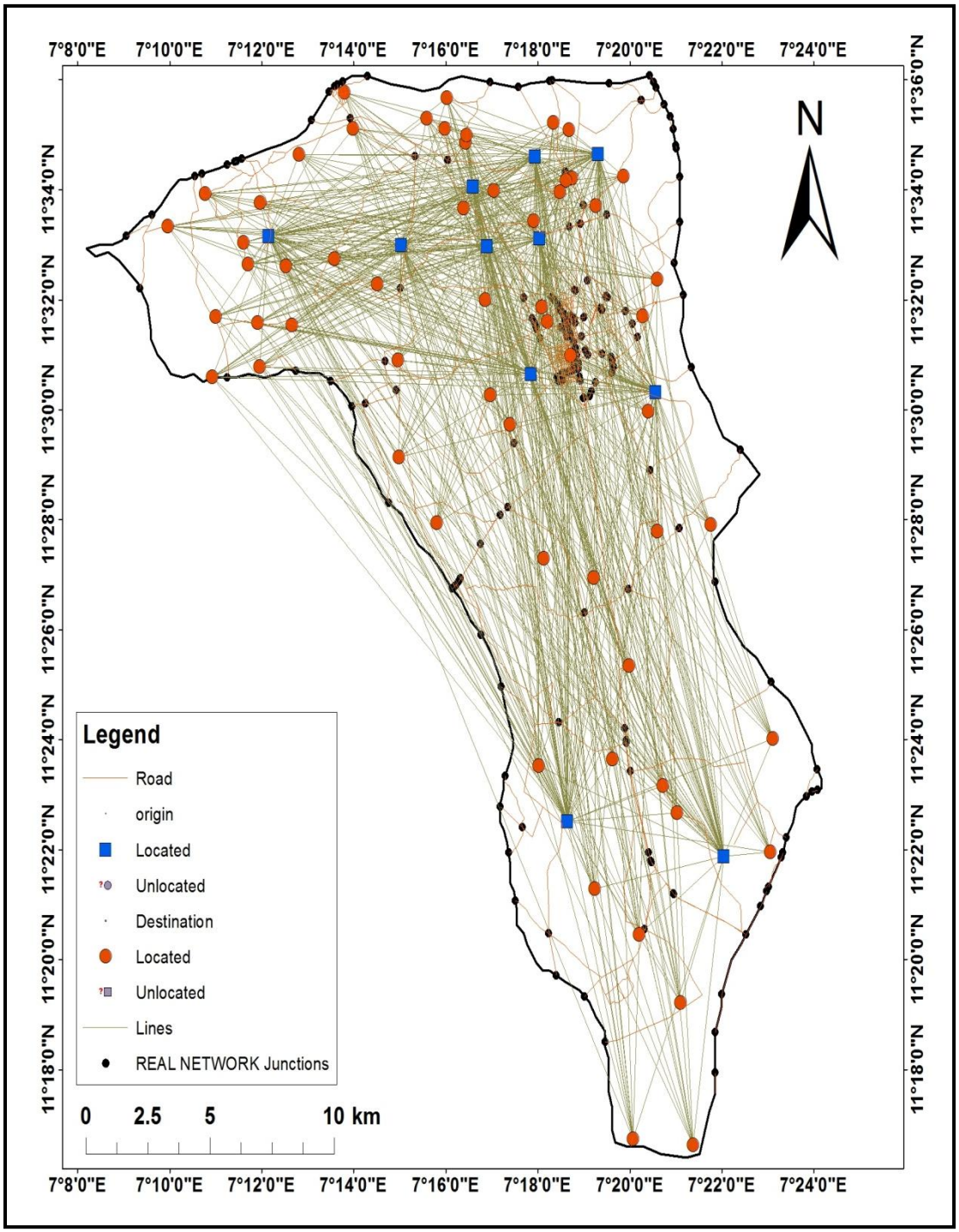

Figure 4.4: Origin-Destination Cost Matrix Model of Funtua LGA
Source: Author's Analysis, 2016

It could be seen from Figure 4.4 that each of the located origin (ward) is connected via the transport network to all the located destinations (Health Care facilities) as displayed by a series of connectivity of lines as crow flies from where distances were measured. This means that, each ward has access to all the available Health Care facilities along the existing road network within this area when the need arises, although this depend upon individual choice to patronize those closed by or far away from their residence and the affordability of transport fare.This result agrees with Umar (2016) findings shows that all the wards in the selected LGAs of Kano south senatorial district, Kano had access to all the available Health Carefacilities along the existing road networks as shown by the origin-destination cost matrix analysis.The results obtained helped in identifying the areas that are easily accessible in terms of Health Care facilities within the standard distance recommended by WHO. The results in Table 4.4 shows the wards, the minimum, the maximum and the average distances covered along the road network to access the nearest Health Care facilities among the facilities in each of the electoral ward.

Table 4.4: Origin-Destination Matrix from Wards' Centroid toHealth Care Facilities in Funtua LGA

Electoral Ward	Minimum distance to the nearest facilities (m)	Minimum distance to the nearest facilities (km)	Maximum distance to the nearest facilities (m)	Maximum distance to the nearest facilities (km)	Average distance to the nearest facilities (m)	Average distance to the nearest facilities (km)
Dukke	1019.48	1.02	34798.49	34.80	12458.38	12.46
Makera	1627.47	1.63	32322.50	32.32	10303.51	10.30
Ung. Musa	827.94	0.83	33311.77	33.31	10530.62	10.53
Ung. Ibrahim	1587.77	1.59	31217.47	31.22	9918.01	9.92
Nasarawa	1339.73	1.34	33749.92	33.75	11284.62	11.28
Sabongari	1240.75	1.24	33446.31	33.45	12172.59	12.17
Dandutse	637.59	0.64	31015.99	31.02	10240.46	10.24
Maigamji	1675.58	1.68	26646.39	26.65	9876.92	9.88
Goya	701.58	0.70	25300.29	25.30	11749.54	11.75
Tudun Iya	1833.81	1.83	30489.90	30.49	19321.76	19.32
Maska	2183.00	2.18	25970.48	25.97	16872.35	16.87

Source: Author's Analysis, 2016

The result of the O-D cost matrix as shown in Table 4.4 indicates that the minimum distance from the communities to the nearest facility is 0.64 Km and the

maximum distance is 34.80 Km. The result revealed that Dandutse ward had the highest access to the nearest Health Care facility with a minimum distance of 0.64Km, while Maska ward had the least access to the nearest facility with a minimum distance of 2.18Km. While, Goya ward had the lowest distance from its household within the ward to the farthest Health Care facility with a maximum distance of 25.30Km, Dukke ward had the longest distance from the ward to the farthest Health Care facility with a maximum distance of 34.80Km. The result indicated that Maigamji ward was more centrally located to all Health Care facilities within the study area with an average distance of 9.88km from its closest facility to the farthest. This implies that households within Maigamji were well served and have access to different types of Health Care with Tudun-Iya ward been the least served with an average distance between the closest facilities to the farthest facility of 19.32km. This means that households within the ward had to travel farther to access particular type of facility that was not available within the ward. Hence, all these variations interms of spatial accessibility to Health Care facilities in those locations might have restricted movement in the deprived areas due to the frictional effect of distance. Thus, in CPT, movement is recognized by the frequent reference to distance and travel cost which affect the range of service and the size of the complementary region within which it is offered. However, another look at the spatial accessibility of the facilities in the study area shows that, some areas such as, Dandutse, Goya, Ung.-Musa and Dukke covers a range of 0.64-1.02 km only to access some of the nearest Health Care services within the study area.

Table 4.5: Closest Routes to Health Care Facilities in Funtua LGA

S/N	Ward	Health Facility	Distance (m)	Distance (km)
1	Dandutse	Dandutse HP	438.67	0.44
2	Dukke	Ung. Biri HP	627.13	0.63
3	Goya	Goya PHC	111.73	0.11
4	Makera	Ung. Musa HP	135.41	0.14
5	Maska	Ung. Musa HP	545.70	0.55
6	Maigamji	Ung. Musa HP	1338.24	1.34
7	Nasarawa	Bistit Hospital	1379.13	1.38
8	Sabongari	BCGA	1029.24	1.03
9	Tudun Iya	Tudun Iya PHC	2462.94	2.46
10	Ung. Ibrahim	Maruf MC	1465.00	1.47
11	Ung. Musa	Maruf MC	294.76	0.29

Source: Author's Analysis, 2016

4.3.2 Shortest Distance

AnalysisAnother analysis performed with regard to spatial analysis of accessibility to Health Care facilities is the "shortest distance" analysis. This analysis was performed to enable us see the closest route to Health Care facilities (Fig 4.5).The shortest route to Health Care facilities is seen moving along the meandring of the roads against the straight lines or as crow flies as seen in O-D Cost Matrix Model. Hence, the closest facility was that of Goya to Goya PHC which is 0.11 km, followed by Makera to Unguwar-Musa HP (0.14 km), Unguwar Musa to Maaruf Medical Center (0.29km), Maska to Ungwar Musa HP (0.55km), Dandutse to Dandutse HP (0.44 Km) and Dukke to Unguwar Biri (0.6 Km). The farthestof the closest route was that of Tudun-Iya which was 2.46 Km.This means that a person who resides there could reach the closest Health Care center by car in less or no more than 5 minutes given the low population density and easier traffic in this part of the LGA. By public transport this may take longer but still within the 30 minutes considered acceptable by (Rovali and Kiivet, 2006)

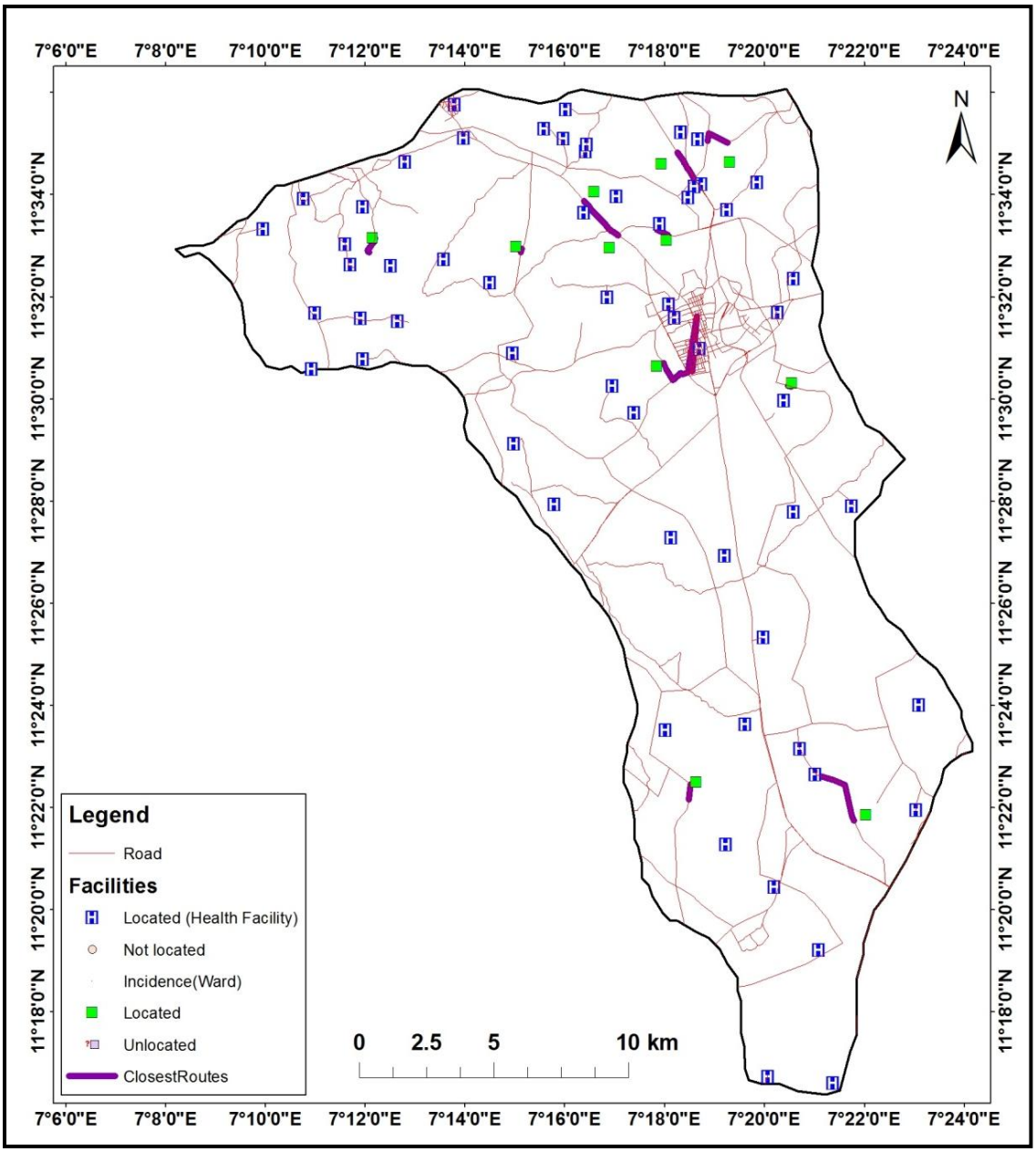

Figure 4.5: Shortest Route Distance Analysis
Source: Author's Analysis, 2016

4.5 AVAILABLE FACILITIES AND PERSONNEL IN THE HEALTH CARECENTRES

The spatial database which consist these attributes: name of Health Care facility, ownership, year of establishment, bed capacity, number of doctors, number of nurses, number of midwives, number of ward attendants and category of Health Care. Query operations were performed from the database created in orderto provide answers to questions asked in the study area.

There are two basic queries criterions, it is either multiple or single. Single query brings out one field result while multi-criterion brings more than one field to generate result. Single query were employed in this study to answer specific questions using query builder for basic commands. Results of the query operations are shown in Figures 4.5 to 4.11and Tables 4.5 to 4.11. The Tables and Figures represent the summaries of some attributes of Health Care facilities and their spatial distribution within the study area based on wards.

4.5.1 Personnel

Health Care personnel according to WHO, (2000) are persons who have specialeducation on Health Care and who are directly related to provision of health care services. Health care personnel such as doctors, midwives, nurses, pharmacists, and ward attendants available at the various health care facilities were examined based on wards to see their distribution across the study area.

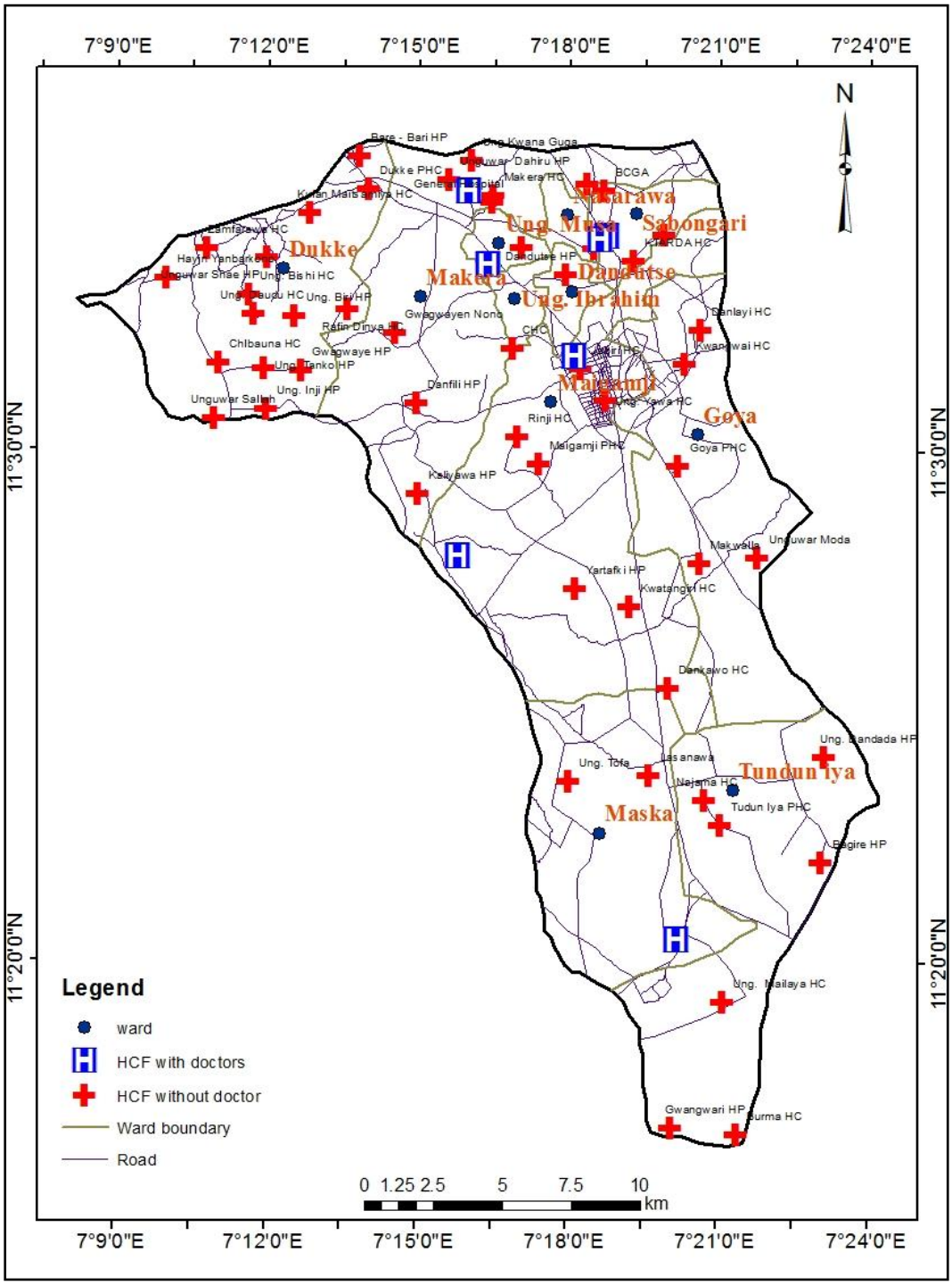

Figure 4.6: Health Care Facilities with Doctors in Funtua LGA
Source: Author's Analysis, 2016

Table 4.6: Ward Distribution ofHealth Care Facilities with Doctors

Wards	PHC Number of doctors	SHC Number of doctors	Total	Percentage (%)
Dukke	0	0	0	0.0
Ung.Ibrahim	0	0	0	0.0
Maigamji	0	2	2	28.5
Dandutse	0	0	0	0.0
Sabon-Gari	0	2	2	28.5
Nasarawa	0	0	0	0.0
Maska	1	0	1	14.2
Unguwar Musa	0	1	1	14.2
Goya	0	0	0	0.0
Makera	0	1	1	14.2
Tudun Iya	0	0	0	0.0
Total	**1**	**6**	**7**	**100.0**

Source: Author's Analysis, 2016

The distribution of health care facilities with doctors in Funtua LGA could be seen in Figure 4.6. The health care facilities were found to be clustered towards the northern part, with disperse distribution towards the southern part of the study area.This might be due to the fact thatthese parts of the area are the urban centre where population is dense and of which the private health providers invested.

Furthermore, Table 4.6 revealed the distribution of doctors in HCFs across the wards, thus, it was discovered that the HCFs in the study area only have a total of 15 doctors. The result shows that 45.4% of the wards haveHCFs with at least a doctor, while 54.5 % do not have even a doctor. Maigamji and Sabon Gari wards having the highest (28.5%) HCFs with doctorswhile Maska, Makera, and unguwar Musa wards (each) has 14.2% of HCFs with doctors. Doctors in the study area were inconsistently distributed even though it was the privately owned health care facilities that recorded more than one

doctor and this were only in Maigamji and Sabon-Gari wards respectively. It was further revealed that only 14.3% of the primary health care facilities has a doctor while the secondary health care facilities has 85.7% doctors.

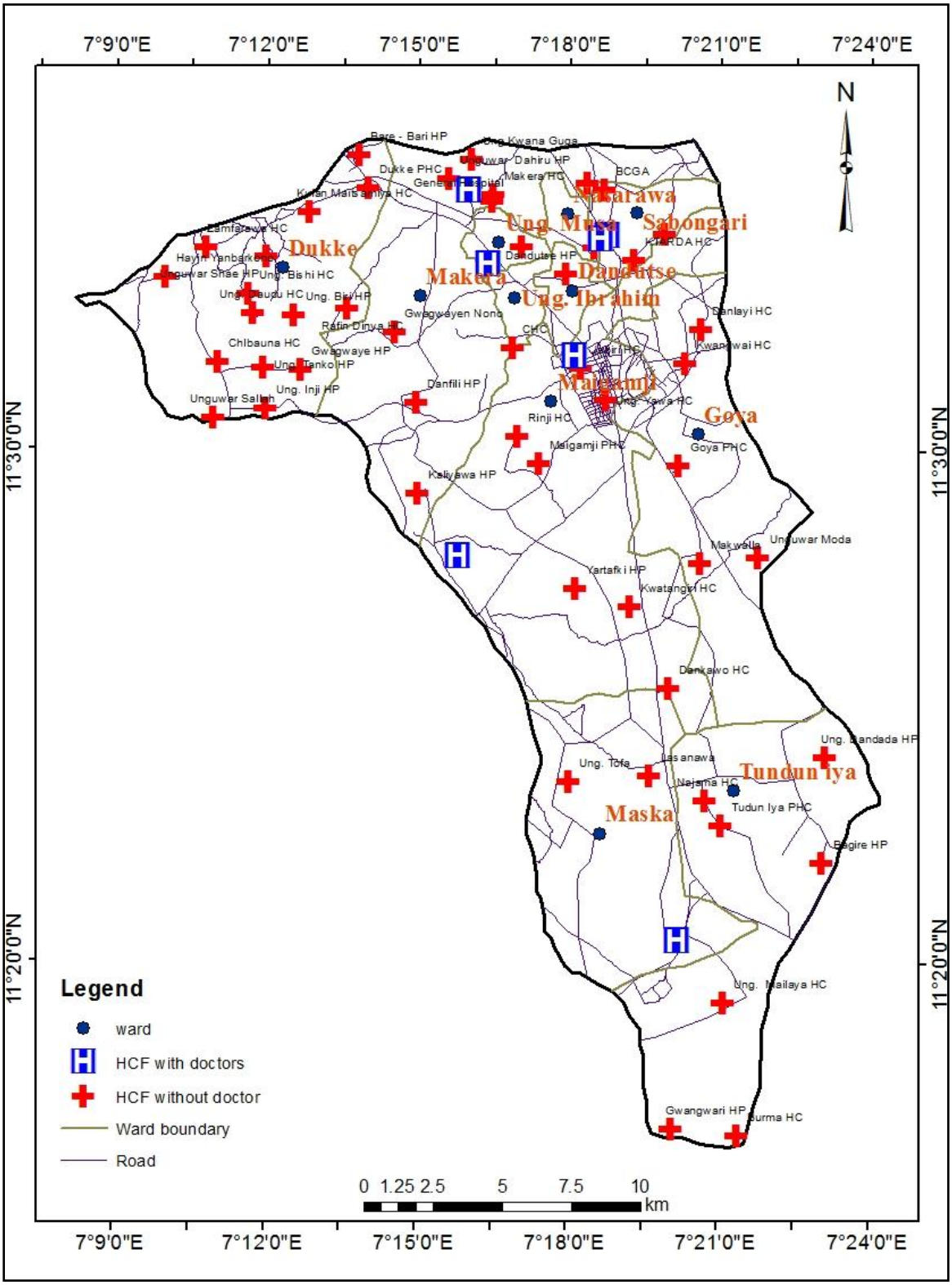

Figure 4.6: Distribution of Health Care Facilities with Doctors
Source: Author's Aalysis, 2016

Table 4.7: Wards Distribution of Health Care Facilities with Nurses

Wards	PHC Numberof Nurses	SHC Number of Nurses	Total	Percentage (%)
Dukke	0	0	0	0.0
Ung.Ibrahim	0	0	0	0.0
Maigamji	0	2	2	22.2
Dandutse	0	0	0	0.0
Sabon-Gari	0	2	2	22.2
Nasarawa	0	0	0	0.0
Maska	1	0	1	11.1
Unguwar Musa	0	1	1	11.1
Goya	0	0	0	0.0
Makera	0	1	1	11.1
Tudun Iya	2	0	2	22.2
Total	**3**	**6**	**9**	**100**

Source: Author's Analysis, 2016

Table 4.7 shows the distribution of nurses in the HCF across the eleven wards in the study area. It was revealed that there were only 31 nurses in all the HCFs in the LGA with only 15.3% of the HCFs having at least a nurse, while 84.7% do not. Maigamji and Sabon-Gari wards have the highest (22.2%), of the HCFs with at least a nurse; with no nurse in Unguwar-Ibrahim, Dandutse, Nasarawa, Maska, and Goya wards.

Furthermore, the distribution of heath care facilities with nurses is shown in Figure 4.7. It was reaveled that 66.7% of the secondary health care facilities had at least a nurse while 33.3% of the primary health care facilities had at least a nurse. Findings revealed that most of the primary health care facilities in the study area do not have nurses;these facilities were mostly headed by Community Health Extension Workers

(CHEW). CHEW is medical personnel who plan, deliver and manage PHC services at community level.

Maigamji, Dandutse and Tudun Iya had 22.2% of nurses each, and Maska, Makera and Unguwar Musa with 11.1% each. However, health care facilities in Dandutse, Dukke, Unguwar Ibrahim, Nasarawa and Goya wards had no nurses at all. These health care facilities however, had health technicians and CHEW. Thus, the distributions of health care personnel such as nurses were inadequate.

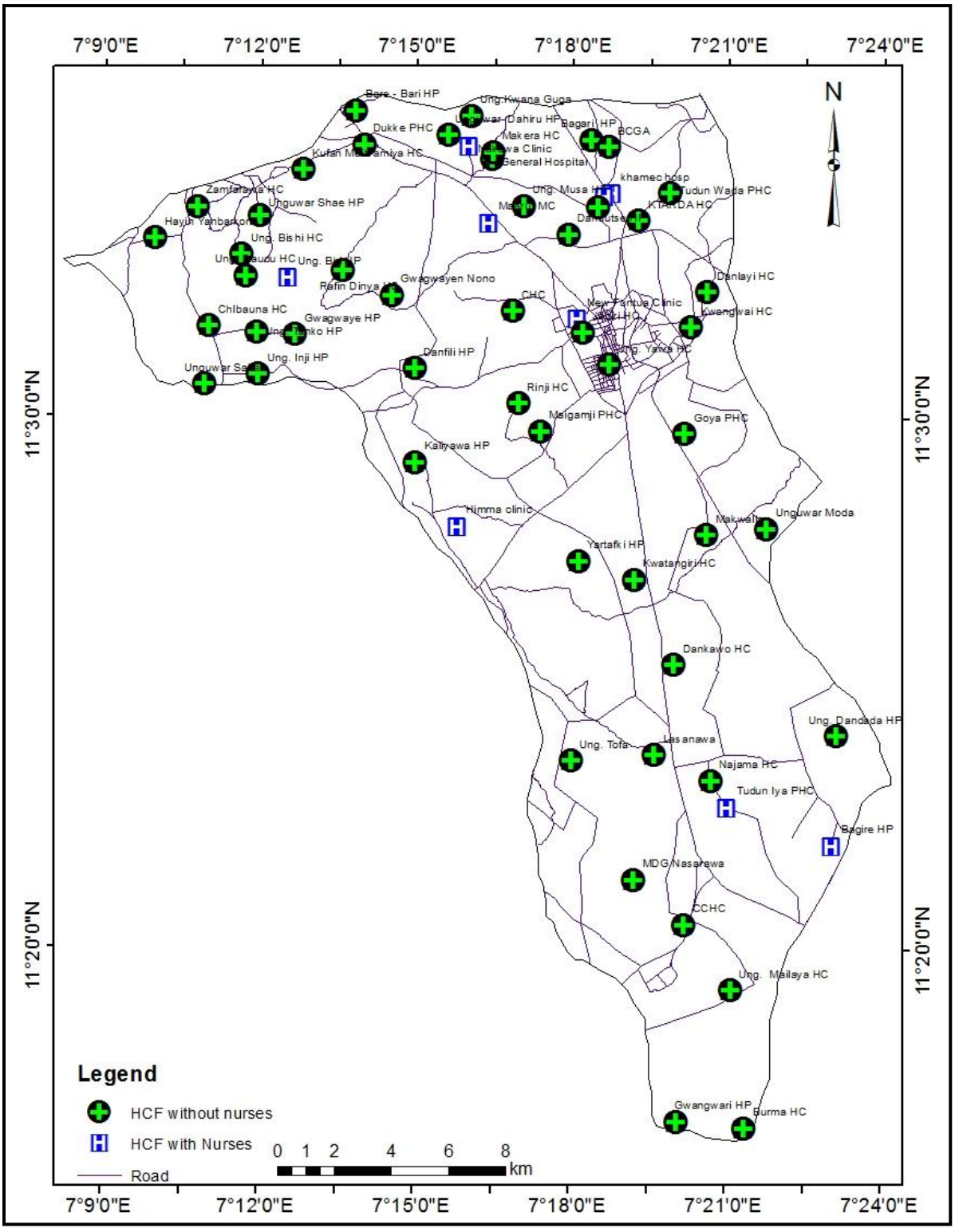

Figure 4.7: Distribution of Health Care Facilities with Nurses

Source: Author's Analysis, 2016

Table 4.8: Ward Distribution of Health Care Facilities with Midwives

Wards	(PHC) Number ofMidwives	(SHC) Number of Midwives	Total	Percentage (%)		
Dukke	1	0	1	8.3		
Ung.Ibrahim			0	0	0	0.0
Maigamji			1	2	3	25.0
Dandutse			0	0	0	0.0
Sabon-Gari			1	2	3	25.0
Nasarawa			0	0	0	0.0
Maska			1	0	1	8.3
Unguwar Musa			1	1	2	16.7
Goya			0	0	0	0.0
Makera			0	1	1	8.3
Tudun Iya			1	0	1	8.3
Total			**6**	**6**	**12**	**100.0**

Source: Author's Analysis, 2016

Table 4.8 shows the distribution of health care facilities with midwives in each ward; it was revealed that 20.3% out of 59 health care facilities in the area have at least a midwife, whereas 79.7% of the HCFs had no midwife. The result further revealed that Maigamji and Sabon-Gari wards (each) had 25.0%, followed by Unguwar Musa (16.2%), while Dukke, Maska, Makera, Tudun-Iya (each) had 8.3% of HCFs with midwives while Unguwar-Ibrahim, Dandutse, Nasarawa and Goya had 0.0%of HCF with midwife.

The distribution of these facilities for visual percepton is shown in Figure 4.8. The findings further revealed that 50.0% of the primary health care facilities had midwives; similarly, the secondary health care facilities also had 50.0% of midwives. It could be

assumed that the midwives also perform the duties of the nurses in some of the health care facilities.

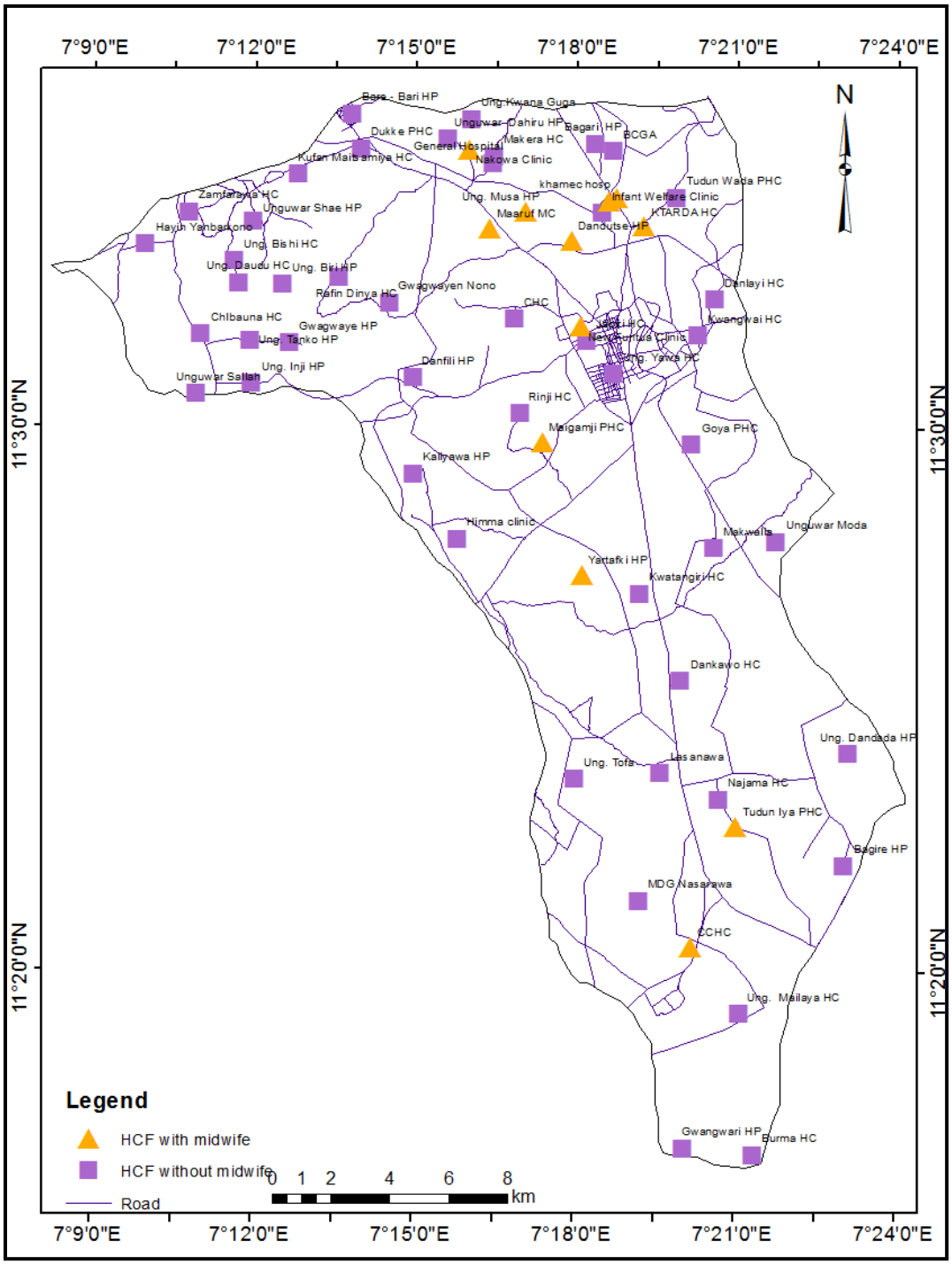

Figure: 4.8: Distribution of Health Care Facilitieswith Midwife
Source: Author's Analysis, 2016

Table 4.9: Distribution of Health Care Facilities with Pharmacists

Wards	PHC Number of pharmacists	SHC Number of pharmacists	Total	Percentage (%)
Dukke	0	0	0	0.0
Ung. Ibrahim	0	0	0	0.0
Maigamji	0	2	2	22.2
Dandutse	0	0	0	0.0
Sabon-Gari	1	2	3	33.3
Nasarawa	0	0	0	0.0
Maska	1	0	1	11.1
Ung.Musa	0	1	1	11.1
Goya	0	0	0	0.0
Makera	0	1	1	11.1
Tudun Iya	1	0	1	11.1
Total	**3**	**6**	**9**	**100.0**

Source: Author's Analysis, 2016

Table 4.9 shows the distribution of health care facilities with Pharmacists in each ward, it was revealed that 15.3% of the health care facilities in the area had at least one pharmacist, while 84.7% do not have. The result indicated that 54.5% of the wards in thestudy area hadhealth care facilitieswith atleast one pharmacist, while 45.5% had no health care facility with any pharmacist. It further revealed that Sabon-Gari had 33.3% of health care facilities with pharmacist, Maigamji (22.2%), while Maska, Unguwar Musa, Makera, Tudun Iya wards (each) had 11.1% of health care facilities with a pharmacist. However, Dukke, Unguwar Ibrahim, Dandutse, Nasarawa, Goya do not have health care facilities with at least a pharmacist.

However, it is interesting to note that some of these health care facilities are with pharmacies but no pharmacist; the nurses in most cases perform the duties of the pharmacists. The distribution of health care facilities with pharmacist is shown in Figure 4.9. The findings further revealed that 66.7% of pharmacists are found in the Secondary health care facilities while the primary health care facilities recorded 33.3% pharmacists.

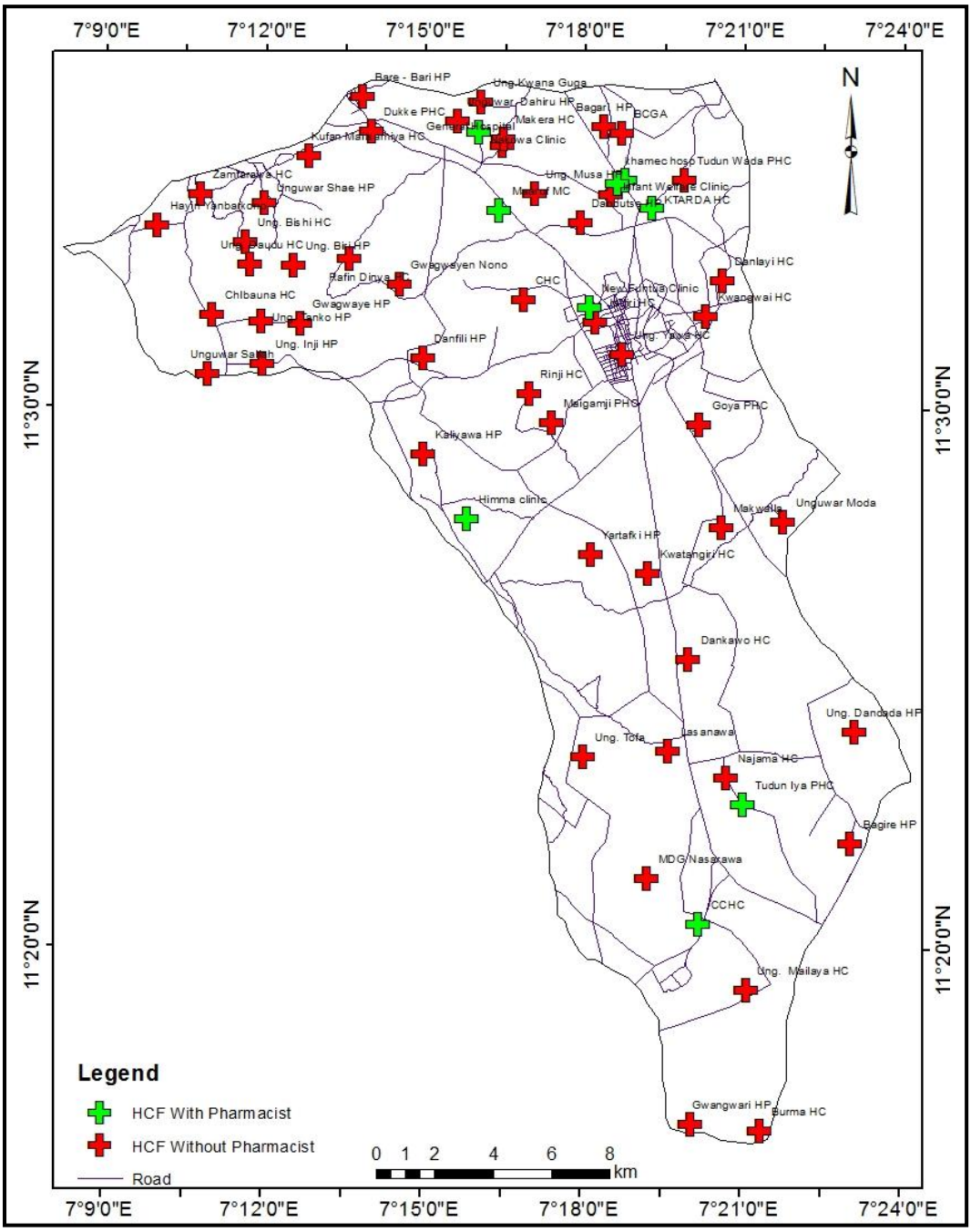

Figure 4.9: Distribution of HCF with Pharmacistin Funtua LGA
Source: Author's Analysis, 2016

Table 4.10: Distribution of Health Care Facilities with Ward Attendant

Wards	PHC Number of Ward Attendants	SHC Number of Ward Attendants	Total	Percentage (%)
Dukke	4	0	4	20.0
Unguwar Ibrahim	0	0	0	0.0
Maigamji	0	1	1	5.0
Dandutse	0	0	0	0.0
Sabon-Gari	3	2	5	25.0
Nasarawa	0	0	0	0.0
Maska	1	0	1	5.0
Unguwar Musa	1	1	2	10.0
Goya	1	0	1	5.0
Makera	1	1	2	10.0
Tudun Iya	4	0	4	20.0
Total	**15**	**5**	**20**	**100.0**

Source: Author's Analysis, 2016

Table 4.10 shows the distribution of health care facilities with ward attendant in each ward. It was revealed that 33.9% of the total 59 health care facilitiess in the area had at least one ward attendant, while 66.1% of HCFs do not have ward attendant About 72.7% of the wards in the area have HCFs with at least one ward attendant, while 23.3% do not have any ward attendant. Table 4.10 further revealed that Sabon-Gari has the highest (25.0%) HCFs with ward attendant followed by Dukke and Tudun-Iya (each) have 20.0% whereas Unguwar-Ibrahim, Dandutse and Nasarawa do not have HCF with ward attendant. It was further revealed that the primary health care facilities had a total of

75.0% of ward attendants while the secondary health care facilities had 25.0%. Figure 4.10 shows the distribution of health care facilities with ward attendants in the study area.

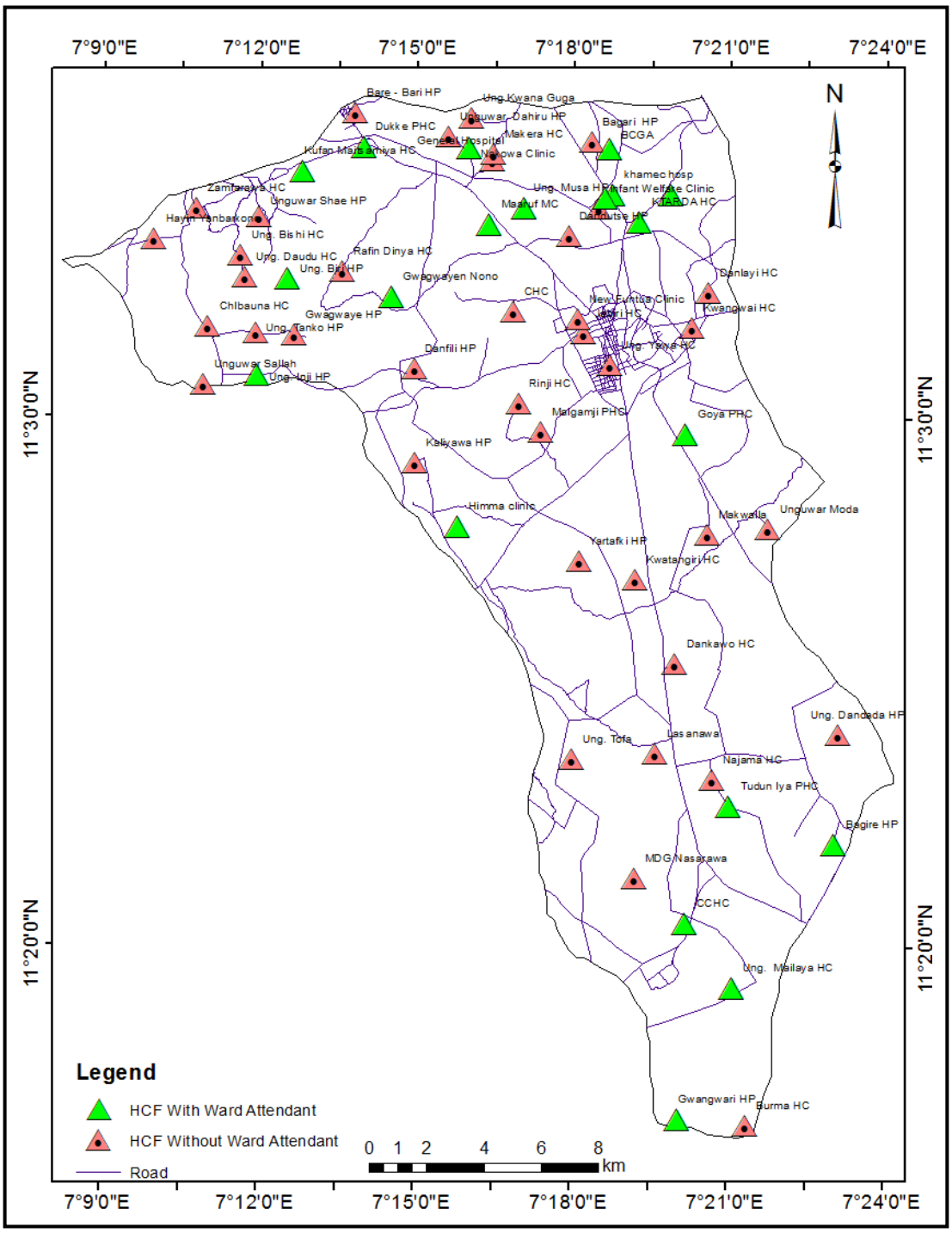

Figure 4.10: Distribution of Health Care Facilities with Ward Attendants
Source: Author's Analysis, 2016

Table 4.11: Distribution of Health Care Facilities with Bed

Wards	PHC Frequency	SHC Frequency	Total	Percentage (%)
Dukke	12	0	12	34.3
U/Ibrahim	0	0	0	0.0
Maigamji	4	2	6	17.1
Dandutse	0	0	0	0.0
Sabon-Gari	3	2	5	14.3
Nasarawa	0	0	0	0.0
Maska	3	0	3	8.6
U/Musa	0	1	1	2.9
Goya	1	0	1	2.9
Makera	2	1	3	8.6
Tudun Iya	4	0	4	11.4
Total	**29**	**6**	**35**	**100.0**

Source: Author's Analysis, 2016

Table 4.12 shows the distribution of HCF with bed in each ward, it was revealed that 59.3% of the HCFs in the area had at least one bed, while 40.7% of the HCFs do not have. About 72.7% of the wards in the area had HCFs with atleast one bed, while 23.3% do not have even one HCF with a bed. Furthermore, it was revealed that Dukke ward had the highest (34.2%) HCFs with bed followed by Maigamji (17.1%), while Unguwar Musa and Goya each accounting the least with 2.9% of HCF with bed. However, Dandutse, Nasarawa and Unguwar Ibrahim do not have HCF with bed.

Figure 4.11 illustrates the health care facilities with bed capacity.

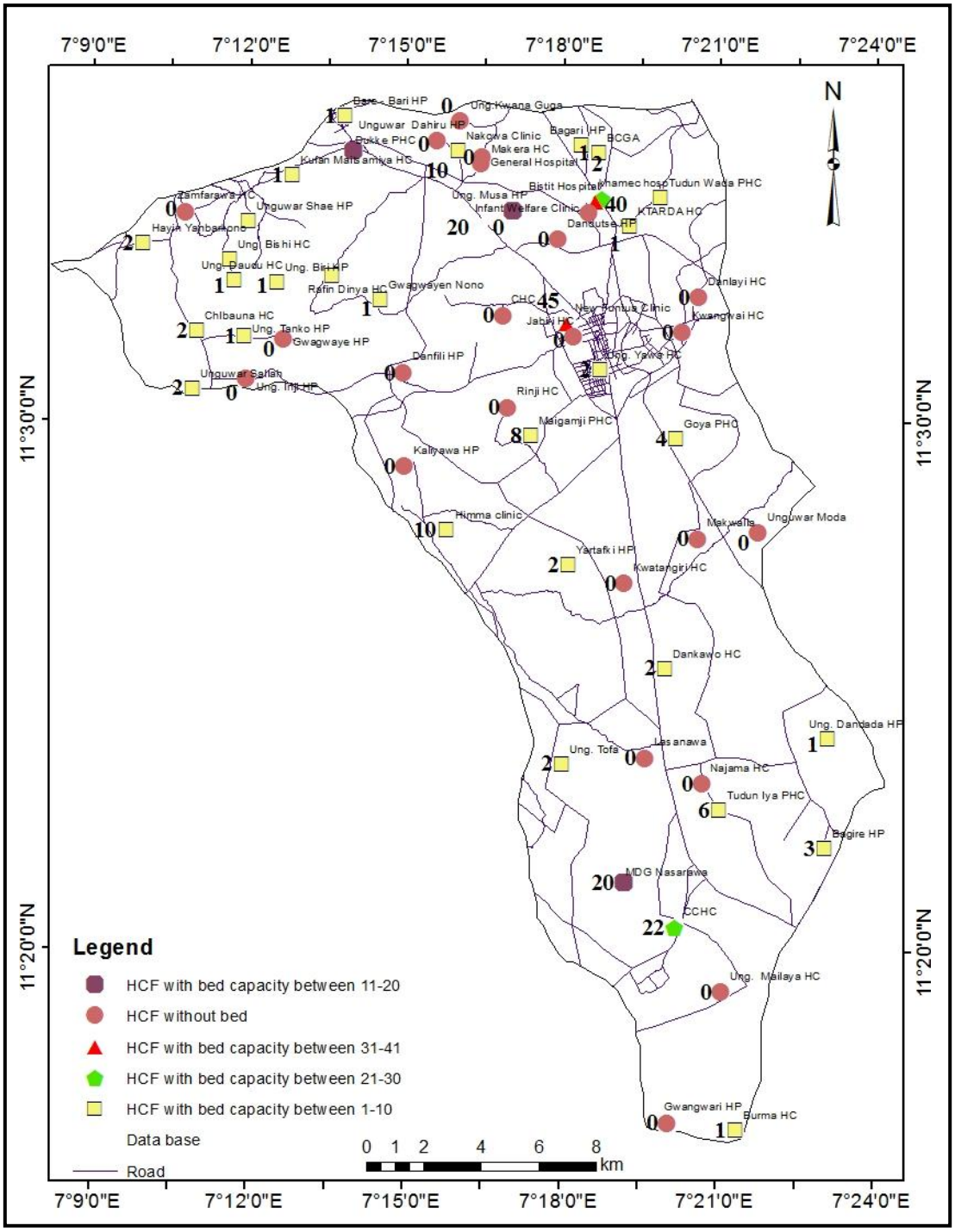

Figure 4.11: Distribution of Health Care Facilities with Bed Capacity
Source: Author's Analysis, 2016

Other attributes could as well be queried but these six attributes were queried since they are the most essential aspects of any Health Care facilities. However, other attributes of the Health Carefacilities could be seen from the database created in Appendix III.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter presents the summary, conclusion and recommendations of the study. The summary highlights the distribution of Health Care facilities in terms of their pattern, availability and accessibility. The study was concluded based on findings, and recommendations were made for further studies as well as contribution to knowledge.

5.2 SUMMARY OF FINDINGS

The study employed the use of GIS techniques in mapping the distribution and analyzing the spatial accessibility of Health Care facilities in Funtua LGA. The distribution and accessibility ofthe Health Care facilities were examined based on the WHO recommended standards.

The findings revealed that 59 Health Care facilities wereprovided and distributed across the eleven electoral wards in the LGA.The primary Health Care facilities constituted 88.1% while the secondary Health Care facilities constituted 11.9%. However, 85.7% of the secondary Health Care facilities were provided by the private sectors while 14.3% of the SHC facilities are government owned. Dukke ward had the highest percentage (27.0%) of the primary health care facilities, followed by Makera (17.0%) and Maigamji (15.0%), while Unguwar Ibrahim had0.0%. The spatial pattern of the Health Care facilities in the study area was statistically proven to be random as shown by the result of the average nearest neighbour analysis. However, the OD Matrix network analysis indicated that people travels a minimum range of 0.64km-2.18km, and maximum distance of 25.30km - 34.80km to access the nearest or closets facilities in the study area.

From the closest route to facilities analysis, itwas observed that Goya ward had the closest route to Health Care facilities at a distance of 0.11km while Tudun Iya had the farthest route to facilities at a distance of 2.46km. From the database created on HCFs,

single query operationswere carried out for these attributes: the doctors, nurses, Pharmacists, bed capacity, and ward attendants. The result showed that 12% of the HCF had at least a doctor while 88% of the HCFs do not have any. Also, 15% of the HCFs had at least a nurse while 85% do not have. It was revealed that 33.9% of the HCFs in the area had at least one ward attendant, while 66.1% of HCFs do not have. It was also revealed that 59.3% of HCFs in the area had at least one bed, while 40.7% of the HCFs do not have. It was further discovered that 15.3% of the HCFs in the area had at least one pharmacist, while 84.7% do not have.

5.3 CONCLUSION

The distribution of Health Care facilities in Nigeria has been characterized by significant disparity. Such disparity is shown in the ways some of these facilities are concentrated in one area at the expense of others. This often resulted in spatial inequality that characterizes Nigeria's socio-political landscape hence this study assessed the spatial accessibility to Health Care facilities in Funtua LGA using multiple GIS analytical tools. The result shows that the study area is fairly provided with primaryHealth Care facilities. However, it was unevenly distributed given the concentration of Health Care facilities in Dukke ward which was around the center of the town while other wards were inadequately served. Thus, this disparity in the distribution of health facilities has generated different accessibility level to Health Care facilities in the LGA. This therefore calls for the concerted effort by the various stakeholders in the health sector towards the provision of Health Care facilities in order to improve access to the Health Care facilities by the people.

5.4 RECOMMENDATIONS

In the light of the problems associated with accessibility toHealth Care facilities as revealed in this study; it therefore recommends that;

i) Government and the Non-govrernmental organization should provide Health Care facilities in the wards that do not have HCF. These wards include Unguwar Ibrahim, Dandutse and Unguwar Musa wards. This will further improve access to Health Care facilities in the study area.

ii) Government should ensure that medical personnels are been employed and posted to all the public Health Care facilities in the study area since they are easily accessed by the populace. Also, the medical personnel posted in the rural areas should be given special incentives to stay.

iii) Dilapidated Health Care facilities in the study area should be rehabilitated and upgraded both the buildings and the medical facilities.

5.5 SUGGESTIONS FOR FURTHER STUDIES

The following areas are recommended for further studies:

i) The Socio-economical impact of accessibility to Health Care Facilitiesin Funtua LGA

ii) Analysis of Health Care Delivery system in the study area.

5.6 CONTRIBUTIONS TO KNOWLEDGE

This study contributes the following to the body of knowledge within the study area.

i) Various maps were generated for visual understanding of the distribution of Health CareFacilities in the study area. Thus, the categories and ownership of Health Care facilities were visually displayed.

ii) The distance along the existing roads and as the crow flies from each ward to every available Health CareFacilities were not only visually displayed in the map but were also known.

iii) The shortest route to facilities from each electoral ward to Health CareFacilities was also determined in the study which will aid anyone to know the Health CareFacilities that is easily accessible in case of emergency.

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Appendix I:Checklist

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This checklist is designed to obtain information for a research study titled: **Spatial Analysis of Accessibility to Health Care Facilities in Funtua Local Government Area of Katsina State.** The study is an academic research leading to the award of Master of Science in GIS and Remote Sensing. I solicit for your support to provide adequate and accurate information as all information provided will be used for academic purpose and treated as confidential.

Thank you.

A.Y. Oyewole

P13SCGS8203

1. Physical Health Care Facility Geographic Coordinates: Northing……Easting…….....
2. Ward……
3. Name of Health Care Facility……..
4. Year of Establishment……
5. Ownership……..
6. Number of Doctors…….
7. Number of Nurses…….....
8. Number of midwives…….
9. Number of Pharmacists……..
10. Number of Lab Technicians……..
11. Number of Opticians……..
12. Number of ward attendants……
13. Number of Cleaners……
14. Number of Community Health Extension Workers (CHEW)……
15. Number of Wards……
16. Bed Capacity…….....
17. Availability of Laboratories……
18. Number of Ambulances……...

19. Surgical Theatre…….
20. X-ray/Ultrasound…….
21. Pharmacy Store…….
22. Delivery Room……..
23. Emergency Room…….
24. Admin.Block…….
25. Borehole/Tap water……
26. Well water…….
27. Generator……

Appedix II: Inventory of Health Care Facilities in Funtua LGA

S/N	Name of Facility	Ward	Type of Facility	Latitude	Longitude
1	Zamfarawa HC	Dukke	Health Clinic	11.5655	7.17943
2	Ung. Bishi HC	Dukke	Health Clinic	11.5506	7.19347
3	Ung. Daudu HC	Dukke	Health Clinic	11.544	7.19503
4	Chibauna HC	Dukke	Health Clinic	11.5281	7.18331
5	Ung. Tanko HP	Dukke	Health Post	11.5264	7.19848
6	Gwagwaye HC	Dukke	Health Clinic	11.5256	7.21091
7	Rafin Dinya HC	Dukke	Health Clinic	11.5457	7.22625
8	Ung. Biri HP	Dukke	Health Post	11.5435	7.20868
9	Dukke PHC	Dukke	Pry Health Centre	11.5852	7.23297
10	Ung. Inji HP	Dukke	Health Post	11.5131	7.19923
11	Bare - Bari HP	Dukke	Health Post	11.596	7.22999
12	Hayin Yanbarkono	Dukke	Health Post	11.5557	7.16601
13	Unguwar Sallah	Dukke	Health Centre	11.5099	7.18209
14	Unguwar Sha'e HP	Dukke	Health Post	11.5628	7.19934
15	K/ Maitsamiya HC	Dukke	Health Centre	11.5774	7.21341
16	Kaliyawa HP	Makera	Health Post	11.4856	7.24972
17	Danfili HP	Makera	Health Post	11.5151	7.24935
18	CHC	Makera	Health Centre	11.5333	7.28086
19	General Hospital	Makera	Hospital	11.581	7.27378
20	Makera HC	Makera	Health Clinic	11.5831	7.27415
21	Nakowa Clinic	Makera	Health Centre	11.5851	7.26638
22	Ung. Dahiru HP	Makera	Health Post	11.5883	7.25976
23	Ung.Kwana Guga	Makera	Health Post	11.5945	7.2671
24	Bagari HP	Makera	Health Post	11.5871	7.30557
25	Ung. Musa HP	U/Musa	Health Post	11.5663	7.28399
26	Dandutse HP	Dandutse	Health Post	11.5573	7.2984
27	Maruf MC	U/Musa	Health Centre	11.561	7.27306
28	BCGA	Sabongari	Health Centre	11.5849	7.31122
29	khamec hosp	Sabongari	Health Centre	11.5703	7.31238
30	Bistit Hospital	Sabongari	Health Centre	11.5694	7.31015
31	KTARDA HC	Sabongari	Health Clinic	11.5618	7.32096
32	I. Welfare Clinic	Nasarawa	Health Clinic	11.5659	7.30796
33	Tudun Wada PHC	Sabongari	Pry Health Centre	11.5707	7.33097
34	Jabiri HC	Maigamji	Health Centre	11.5267	7.30343
35	New Funtua Clinic	Maigamji	Health Centre	11.531	7.30147
36	Rinji HC	Maigamji	Health Clinic	11.5043	7.28271
37	Maigamji PHC	Maigamji	Pry Health Centre	11.4955	7.2898
38	Ung. Yawa HC	Maigamji	Health Clinic	11.5165	7.31174
39	Yartafki HP	Maigamji	Health Post	11.4549	7.30217
40	Kwatangiri HC	Maigamji	Health Centre	11.4491	7.32014
41	Dankawo HC	Maigamji	Health Centre	11.4224	7.33302
42	Danlayi HC	Goya	Heath clinic	11.5394	7.3432
43	Kwangwai HC	Goya	Health Clinic	11.5284	7.33793
44	Goya PHC	Goya	Pry Health Centre	11.4949	7.33618
45	Makwalla	Goya	Health Clinic	11.4632	7.34323
46	Unguwar Moda	Goya	Health Post	11.4651	7.36262
47	Lasanawa	Maska	Health Post	11.394	7.32697
48	Ung. Tofa	Maska	Health Post	11.3921	7.30031
49	MDG Nasarawa	Maska	Health Clinic	11.3548	7.32053
50	CCHC	Maska	Health Centre	11.3408	7.33667
51	Ung. Dandada HP	T/Iya	Health Post	11.4003	7.38511
52	Najama HC	T/ Iya	Health Centre	11.386	7.3452
53	Tudun Iya PHC	T/ Iya	Pry Health Centre	11.3777	7.3504
54	Bagire HP	T/Iya	Health Post	11.3659	7.3841
55	Ung. Mailaya HC	T/Iya	Health Clinic	11.3203	7.35163
56	Burma HC	T/Iya	Health Clinic	11.277	7.35626
57	Gwangwari HP	T/Iya	Health Post	11.279	7.33453
58	Gwagwayen Nono	Makera	Health Post	11.538	7.24182
59	Himma clinic	Maigamji	Health Centre	11.4657	7.26329

Appendix III:Geo-data Base of Health Facilities in the Study Area

Name of Facility	Ward	Type of Facility	Latitude	Longitude	Ownership	Yr of Establishment	Doctors	Nruses	Midwives	Lab Tech	Opticians	W/Attendants	Cleaners	CHEW	No. of Wards	Bed Capacity	Laboratories	Ambulances	S/Theatre	X-Ray	Pharmacy	Delivery Room	Emergency	Admin. Block	Borehole	Well	Generator
Zamfarawa HC	Dukke	Health Clinic	11.5655	7.17943	Government	2000	0	0		0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
Ung. Bishi HC	Dukke	Health Clinic	11.5506	7.19347	Government	1999	0	0	0	0	0	0	0	1	1	4	0	0	0	0	0	0	0	1	0	0	0
Ung. Daudu HC	Dukke	Health Clinic	11.544	7.19503	Government	1999	0	0	0	0	0	0	0		0	1	0	0	0	0	0	0	0	1	0	0	0
ChIbauna HC	Dukke	Health Clinic	11.5281	7.18331	Government	1998	0	0	0	0	0	0	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0
Ung. Tanko HP	Dukke	Health Post	11.5264	7.19848	Government	2011	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Gwagwaye HP	Dukke	Health Post	11.5256	7.21091	Government	2010	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Rafin Dinya HC	Dukke	Health Clinic	11.5457	7.22625	Government	2008	0	0	0	0	0	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0
Ung. Biri HP	Dukke	Health Post	11.5435	7.20868	Government	2000	0	1	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Dukke PHC	Dukke	PHC	11.5852	7.23297	Government	1993	0	0	0	1	0	3	1	1	2	16	0	0	0	0	0	1	0	1	1	0	0
Ung. Inji HP	Dukke	Health Post	11.5131	7.19923	Government	1999	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bare - Bari HP	Dukke	Health Post	11.596	7.22999	Government	2000	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0
Hayin Yanbarkono	Dukke	Health Post	11.5557	7.16601	Government	2003	0	0	0	0	0	0	0	1	1	2	0	0	0	0	0	0	0	1	0	0	0
Unguwar Sallah	Dukke	Health Centre	11.5099	7.18209	Government	2000	0	0	0	0	0	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0
Unguwar Shae HP	Dukke	Health Post	11.5628	7.19934	Government	2006	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
Kufan Maitsamiya HC	Dukke	Health Centre	11.5774	7.21341	Government	2001	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Danlayi HC	Goya	Heath clinic	11.5394	7.3432	Government	2007	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Kwangwai HC	Goya	Health Clinic	11.5284	7.33793	Government	1993	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Goya PHC	Goya	PHC	11.4949	7.33618	Government	1992	0	0	0	2	0	1	1	1	2	4	1	0	0	0	0	1	0	1	0	0	0
Makwalla	Goya	Health Clinic	11.4632	7.34323	Government	1993	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
Unguwar Moda	Goya	Health Post	11.4651	7.36262	Government	2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Jabiri HC	Maigamji	Health Centre	11.5267	7.30343	Government	2011	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
New Funtua Clinic	Maigamji	Health Centre	11.531	7.30147	Private	2000	4	6	2	2	0	0	3	0	3	45	1	0	1	1	1	1	1	1	1	0	2
Rinji HC	Maigamji	Health Clinic	11.5043	7.28271	Government	2011	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Maigamji PHC	Maigamji	PHC	11.4955	7.2898	Government	2004	0	0	1	0	0	0	1	2	1	8	0	0	0	0	0	0	0	0	0	1	0
Ung. Yawa HC	Maigamji	Health Clinic	11.5165	7.31174	Government	2006	0	0	0	0	0	0	1	1	1	2	0	0	0	0	0	0	0	1	0	0	0
Yartafki HP	Maigamji	Health Post	11.4549	7.30217	Government	2006	0	0	1	0	0	0	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0
Kwatangiri HC	Maigamji	Health Centre	11.4491	7.32014	Government	2006	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Dankawo HC	Maigamji	Health Centre	11.4224	7.33302	Government	2006	0	0	0	0	0	0	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0
Himma clinic	Maigamji	Health Centre	11.4657	7.26329	Private	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Kaliyawa HP	Makera	Health Post	11.4856	7.24972	Government	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Danfili HP	Makera	Health Post	11.5151	7.24935	Government	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CHC	Makera	Health Centre	11.5333	7.28086	Government	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
General Hospital	Makera	Hospital	11.581	7.27378	Government	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Makera HC	Makera	Health Clinic	11.5831	7.27415	Government	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nakowa Clinic	Makera	Health Centre	11.5851	7.26638	Private	1995	1	3	1	2	0	2	4	0	2	10	1	0	1	0	1	1	0	1	0	1	1
Unguwar Dahiru HP	Makera	Health Post	11.5883	7.25976	Government	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ung.Kwana Guga	Makera	Health Post	11.5945	7.2671	Government	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bagari HP	Makera	Health Post	11.5871	7.30557	Government	2000	0	0	0	0	0	0	1	1	1	2	0	0	0	0	0	1	0	0	0	0	0
Gwagwayen Nono	Makera	Health Post	11.538	7.24182	Government	2006	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Lasanawa	Maska	Health Post	11.394	7.32697	Government	2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ung. Tofa	Maska	Health Post	11.3921	7.30031	Government	2004	0	0	0	0	0	0	1	0	1	2	0	0	0	0	0	1	0	0	0	0	0

MDG Nasarawa	Maska	Health Clinic	11.3548	7.32053	Government	2005	0	0	0	0	0	0	1	2	2	20	0	0	0	0	0	0	0	1	1	0	0
CCHC	Maska	Health Centre	11.3408	7.33667	Government	1985	1	0	2	2	0	2	4	5	4	22	1	0	1	0	1	1	0	1	0	1	2
BCGA	Sabongari	Health Centre	11.5849	7.31122	Government	2003	0	0	0	0	0	1	2	4	1	1	0	0	0	0	1	1	1	1	0	0	0
khamec hosp	Sabongari	Health Centre	11.5703	7.31238	Private	1998	2	3	3	2	0	2	2	0	2	30	1	0	1	1	1	1	1	1	1	1	2
Bistit Hospital	Sabongari	Health Centre	11.5694	7.31015	Private	1996	4	7	2	3	0	3	3	0	3	40	1	0	1	1	1	1	1	1	1	0	1
KTARDA HC	Sabongari	Health Clinic	11.5618	7.32096	Government	2009	0	0	1	1	0	2	2	3	1	1	0	0	0	0	0	1	0	1	0	0	0
Tudun Wada PHC	Sabongari	PHC	11.5707	7.33097	Government	2010	0	0	0	0	0	3	2	8	1	4	0	0	0	0	1	1	1	1	0	0	0
Najama HC	Tudun Iya	Health Centre	11.386	7.3452	Government	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tudun Iya PHC	Tudun Iya	PHC	11.3777	7.3504	Government	1997	0	4	1	1	0	2	2	2	2	6	1	0	0	0	0	0	0	1	0	1	0
Bagire HP	Tudun Iya	Health Post	11.3659	7.3841	Government	2006	0	1	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0	1	0
Ung. Mailaya HC	Tudun Iya	Health Clinic	11.3203	7.35163	Government	2014	0	0	0	0	0	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Burma HC	Tudun Iya	Health Clinic	11.277	7.35626	Government	2010	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Gwangwari HP	Tudun Iya	Health Post	11.279	7.33453	Government	1999	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Ung. Dandada HP	Tudun iya	Health Post	11.4003	7.38511	Government	2001	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Ung. Musa HP	Ung. Musa	Health Post	11.5663	7.28399	Government	2014	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Maaruf MC	Ung. Musa	Health Centre	11.561	7.27306	Private	2015	2	4	2	2	0	2	2	0	2	20	1	0	1	1	1	1	1	1	1	0	1
Dandutse HP	Dandutse	Health Post	11.5573	7.2984	Government	2012	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Infant Welfare Clinic	Nasarawa	Health Clinic	11.5659	7.30796	Government	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Appendix IV:List of Origin-Destination Cost Matrix Results of Dandutse

S/N	Ward	HCF	Distance (m)	Distance (km)
1	Dandutse	Bagari H/F	3789.99	3.79
2	Dandutse	Bagire HP	2983.23	2.98
3	Dandutse	Bare - Bari HP	2210.52	2.21
4	Dandutse	BCGA	3553.38	3.55
5	Dandutse	Bistit Hospital	2297.93	2.30
6	Dandutse	Burma	2711.18	2.71
7	Dandutse	CCHC	2246.52	2.25
8	Dandutse	CHC	3255.82	3.26
9	Dandutse	Chibauna HC	1691.98	1.69
10	Dandutse	Dandutse HP	438.67	0.44
11	Dandutse	Danfili	2045.57	2.05
12	Dandutse	Dankawo HC	3627.46	3.63
13	Dandutse	Danlayi HC	3551.43	3.55
14	Dandutse	Dukke PHC	1434.55	1.43
15	Dandutse	General Hospital	2131.91	2.13
16	Dandutse	Goya PHC	2282.69	2.28
17	Dandutse	Gwagwaye HC	4583.97	4.58
18	Dandutse	Gwagwayen Nono	2536.60	2.54
19	Dandutse	Gwangwari	4977.35	4.98
20	Dandutse	Hayin Yanbarkono	6633.85	6.63
21	Dandutse	Himma clinic	5969.70	5.97
22	Dandutse	IWC	1464.33	1.46
23	Dandutse	Jabiri	1683.17	1.68
24	Dandutse	Kaliyawa	7473.77	7.47
25	Dandutse	khamec hosp	2377.25	2.38
26	Dandutse	KTARDA HC	2231.78	2.23
27	Dandutse	Kufan Maitsamiya	3949.61	3.95
28	Dandutse	Kwangwai HC	2023.94	2.02
29	Dandutse	Kwatangiri	3413.35	3.41
30	Dandutse	Lasanawa	2416.09	2.42
31	Dandutse	Maigamji PHC	1630.42	1.63
32	Dandutse	Makera HC	2370.10	2.37
33	Dandutse	Makwalla	1592.02	1.59
34	Dandutse	Maruf MC	3077.54	3.08
35	Dandutse	MDG Nasarawa	2651.20	2.65
36	Dandutse	Najama HC	2289.82	2.29
37	Dandutse	Nakowa Clinic	2174.10	2.17
38	Dandutse	New Funtua Clinic	1976.05	1.98
39	Dandutse	Rafin Dinya HC	6629.96	6.63
40	Dandutse	Rinji HC	3826.77	3.83
41	Dandutse	Tudun Iya PHC	3370.93	3.37

42	Dandutse	Tudun Wada	3661.01	3.66
43	Dandutse	Ung. Mailaya	2993.71	2.99
44	Dandutse	Ung. Biri HP	8616.95	8.62
45	Dandutse	Ung. Bishi HC	8511.01	8.51
46	Dandutse	Ung. Dandada HP	1859.77	1.86
47	Dandutse	Ung. Daudu HC	9329.58	9.33
48	Dandutse	Ung. Inji HP	2918.55	2.92
49	Dandutse	Ung. Musa HP	1153.73	1.15
50	Dandutse	Ung. Tanko HP	3154.17	3.15
51	Dandutse	Ung. Tofa	1987.66	1.99
52	Dandutse	Ung. Yawa	1519.81	1.52
53	Dandutse	Unguwar Dahiru	2930.52	2.93
54	Dandutse	Unguwar Kwana Guga	4802.83	4.80
55	Dandutse	Unguwar Moda	5507.35	5.51
56	Dandutse	Unguwar Sallah	2157.19	2.16
57	Dandutse	Unguwar Shae HP	6676.47	6.68
58	Dandutse	Yartafki HP	2268.02	2.27
59	Dandutse	Zamfarawa HC	7945.44	7.95

Appendix V:List of Origin Destination Cost Matrix Results of Dukke Ward

SN	Ward	HCF	Distance(m)	Distance (km)
1	Dukke	Bagari H/F	9472.36	9.47
2	Dukke	Bagire HP	8665.60	8.67
3	Dukke	Bare - Bari HP	7892.89	7.89
4	Dukke	BCGA	9235.75	9.24
5	Dukke	Bistit Hospital	7980.30	7.98
6	Dukke	Burma	8393.55	8.39
7	Dukke	CCHC	7928.89	7.93
8	Dukke	CHC	8938.19	8.94
9	Dukke	Chibauna HC	7374.34	7.37
10	Dukke	Dandutse HP	8428.49	8.43
11	Dukke	Danfili	7727.94	7.73
12	Dukke	Dankawo HC	9309.83	9.31
13	Dukke	Danlayi HC	9233.80	9.23
14	Dukke	Dukke PHC	6793.80	6.79
15	Dukke	General Hospital	7814.28	7.81
16	Dukke	Goya PHC	7965.06	7.97
17	Dukke	Gwagwaye HC	10266.34	10.27
18	Dukke	Gwagwayen Nono	8218.97	8.22
19	Dukke	Gwangwari	10659.71	10.66
20	Dukke	Hayin Yanbarkono	3936.72	3.94
21	Dukke	Himma clinic	11652.07	11.65
22	Dukke	IWC	7146.70	7.15
23	Dukke	Jabiri	7365.54	7.37
24	Dukke	Kaliyawa	13156.14	13.16
25	Dukke	khamec hosp	8059.62	8.06
26	Dukke	KTARDA HC	7914.15	7.91
27	Dukke	Kufan Maitsamiya	4624.88	4.62
28	Dukke	Kwangwai HC	7706.31	7.71
29	Dukke	Kwatangiri	9095.72	9.10
30	Dukke	Lasanawa	8098.45	8.10
31	Dukke	Maigamji PHC	7312.79	7.31
32	Dukke	Makera HC	8052.47	8.05
33	Dukke	Makwalla	7274.39	7.27
34	Dukke	Maruf MC	8759.91	8.76
35	Dukke	MDG Nasarawa	8333.56	8.33
36	Dukke	Najama HC	7972.19	7.97
37	Dukke	Nakowa Clinic	7856.46	7.86
38	Dukke	New Funtua Clinic	7658.42	7.66
39	Dukke	Rafin Dinya HC	12312.33	12.31
40	Dukke	Rinji HC	9509.14	9.51
41	Dukke	Tudun Iya PHC	9053.30	9.05
42	Dukke	Tudun Wada	9343.38	9.34
43	Dukke	Ung. Mailaya	8676.07	8.68
44	Dukke	Ung. Biri HP	627.13	0.63

45	Dukke	Ung. Bishi HC	5813.89	5.81
46	Dukke	Ung. Dandada HP	7542.14	7.54
47	Dukke	Ung. Daudu HC	6632.46	6.63
48	Dukke	Ung. Inji HP	8600.92	8.60
49	Dukke	Ung. Musa HP	6836.09	6.84
50	Dukke	Ung. Tanko HP	8836.54	8.84
51	Dukke	Ung. Tofa	7670.03	7.67
52	Dukke	Ung. Yawa	7202.18	7.20
53	Dukke	Unguwar Dahiru	8612.89	8.61
54	Dukke	Ung. Kwana Guga	10485.20	10.49
55	Dukke	Unguwar Moda	11189.72	11.19
56	Dukke	Unguwar Sallah	7839.56	7.84
57	Dukke	Unguwar Shae HP	3979.35	3.98
58	Dukke	Yartafki HP	7950.39	7.95
59	Dukke	Zamfarawa HC	5248.31	5.25

Appendix VI:List of Origin-Destination Cost Matrix Results of Goya Ward

S/N	Ward	HCF	Distance (m)	Distance (km)
1	Goya	Bagari H/F	3876.96	3.88
2	Goya	Bagire HP	3070.20	3.07
3	Goya	Bare - Bari HP	2297.49	2.30
4	Goya	BCGA	3640.35	3.64
5	Goya	Bistit Hospital	2384.90	2.38
6	Goya	Burma	2798.15	2.80
7	Goya	CCHC	2333.49	2.33
8	Goya	CHC	3341.63	3.34
9	Goya	Chibauna HC	1777.79	1.78
10	Goya	Dandutse HP	2833.09	2.83
11	Goya	Danfili	2132.54	2.13
12	Goya	Dankawo HC	3714.43	3.71
13	Goya	Danlayi HC	3638.40	3.64
14	Goya	Dukke PHC	1521.52	1.52
15	Goya	General Hospital	2218.88	2.22
16	Goya	Goya PHC	111.73	0.11
17	Goya	Gwagwaye HC	4670.94	4.67
18	Goya	Gwagwayen Nono	2623.57	2.62
19	Goya	Gwangwari	5064.32	5.06
20	Goya	Hayin Yanbarkono	6720.81	6.72
21	Goya	Himma clinic	6056.67	6.06
22	Goya	IWC	1551.30	1.55
23	Goya	Jabiri	1768.98	1.77
24	Goya	Kaliyawa	7560.74	7.56
25	Goya	khamec hosp	2464.22	2.46
26	Goya	KTARDA HC	2318.75	2.32
27	Goya	Kufan Maitsamiya HC	4036.58	4.04
28	Goya	Kwangwai HC	2110.91	2.11
29	Goya	Kwatangiri	3499.17	3.50
30	Goya	Lasanawa	2503.06	2.50
31	Goya	Maigamji PHC	1717.39	1.72
32	Goya	Makera HC	2457.07	2.46
33	Goya	Makwalla	1677.83	1.68
34	Goya	Maruf MC	3164.51	3.16
35	Goya	MDG Nasarawa	2738.17	2.74
36	Goya	Najama HC	2376.79	2.38
37	Goya	Nakowa Clinic	2261.06	2.26
38	Goya	New Funtua Clinic	2061.86	2.06
39	Goya	Rafin Dinya HC	6716.93	6.72
40	Goya	Rinji HC	3913.74	3.91
41	Goya	Tudun Iya PHC	3457.90	3.46
42	Goya	Tudun Wada	3747.98	3.75
43	Goya	Ung. Mailaya	3080.67	3.08
44	Goya	Ung. Biri HP	8703.92	8.70

45	Goya	Ung. Bishi HC	8597.98	8.60
46	Goya	Ung. Dandada HP	1946.74	1.95
47	Goya	Ung. Daudu HC	9416.54	9.42
48	Goya	Ung. Inji HP	3005.52	3.01
49	Goya	Ung. Musa HP	1240.69	1.24
50	Goya	Ung. Tanko HP	3241.14	3.24
51	Goya	Ung. Tofa HP	2074.63	2.07
52	Goya	Ung. Yawa	1605.62	1.61
53	Goya	Unguwar Dahiru	3017.49	3.02
54	Goya	Unguwar Kwana Guga	4889.80	4.89
55	Goya	Unguwar Moda	5593.16	5.59
56	Goya	Unguwar Sallah	2244.16	2.24
57	Goya	Unguwar Shae HP	6763.44	6.76
58	Goya	Yartafki HP	2354.99	2.35
59	Goya	Zamfarawa HC	8032.40	8.03

Appendix VII:List of Origin-Destination Cost Matrix Results of Maigamji

S/N	Ward	HCF	Distance(m)	Distance (km
1	Maigamji	Bagari H/F	3974.50	3.97
2	Maigamji	Bagire HP	3167.74	3.17
3	Maigamji	Bare - Bari HP	2395.03	2.40
4	Maigamji	BCGA	3737.89	3.74
5	Maigamji	Bistit Hospital	2482.45	2.48
6	Maigamji	Burma	2895.69	2.90
7	Maigamji	CCHC	2431.03	2.43
8	Maigamji	CHC	3439.17	3.44
9	Maigamji	Chibauna HC	1875.33	1.88
10	Maigamji	Dandutse HP	2930.63	2.93
11	Maigamji	Danfili	2230.08	2.23
12	Maigamji	Dankawo HC	3811.98	3.81
13	Maigamji	Danlayi HC	3735.95	3.74
14	Maigamji	Dukke PHC	1619.06	1.62
15	Maigamji	General Hospital	2316.42	2.32
16	Maigamji	Goya PHC	2466.05	2.47
17	Maigamji	Gwagwaye HC	4768.48	4.77
18	Maigamji	Gwagwayen Nono	2721.11	2.72
19	Maigamji	Gwangwari	5161.86	5.16
20	Maigamji	Hayin Yanbarkono	6818.36	6.82
21	Maigamji	Himma clinic	6154.21	6.15
22	Maigamji	IWC	1648.85	1.65
23	Maigamji	Jabiri	1866.53	1.87
24	Maigamji	Kaliyawa	7658.28	7.66
25	Maigamji	khamec hosp	2561.76	2.56
26	Maigamji	KTARDA HC	2416.29	2.42
27	Maigamji	Kufan Maitsamiya	4134.13	4.13
28	Maigamji	Kwangwai HC	2208.45	2.21
29	Maigamji	Kwatangiri	3596.71	3.60
30	Maigamji	Lasanawa	2600.60	2.60
31	Maigamji	Maigamji PHC	1814.93	1.81
32	Maigamji	Makera HC	2554.62	2.55
33	Maigamji	Makwalla	1775.37	1.78
34	Maigamji	Maruf MC	3262.05	3.26
35	Maigamji	MDG Nasarawa	2835.71	2.84
36	Maigamji	Najama HC	2474.33	2.47
37	Maigamji	Nakowa Clinic	2358.61	2.36
38	Maigamji	New Funtua Clinic	2159.41	2.16
39	Maigamji	Rafin Dinya HC	6814.47	6.81
40	Maigamji	Rinji HC	4011.28	4.01
41	Maigamji	Tudun Iya PHC	3555.45	3.56
42	Maigamji	Tudun Wada	3845.52	3.85
43	Maigamji	Ung. Mailaya	3178.22	3.18
44	Maigamji	Ung. Biri HP	8801.46	8.80

45	Maigamji	Ung. Bishi HC	8695.53	8.70
46	Maigamji	Ung. Dandada HP	2044.29	2.04
47	Maigamji	Ung. Daudu HC	9514.09	9.51
48	Maigamji	Ung. Inji HP	3103.06	3.10
49	Maigamji	Ung. Musa HP	1338.24	1.34
50	Maigamji	Ung. Tanko HP	3338.69	3.34
51	Maigamji	Ung. Tofa	2172.18	2.17
52	Maigamji	Ung. Yawa	1703.17	1.70
53	Maigamji	Unguwar Dahiru	3115.03	3.12
54	Maigamji	Ung. Kwana Guga	4987.34	4.99
55	Maigamji	Unguwar Moda	5690.70	5.69
56	Maigamji	Unguwar Sallah	2341.71	2.34
57	Maigamji	Unguwar Shae HP	6860.98	6.86
58	Maigamji	Yartafki HP	2452.53	2.45
59	Maigamji	Zamfarawa HC	8129.95	8.13

Appendix VIII:List of Origin-Destination Cost Matrix Results of Makera

S/N	Ward	HCF	Distance (m)	Distance (km)
1	Makera	Bagari H/F	2771.68	2.77
2	Makera	Bagire HP	1964.92	1.96
3	Makera	Bare - Bari HP	1192.21	1.19
4	Makera	BCGA	2535.06	2.54
5	Makera	Bistit Hospital	1279.62	1.28
6	Makera	Burma	1692.87	1.69
7	Makera	CCHC	1228.21	1.23
8	Makera	CHC	2237.51	2.24
9	Makera	Chibauna HC	673.66	0.67
10	Makera	Dandutse HP	1727.81	1.73
11	Makera	Danfili	1027.26	1.03
12	Makera	Dankawo HC	2609.15	2.61
13	Makera	Danlayi HC	2533.12	2.53
14	Makera	Dukke PHC	416.23	0.42
15	Makera	General Hospital	1113.59	1.11
16	Makera	Goya PHC	1264.38	1.26
17	Makera	Gwagwaye HC	3565.66	3.57
18	Makera	Gwagwayen Nono	1518.29	1.52
19	Makera	Gwangwari	3959.03	3.96
20	Makera	Hayin Yanbarkono	5615.53	5.62
21	Makera	Himma clinic	4951.39	4.95
22	Makera	IWC	446.02	0.45
23	Makera	Jabiri	664.86	0.66
24	Makera	Kaliyawa	6455.46	6.46
25	Makera	khamec hosp	1358.94	1.36
26	Makera	KTARDA HC	1213.47	1.21
27	Makera	Kufan Maitsamiya HC	2931.30	2.93
28	Makera	Kwangwai HC	1005.63	1.01
29	Makera	Kwatangiri	2395.04	2.40
30	Makera	Lasanawa	1397.77	1.40
31	Makera	Maigamji PHC	612.10	0.61
32	Makera	Makera HC	1351.79	1.35
33	Makera	Makwalla	573.70	0.57
34	Makera	Maruf MC	2059.23	2.06
35	Makera	MDG Nasarawa	1632.88	1.63
36	Makera	Najama HC	1271.51	1.27
37	Makera	Nakowa Clinic	1155.78	1.16
38	Makera	New Funtua Clinic	957.74	0.96
39	Makera	Rafin Dinya HC	5611.65	5.61
40	Makera	Rinji HC	2808.46	2.81
41	Makera	Tudun Iya PHC	2352.62	2.35
42	Makera	Tudun Wada	2642.70	2.64
43	Makera	Ung. Mailaya	1975.39	1.98
44	Makera	Ung. Biri HP	7598.64	7.60

45	Makera	Ung. Bishi HC	7492.70	7.49
46	Makera	Ung. Dandada HP	841.46	0.84
47	Makera	Ung. Daudu HC	8311.26	8.31
48	Makera	Ung. Inji HP	1900.24	1.90
49	Makera	Ung. Musa HP	135.41	0.14
50	Makera	Ung. Tanko HP	2135.86	2.14
51	Makera	Ung. Tofa	969.35	0.97
52	Makera	Ung. Yawa	501.50	0.50
53	Makera	Unguwar Dahiru	1912.21	1.91
54	Makera	Unguwar Kwana Guga	3784.52	3.78
55	Makera	Unguwar Moda	4489.03	4.49
56	Makera	Unguwar Sallah	1138.88	1.14
57	Makera	Unguwar Shae HP	5658.16	5.66
58	Makera	Yartafki HP	1249.71	1.25
59	Makera	Zamfarawa HC	6927.12	6.93

Appendix IX:List of Origin-Destination Cost Matrix Results of Maska Ward

S/N	Ward	HCF	Distance (m)	Distance (km)
1	Maska	Bagari H/F	3181.97	3.18
2	Maska	Bagire HP	2375.21	2.38
3	Maska	Bare - Bari HP	1602.50	1.60
4	Maska	BCGA	2945.35	2.95
5	Maska	Bistit Hospital	1689.91	1.69
6	Maska	Burma	2103.16	2.10
7	Maska	CCHC	1638.50	1.64
8	Maska	CHC	2647.80	2.65
9	Maska	Chibauna HC	1083.95	1.08
10	Maska	Dandutse HP	2138.10	2.14
11	Maska	Danfili	1437.55	1.44
12	Maska	Dankawo HC	3019.44	3.02
13	Maska	Danlayi HC	2943.41	2.94
14	Maska	Dukke PHC	826.52	0.83
15	Maska	General Hospital	1523.88	1.52
16	Maska	Goya PHC	1674.67	1.67
17	Maska	Gwagwaye HC	3975.95	3.98
18	Maska	Gwagwayen Nono	1928.58	1.93
19	Maska	Gwangwari	4369.32	4.37
20	Maska	Hayin Yanbarkono	6025.82	6.03
21	Maska	Himma clinic	5361.68	5.36
22	Maska	IWC	856.31	0.86
23	Maska	Jabiri	1075.15	1.08
24	Maska	Kaliyawa	6865.75	6.87
25	Maska	khamec hosp	1769.22	1.77
26	Maska	KTARDA HC	1623.76	1.62
27	Maska	Kufan Maitsamiya HC	3341.59	3.34
28	Maska	Kwangwai HC	1415.92	1.42
29	Maska	Kwatangiri	2805.33	2.81
30	Maska	Lasanawa	1808.06	1.81
31	Maska	Maigamji PHC	1022.39	1.02
32	Maska	Makera HC	1762.08	1.76
33	Maska	Makwalla	983.99	0.98
34	Maska	Maruf MC	2469.52	2.47
35	Maska	MDG Nasarawa	2043.17	2.04
36	Maska	Najama HC	1681.80	1.68
37	Maska	Nakowa Clinic	1566.07	1.57
38	Maska	New Funtua Clinic	1368.03	1.37
39	Maska	Rafin Dinya HC	6021.94	6.02
40	Maska	Rinji HC	3218.75	3.22
41	Maska	Tudun Iya PHC	2762.91	2.76
42	Maska	Tudun Wada	3052.99	3.05
43	Maska	Ung. Mailaya	2385.68	2.39

44	Maska	Ung. Biri HP	8008.92	8.01
45	Maska	Ung. Bishi HC	7902.99	7.90
46	Maska	Ung. Dandada HP	1251.75	1.25
47	Maska	Ung. Daudu HC	8721.55	8.72
48	Maska	Ung. Inji HP	2310.53	2.31
49	Maska	Ung. Musa HP	545.70	0.55
50	Maska	Ung. Tanko HP	2546.15	2.55
51	Maska	Ung. Tofa	1379.64	1.38
52	Maska	Ung. Yawa	911.79	0.91
53	Maska	Unguwar Dahiru	2322.50	2.32
54	Maska	Unguwar Kwana Guga	4194.81	4.19
55	Maska	Unguwar Moda	4899.32	4.90
56	Maska	Unguwar Sallah	1549.17	1.55
57	Maska	Unguwar Shae HP	6068.45	6.07
58	Maska	Yartafki HP	1660.00	1.66
59	Maska	Zamfarawa HC	7337.41	7.34

Appendix X:List of Origin-Destination Cost Matrix Results of Nasarawa Ward

S/N	Ward	HCF	Distance(m)	Distance(km)
1	Nasarawa	Bagari H/F	1442.54	1.44
2	Nasarawa	Bagire HP	3843.99	3.84
3	Nasarawa	Bare - Bari HP	3071.28	3.07
4	Nasarawa	BCGA	2601.93	2.60
5	Nasarawa	Bistit Hospital	1379.13	1.38
6	Nasarawa	Burma	3571.94	3.57
7	Nasarawa	CCHC	3107.28	3.11
8	Nasarawa	CHC	4116.58	4.12
9	Nasarawa	Chibauna HC	2552.73	2.55
10	Nasarawa	Dandutse HP	3606.88	3.61
11	Nasarawa	Danfili	2906.33	2.91
12	Nasarawa	Dankawo HC	4488.22	4.49
13	Nasarawa	Danlayi HC	4412.19	4.41
14	Nasarawa	Dukke PHC	2295.31	2.30
15	Nasarawa	General Hospital	2992.67	2.99
16	Nasarawa	Goya PHC	3143.45	3.14
17	Nasarawa	Gwagwaye HC	5444.73	5.44
18	Nasarawa	Gwagwayen Nono	3397.36	3.40
19	Nasarawa	Gwangwari	5838.11	5.84
20	Nasarawa	Hayin Yanbarkono	7494.61	7.49
21	Nasarawa	Himma clinic	6830.46	6.83
22	Nasarawa	IWC	2325.09	2.33
23	Nasarawa	Jabiri	2543.93	2.54
24	Nasarawa	Kaliyawa	8334.53	8.33
25	Nasarawa	khamec hosp	1422.43	1.42
26	Nasarawa	KTARDA HC	2885.17	2.89
27	Nasarawa	Kufan Maitsamiya	4810.37	4.81
28	Nasarawa	Kwangwai HC	2884.70	2.88
29	Nasarawa	Kwatangiri	4274.11	4.27
30	Nasarawa	Lasanawa	3276.85	3.28
31	Nasarawa	Maigamji PHC	2491.18	2.49
32	Nasarawa	Makera HC	3230.86	3.23
33	Nasarawa	Makwalla	2452.78	2.45
34	Nasarawa	Maruf MC	3938.30	3.94
35	Nasarawa	MDG Nasarawa	3511.96	3.51
36	Nasarawa	Najama HC	3150.58	3.15
37	Nasarawa	Nakowa Clinic	3034.86	3.03
38	Nasarawa	New Funtua Clinic	2836.81	2.84
39	Nasarawa	Rafin Dinya HC	7490.72	7.49
40	Nasarawa	Rinji HC	4687.53	4.69
41	Nasarawa	Tudun Iya PHC	4231.69	4.23
42	Nasarawa	Tudun Wada	4314.40	4.31
43	Nasarawa	Ung. Mailaya	3854.47	3.85

44	Nasarawa	Ung. Biri HP	9477.71	9.48
45	Nasarawa	Ung. Bishi HC	9371.77	9.37
46	Nasarawa	Ung. Dandada HP	2720.53	2.72
47	Nasarawa	Ung. Daudu HC	10190.34	10.19
48	Nasarawa	Ung. Inji HP	3779.31	3.78
49	Nasarawa	Ung. Musa HP	2014.49	2.01
50	Nasarawa	Ung. Tanko HP	4014.93	4.01
51	Nasarawa	Ung. Tofa	2848.42	2.85
52	Nasarawa	Ung. Yawa	2380.57	2.38
53	Nasarawa	Unguwar Dahiru	3791.28	3.79
54	Nasarawa	Ung.Kwana Guga	5663.59	5.66
55	Nasarawa	Unguwar Moda	6368.11	6.37
56	Nasarawa	Unguwar Sallah	3017.95	3.02
57	Nasarawa	Unguwar Shae HP	7537.23	7.54
58	Nasarawa	Yartafki HP	3128.78	3.13
59	Nasarawa	Zamfarawa HC	8806.20	8.81

Appendix XI:List of Origin-Destination Cost Matrix Results of Sabon-Gari

S/N	Ward	HCF	Distance(M)	Distance (km)
1	Sabongari	Bagari H/F	4252.94	4.25
2	Sabongari	Bagire HP	5258.39	5.26
3	Sabongari	Bare - Bari HP	4485.68	4.49
4	Sabongari	BCGA	1029.24	1.03
5	Sabongari	Bistit Hospital	2793.53	2.79
6	Sabongari	Burma	4986.34	4.99
7	Sabongari	CCHC	4521.68	4.52
8	Sabongari	CHC	5530.98	5.53
9	Sabongari	Chibauna HC	3967.14	3.97
10	Sabongari	Dandutse HP	5021.28	5.02
11	Sabongari	Danfili	4320.73	4.32
12	Sabongari	Dankawo HC	5902.62	5.90
13	Sabongari	Danlayi HC	5826.60	5.83
14	Sabongari	Dukke PHC	3709.71	3.71
15	Sabongari	General Hospital	4407.07	4.41
16	Sabongari	Goya PHC	4557.85	4.56
17	Sabongari	Gwagwaye HC	6859.13	6.86
18	Sabongari	Gwagwayen Nono	4811.76	4.81
19	Sabongari	Gwangwari	7252.51	7.25
20	Sabongari	Hayin Yanbarkono	8909.01	8.91
21	Sabongari	Himma clinic	8244.86	8.24
22	Sabongari	IWC	3739.49	3.74
23	Sabongari	Jabiri	3958.33	3.96
24	Sabongari	Kaliyawa	9748.93	9.75
25	Sabongari	khamec hosp	2834.02	2.83
26	Sabongari	KTARDA HC	4296.76	4.30
27	Sabongari	Kufan Maitsamiya	6224.77	6.22
28	Sabongari	Kwangwai HC	4299.10	4.30
29	Sabongari	Kwatangiri	5688.51	5.69
30	Sabongari	Lasanawa	4691.25	4.69
31	Sabongari	Maigamji PHC	3905.58	3.91
32	Sabongari	Makera HC	4645.26	4.65
33	Sabongari	Makwalla	3867.18	3.87
34	Sabongari	Maruf MC	5352.70	5.35
35	Sabongari	MDG Nasarawa	4926.36	4.93
36	Sabongari	Najama HC	4564.98	4.56
37	Sabongari	Nakowa Clinic	4449.26	4.45
38	Sabongari	New Funtua Clinic	4251.21	4.25
39	Sabongari	Rafin Dinya HC	8905.12	8.91
40	Sabongari	Rinji HC	6101.93	6.10
41	Sabongari	Tudun Iya PHC	5646.09	5.65
42	Sabongari	Tudun Wada	4906.90	4.91
43	Sabongari	Ung. Mailaya	5268.87	5.27
44	Sabongari	Ung. Biri HP	10892.11	10.89

45	Sabongari	Ung. Bishi HC	10786.17	10.79
46	Sabongari	Ung. Dandada HP	4134.93	4.13
47	Sabongari	Ung. Daudu HC	11604.74	11.60
48	Sabongari	Ung. Inji HP	5193.71	5.19
49	Sabongari	Ung. Musa HP	3428.89	3.43
50	Sabongari	Ung. Tanko HP	5429.33	5.43
51	Sabongari	Ung. Tofa	4262.82	4.26
52	Sabongari	Ung. Yawa	3794.97	3.79
53	Sabongari	Unguwar Dahiru	5205.68	5.21
54	Sabongari	Ung.Kwana Guga	7077.99	7.08
55	Sabongari	Unguwar Moda	7782.51	7.78
56	Sabongari	Unguwar Sallah	4432.36	4.43
57	Sabongari	Unguwar Shae HP	8951.63	8.95
58	Sabongari	Yartafki HP	4543.18	4.54
59	Sabongari	Zamfarawa HC	10220.60	10.22

Appendix XII: List of Origin-Destination Cost Matrix Result of Tudun Iya

S/N	Ward	HCF	Distance (m)	Distance (km)
1	Tudun Iya	Bagari H/F	5722.96	5.72
2	Tudun Iya	Bagire HP	4916.20	4.92
3	Tudun Iya	Bare - Bari HP	4143.49	4.14
4	Tudun Iya	BCGA	5486.35	5.49
5	Tudun Iya	Bistit Hospital	4230.90	4.23
6	Tudun Iya	Burma	4644.15	4.64
7	Tudun Iya	CCHC	4179.49	4.18
8	Tudun Iya	CHC	5188.79	5.19
9	Tudun Iya	Chibauna HC	3624.95	3.62
10	Tudun Iya	Dandutse HP	4679.09	4.68
11	Tudun Iya	Danfili	3978.54	3.98
12	Tudun Iya	Dankawo HC	5553.86	5.55
13	Tudun Iya	Danlayi HC	5484.41	5.48
14	Tudun Iya	Dukke PHC	3367.52	3.37
15	Tudun Iya	General Hospital	4064.88	4.06
16	Tudun Iya	Goya PHC	4215.66	4.22
17	Tudun Iya	Gwagwaye HC	6516.94	6.52
18	Tudun Iya	Gwagwayen Nono	4469.57	4.47
19	Tudun Iya	Gwangwari	6910.32	6.91
20	Tudun Iya	Hayin Yanbarkono	8566.82	8.57
21	Tudun Iya	Himma clinic	7902.67	7.90
22	Tudun Iya	IWC	3397.30	3.40
23	Tudun Iya	Jabiri	3616.14	3.62
24	Tudun Iya	Kaliyawa	9406.74	9.41
25	Tudun Iya	khamec hosp	4310.22	4.31
26	Tudun Iya	KTARDA HC	4164.75	4.16
27	Tudun Iya	Kufan Maitsamiya	5882.58	5.88
28	Tudun Iya	Kwangwai HC	3956.91	3.96
29	Tudun Iya	Kwatangiri	5346.32	5.35
30	Tudun Iya	Lasanawa	4342.48	4.34
31	Tudun Iya	Maigamji PHC	3563.39	3.56
32	Tudun Iya	Makera HC	4303.07	4.30
33	Tudun Iya	Makwalla	3524.99	3.52
34	Tudun Iya	Maruf MC	5010.51	5.01
35	Tudun Iya	MDG Nasarawa	4584.17	4.58
36	Tudun Iya	Najama HC	3544.05	3.54
37	Tudun Iya	Nakowa Clinic	4107.07	4.11
38	Tudun Iya	New Funtua Clinic	3909.02	3.91
39	Tudun Iya	Rafin Dinya HC	8562.93	8.56
40	Tudun Iya	Rinji HC	5759.74	5.76
41	Tudun Iya	Tudun Iya PHC	2462.94	2.46
42	Tudun Iya	Tudun Wada	5593.98	5.59
43	Tudun Iya	Ung. Mailaya	4926.68	4.93
44	Tudun Iya	Ung. Biri HP	10549.92	10.55

45	Tudun Iya	Ung. Bishi HC	10443.98	10.44
46	Tudun Iya	Ung. Dandada HP	3792.74	3.79
47	Tudun Iya	Ung. Daudu HC	11262.55	11.26
48	Tudun Iya	Ung. Inji HP	4851.52	4.85
49	Tudun Iya	Ung. Musa HP	3086.70	3.09
50	Tudun Iya	Ung. Tanko HP	5087.14	5.09
51	Tudun Iya	Ung. Tofa	3920.63	3.92
52	Tudun Iya	Ung. Yawa	3452.78	3.45
53	Tudun Iya	Unguwar Dahiru	4863.49	4.86
54	Tudun Iya	Ung. Kwana Guga	6735.80	6.74
55	Tudun Iya	Unguwar Moda	7440.32	7.44
56	Tudun Iya	Unguwar Sallah	4090.17	4.09
57	Tudun Iya	Unguwar Shae HP	8609.44	8.61
58	Tudun Iya	Yartafki HP	4200.99	4.20
59	Tudun Iya	Zamfarawa HC	9878.41	9.88

AppendixXIII:List of Origin-Destination Cost Matrix Results of U/Ibrahim

S/N	Ward	HCF	Distance(m)	Distance(km)
1	Ung. Ibrahim	Bagari H/F	5300.29	5.30
2	Ung. Ibrahim	Bagire HP	4493.53	4.49
3	Ung. Ibrahim	Bare - Bari HP	3720.82	3.72
4	Ung. Ibrahim	BCGA	5063.68	5.06
5	Ung. Ibrahim	Bistit Hospital	3808.24	3.81
6	Ung. Ibrahim	Burma	4221.48	4.22
7	Ung. Ibrahim	CCHC	3756.82	3.76
8	Ung. Ibrahim	CHC	4665.33	4.67
9	Ung. Ibrahim	Chibauna HC	3201.12	3.20
10	Ung. Ibrahim	Dandutse HP	1579.97	1.58
11	Ung. Ibrahim	Danfili	3555.87	3.56
12	Ung. Ibrahim	Dankawo HC	5137.77	5.14
13	Ung. Ibrahim	Danlayi HC	5061.74	5.06
14	Ung. Ibrahim	Dukke PHC	2944.85	2.94
15	Ung. Ibrahim	General Hospital	3642.21	3.64
16	Ung. Ibrahim	Goya PHC	3791.84	3.79
17	Ung. Ibrahim	Gwagwaye HC	6094.27	6.09
18	Ung. Ibrahim	Gwagwayen Nono	4046.90	4.05
19	Ung. Ibrahim	Gwangwari	6487.65	6.49
20	Ung. Ibrahim	Hayin Yanbarkono	8144.15	8.14
21	Ung. Ibrahim	Himma clinic	7480.00	7.48
22	Ung. Ibrahim	IWC	2974.64	2.97
23	Ung. Ibrahim	Jabiri	3092.55	3.09
24	Ung. Ibrahim	Kaliyawa	8984.08	8.98
25	Ung. Ibrahim	khamec hosp	3887.55	3.89
26	Ung. Ibrahim	KTARDA HC	3742.09	3.74
27	Ung. Ibrahim	Kufan Maitsamiya HC	5459.92	5.46
28	Ung. Ibrahim	Kwangwai HC	3534.25	3.53
29	Ung. Ibrahim	Kwatangiri	4922.50	4.92
30	Ung. Ibrahim	Lasanawa	3926.39	3.93
31	Ung. Ibrahim	Maigamji PHC	3140.72	3.14
32	Ung. Ibrahim	Makera HC	3880.41	3.88
33	Ung. Ibrahim	Makwalla	3101.16	3.10
34	Ung. Ibrahim	Maruf MC	1465.00	1.47
35	Ung. Ibrahim	MDG Nasarawa	4161.50	4.16
36	Ung. Ibrahim	Najama HC	3800.12	3.80
37	Ung. Ibrahim	Nakowa Clinic	3684.40	3.68
38	Ung. Ibrahim	New Funtua Clinic	3385.56	3.39
39	Ung. Ibrahim	Rafin Dinya HC	8140.26	8.14
40	Ung. Ibrahim	Rinji HC	5337.07	5.34
41	Ung. Ibrahim	Tudun Iya PHC	4881.24	4.88
42	Ung. Ibrahim	Tudun Wada	5171.32	5.17
43	Ung. Ibrahim	Ung. Mailaya	4504.01	4.50
44	Ung. Ibrahim	Ung. Biri HP	10127.25	10.13

45	Ung. Ibrahim	Ung. Bishi HC	10021.32	10.02
46	Ung. Ibrahim	Ung. Dandada HP	3370.08	3.37
47	Ung. Ibrahim	Ung. Daudu HC	10839.88	10.84
48	Ung. Ibrahim	Ung. Inji HP	4428.86	4.43
49	Ung. Ibrahim	Ung. Musa HP	2664.03	2.66
50	Ung. Ibrahim	Ung. Tanko HP	4664.48	4.66
51	Ung. Ibrahim	Ung. Tofa	3497.97	3.50
52	Ung. Ibrahim	Ung. Yawa	3028.96	3.03
53	Ung. Ibrahim	Unguwar Dahiru	4440.82	4.44
54	Ung. Ibrahim	Unguwar Kwana Guga	6313.13	6.31
55	Ung. Ibrahim	Unguwar Moda	7016.49	7.02
56	Ung. Ibrahim	Unguwar Sallah	3667.50	3.67
57	Ung. Ibrahim	Unguwar Shae HP	8186.77	8.19
58	Ung. Ibrahim	Yartafki HP	3778.33	3.78
59	Ung. Ibrahim	Zamfarawa HC	9455.74	9.46

Appendix XIV:List of Origin-Destination Cost Matrix Results of U/ Musa

S/N	Ward	HCF	Distance(m)	Distance(km)
1	Ung. Musa	Bagari H/F	4265.32	4.27
2	Ung. Musa	Bagire HP	3458.56	3.46
3	Ung. Musa	Bare - Bari HP	2685.85	2.69
4	Ung. Musa	BCGA	4028.71	4.03
5	Ung. Musa	Bistit Hospital	2773.26	2.77
6	Ung. Musa	Burma	3186.51	3.19
7	Ung. Musa	CCHC	2721.85	2.72
8	Ung. Musa	CHC	3731.15	3.73
9	Ung. Musa	Chibauna HC	2167.30	2.17
10	Ung. Musa	Dandutse HP	3221.45	3.22
11	Ung. Musa	Danfili	2520.90	2.52
12	Ung. Musa	Dankawo HC	4102.79	4.10
13	Ung. Musa	Danlayi HC	4026.76	4.03
14	Ung. Musa	Dukke PHC	1909.87	1.91
15	Ung. Musa	General Hospital	2607.24	2.61
16	Ung. Musa	Goya PHC	2758.02	2.76
17	Ung. Musa	Gwagwaye HC	5059.30	5.06
18	Ung. Musa	Gwagwayen Nono	3011.93	3.01
19	Ung. Musa	Gwangwari	5452.67	5.45
20	Ung. Musa	Hayin Yanbarkono	7109.17	7.11
21	Ung. Musa	Himma clinic	6445.03	6.45
22	Ung. Musa	IWC	1939.66	1.94
23	Ung. Musa	Jabiri	2158.50	2.16
24	Ung. Musa	Kaliyawa	7949.10	7.95
25	Ung. Musa	khamec hosp	2852.58	2.85
26	Ung. Musa	KTARDA HC	2707.11	2.71
27	Ung. Musa	Kufan Maitsamiya	4424.94	4.42
28	Ung. Musa	Kwangwai HC	2499.27	2.50
29	Ung. Musa	Kwatangiri	3888.68	3.89
30	Ung. Musa	Lasanawa	2891.41	2.89
31	Ung. Musa	Maigamji PHC	2105.74	2.11
32	Ung. Musa	Makera HC	2845.43	2.85
33	Ung. Musa	Makwalla	2067.35	2.07
34	Ung. Musa	Maruf MC	294.76	0.29
35	Ung. Musa	MDG Nasarawa	3126.52	3.13
36	Ung. Musa	Najama HC	2765.15	2.77
37	Ung. Musa	Nakowa Clinic	2649.42	2.65
38	Ung. Musa	New Funtua Clinic	2451.38	2.45
39	Ung. Musa	Rafin Dinya HC	7105.29	7.11
40	Ung. Musa	Rinji HC	4302.10	4.30
41	Ung. Musa	Tudun Iya PHC	3846.26	3.85
42	Ung. Musa	Tudun Wada	4136.34	4.14
43	Ung. Musa	Ung. Mailaya	3469.03	3.47
44	Ung. Musa	Ung. Biri HP	9092.28	9.09

45	Ung. Musa	Ung. Bishi HC	8986.34	8.99
46	Ung. Musa	Ung. Dandada HP	2335.10	2.34
47	Ung. Musa	Ung. Daudu HC	9804.90	9.80
48	Ung. Musa	Ung. Inji HP	3393.88	3.39
49	Ung. Musa	Ung. Musa HP	1629.05	1.63
50	Ung. Musa	Ung. Tanko HP	3629.50	3.63
51	Ung. Musa	Ung. Tofa	2462.99	2.46
52	Ung. Musa	Ung. Yawa	1995.14	2.00
53	Ung. Musa	Unguwar Dahiru	3405.85	3.41
54	Ung. Musa	Ung. Kwana Guga	5278.16	5.28
55	Ung. Musa	Unguwar Moda	5982.68	5.98
56	Ung. Musa	Unguwar Sallah	2632.52	2.63
57	Ung. Musa	Unguwar Shae HP	7151.80	7.15
58	Ung. Musa	Yartafki HP	2743.35	2.74
59	Ung. Musa	Zamfarawa HC	8420.76	8.42