



Geospatial Analysis of Accessibility to Healthcare Facilities in Bauchi Local Government Area, Bauchi State, Nigeria

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Abstract

In this study, a Geographic Information System (GIS) based network analysis was used to examine the accessibility to healthcare facilities in Bauchi Local Government Area of Bauchi State in northeastern Nigeria. Accessibility to the healthcare facilities in all the twenty two electoral wards in the area was established using OD (Origin Destination) matrix. The population weighted centroids of the electoral wards were used as origins and the healthcare facilities as destinations. Average nearest neighborhood analysis was carried out to determine the spatial pattern of distribution of the healthcare facilities. Findings of the study revealed that some wards like (Majidadi, Hardo and Makama-B) are poorly served with fewer healthcare facilities than the other wards like Kangere Galambi and Mun/Munsal. It was also found that the healthcare facilities in the area are highly insufficient in relation to the population in the area. In addition, accessibility to the healthcare facilities in wards like Tirwun, Daniya and K/Durum is a serious problem, because people in these areas have to travel very far distances to access the nearest available healthcare facilities. It is therefore recommended that the distribution of health facilities in the area should be based on the density of population of the electoral wards; and the location of a new health center should not be more than 4km from residential areas at a distance of not more than 20m from the major road.

Keywords: GIS; Geographic accessibility; Geospatial analysis; Network analysis; Healthcare.

1.0 INTRODUCTION

Accessibility is defined as the degree to which two places on the same surface are connected, or the degree of interconnection with all other places on the same surface (Ingram, 1971). Accessibility to a given place implies the cost incurred in order to be able to get to that

place through the available means of transport and appropriate infrastructures (Ikporukpo, 1986). All places have some degree of accessibility, but some places are more accessible than others (Hagget, 1976) because the degree of accessibility is influenced by the impacts of the various dimensions of

accessibility. The dimensions of accessibility are availability, acceptability, financial and geographical (Peters et al., 2008).

Geographic accessibility is the physical distance or travel time between the service delivery point (e.g. healthcare center) and the user (population). Geographic accessibility is concerned with the complex relationship between the spatial separation of the population and the location of healthcare facilities. For the purpose of this study, accessibility is considered as a function of the proximity of a population to a healthcare facility measured in distance along access, primary or major roads. Healthcare facilities comprise of healthcare centers such as primary health centers, clinics, hospitals or general hospitals and the available medical facilities. The distance between the population's geographic regions and healthcare facilities, as well as the travel time taken to reach the healthcare delivery system are the most significant factors affecting the health status and health outcomes (Yerramilli and Fonseca, 2014) of a population.

Effective and equitable distribution of healthcare facilities contributes immensely to healthcare service provision and delivery to the people. According to Berman (1998), at independence, most sub-Saharan African countries attempted to provide universal health services to the population through primary healthcare centers. But, the provision of adequate basic health services in developing countries is becoming increasingly difficult by the day. Rapid population growth, widespread poverty and lack of financial resources for the provision of health facilities are identified as the key factors responsible for the poor healthcare delivery systems in the developing countries (Amer, 2007). As such, healthcare service delivery remains one of the biggest problems in developing countries (Kara and Egresi, 2013).

Previous studies on healthcare systems in developing countries revealed serious problems related to location, distribution and accessibility to healthcare facilities. For instance, Kwaku (2008) observed that uneven distribution of healthcare facilities and increasing distance of settlements to hospitals are the major cause of inaccessibility to healthcare facilities in Ajumako-Enyam-Essiam and Denkyira districts

in Central Ghana. Therefore, majority of rural residents in the area rely on the use of traditional medical practices which have serious health implications. Similarly, in a survey of spatial dimensions of accessibility to general hospitals in rural areas of Nigeria, Okafor (1990) discovered that residents living at far distances from health facilities utilize them less than those who live closer to them due to lack of adequate transport facilities. Therefore, many Nigerians remain unhealthy without access to healthcare services (Fanan and Felix, 2014). Moreover, a study conducted by Babatimehin (2011) in Kogi State of north-central Nigeria found that there is a noticeable spatial variation in the distribution of healthcare facilities among the various senatorial districts. It was observed that Kogi central is grossly underserved with fewer healthcare facilities than the other two senatorial districts.

There are various theories and concepts in geographic literature which attempt to explain the spatial distribution and patterns of geographic phenomena and accessibility to public facilities. The Central Place Theory, the Gravity Model, the p-Median Model and the Market Area Analysis are some of these theories. Recently, advances in Geographic Information System (GIS) have contributed to a better understanding and more effective analysis of some aspects of the health system. The use of GIS methods for the measurement of physical accessibility is well established in the literature and has been applied in many areas of healthcare planning (Wilkinson, 1999), healthcare delivery and healthcare management. GIS has been used to assess healthcare needs; analyze access to health services and understand disparities in access among different groups; evaluate healthcare utilization and its geographical variations; plan and evaluate health services; and provide spatial decision-making support for healthcare delivery (McLafferty, 2003).

Accessibility to healthcare facilities is one of the most important factors influencing the health of communities. Also, measuring the accessibility of healthcare institutions is one of the most important indicators of measuring the efficiency of healthcare system. GIS has provided efficient tools that have been used in the measurement of accessibility of healthcare institutions (Kara and

Egresi, 2013) and the analysis of the spatial pattern and distribution of healthcare facilities in different parts of the world. Several studies applied GIS in accessibility analysis. For instance, Paul et al. (2012) measured geographic access to healthcare centers using raster and network-based methods. Ulises and Carina (2012) examined the geographical accessibility and spatial coverage modeling of the primary healthcare network in the Western Province of Rwanda. Also, Bindu and Janak (2013) used geospatial techniques to assess and model the spatial accessibility of primary health centers in Vadodara district. In the framework of healthcare planning, the ability of GIS to identify the geographical extent of health facility service area, which corresponds to the area which contains the population utilizing this facility, is a powerful and very important analytical capability.

In Nigeria, Abbas (2012) used GIS for database creation and mapping of healthcare facilities in Chikun Local Government Area of Kaduna state, in northwestern Nigeria. Findings of his study revealed that serious inequality existed in the distribution of healthcare centers from both the private and public sectors in the districts of the area. Adewoyin et al. (2016) examined the spatial distribution and accessibility of primary health centers in Ife East Local Government of Osun State, in south-western Nigeria. They discovered that some residents in the area travel more than 4 km to access the nearest primary health centre. Similarly, a study by Kibon and Ahmed (2013) on the spatial distribution of Primary Health Care facilities in Kano Metropolis found that most of the facilities were clustered within only four of the local government areas in the metropolis. Likewise, Ismail et al. (2014) analyzed accessibility to healthcare facilities in Giwa and Tofa Local Government Areas of northwestern Nigeria using GIS. Findings of their study revealed that the healthcare facilities within the service area are randomly distributed and grossly inadequate in many of the electoral wards.

Bauchi is situated in northeastern Nigeria. Report by the Bauchi State Strategic Health Development Plan (BSSHDP, 2010) revealed that existent cultural and religious barriers are the main bane of many of the poor health

indices in Bauchi State. Also, access to qualitative healthcare services in rural areas of the state is far below standard. Additionally, a recent population based state wide survey conducted by 'Centro de Investigación de Enfermedades Tropicales'(CIET) for Bauchi State Ministry of Health and the State Primary Health Care Development Agency, indicated a worsening situation of maternal healthcare and low utilization of health facilities in the state.

1.1 Objectives of the Study

This study applied GIS techniques to investigate the level of accessibility (in terms of distance travel) to the healthcare facilities by the people in Bauchi Local Government Area with a view to determine the level of conformity with the WHO Criteria of accessibility and proximity in the location of healthcare facilities.

Also, the pattern of the distribution of healthcare facilities in the area was analyzed in order to determine the level of equity in the provision of healthcare facilities in the area for proper recommendations.

2.0 MATERIALS AND METHODS

2.1 Study Area

Bauchi Local Government Area (LGA) is located between latitudes 9°55' and 10°55' north of the Equator, and between longitudes 9°38' and 10°16' east of the Greenwich Meridian as shown in Figure 1. It covers an area of 32,400 Km² (Bauchi State Agricultural Development Project, BSADP, 1995). It is bounded by Alkali, Toro, Dass and Ganjuwa LGAs to the south, west, north and east respectively as shown in Figure 2. The climate of the area is Aw based on Koppen's classification, and basically comprises of wet and dry season. The area is influenced by two air masses namely tropical continental (north-easterly trade) which is cold and dry, and tropical maritime (south-westerly trade) which is warm and moist. The zone where the two air masses meet is known as the Inter Tropical Convergence Zone (I.T.C.Z.) (Sani et al., 2007). The annual rainfall in the area ranges from 1120mm – 1024mm. The warmest month of the year is May with an average temperature of 29.2 °C. In January, the average temperature is 21.9 °C which is the lowest average temperature of the whole year. The average annual temperature in Bauchi is 24.8 °C (Encyclopedia Britannica, 2014, FAO; 1996).

Generally, soils in the area are ferruginous tropical soils, which are brownish and reddish-brown in color. They are generally low in organic matter content level and are good for the production of cereals. Other soils found in the area are dark lithosols, brownish Latosols and hydromorphic soils. Hydromorphic soils are very common in the fadama areas and they are fertile soils formed as a result of poor drainage in the area (BSADP, 1995). The vegetation in Bauchi reflects that of the Sudan savannah. The dominant tree species in the area include Acacia, Shea butter, Baobab, silk cotton and several exotic species like mango, guava (BSADP, 1995; FAO, 1996).

Bauchi has a population of 493, 730 based on the 2006 population census, and a projected population of 1, 098, 055 based on the Arithmetic Growth Model Analysis. It is a center of commercial activities where most of the residents engage mainly in either secondary, tertiary or quaternary activities. Farmers, herdsmen and fishermen are also found within the locality. A large number of civil servants also reside in Bauchi, being the State capital and administrative headquarter of the state. The availability of roads and railway has a significant influence on the agglomeration of activities in the area.

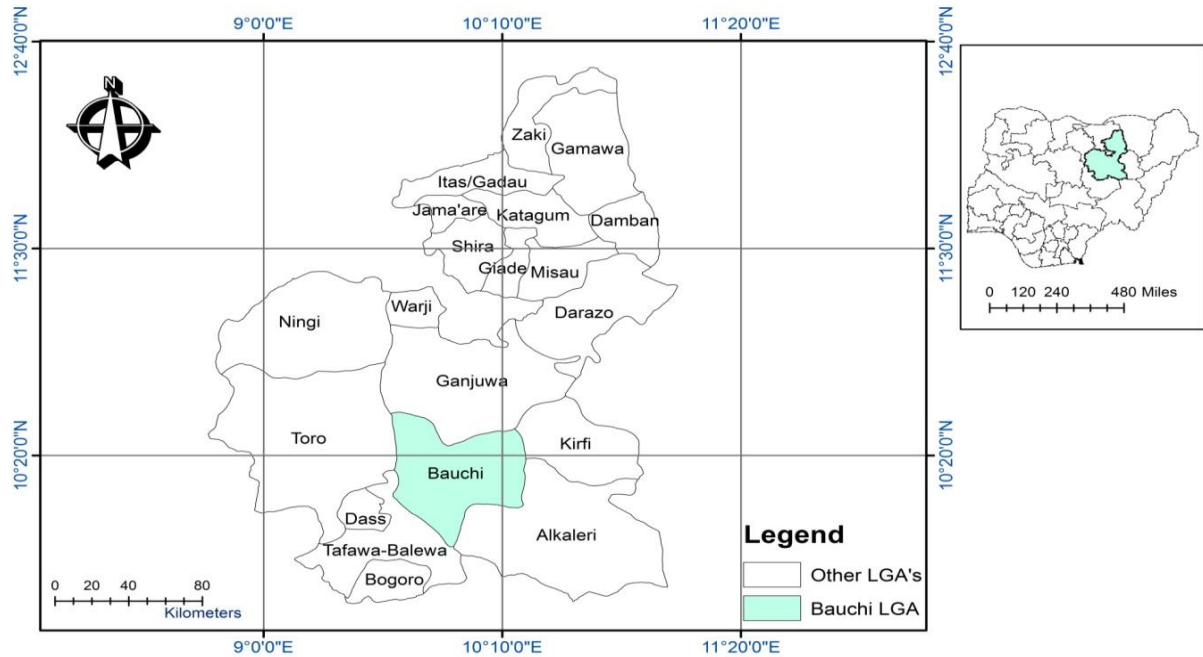


Figure 1: Map of Bauchi State showing Bauchi LGA with an inset map of Nigeria showing Bauchi State. Source: Bauchi State Ministry of Land and Survey (2015).

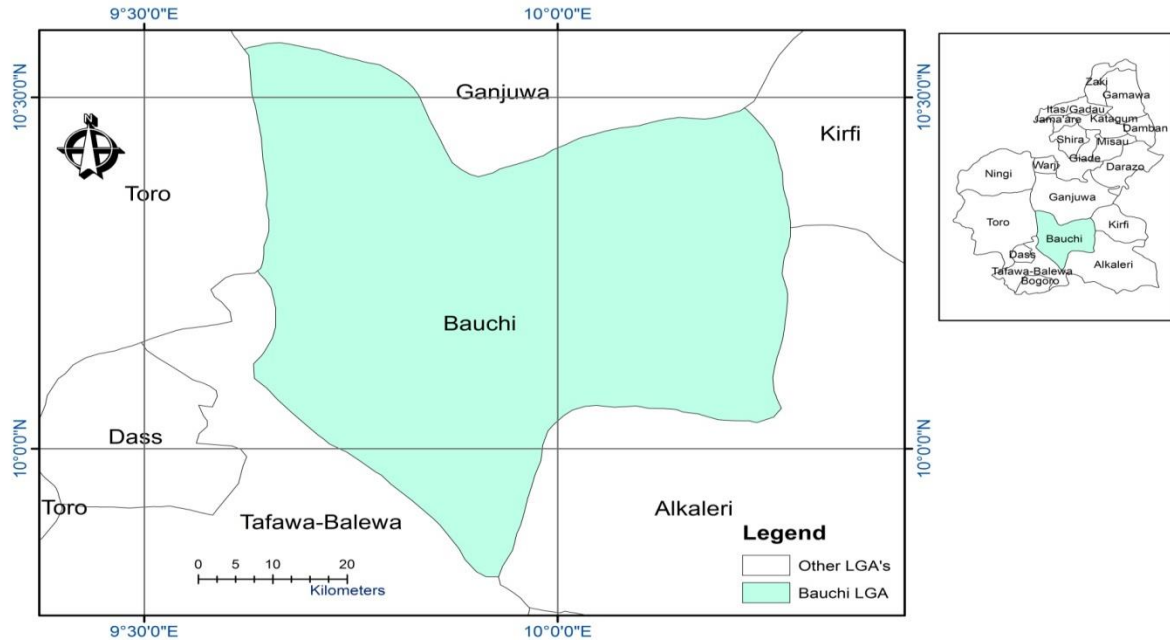


Figure 2: Map of Bauchi Local Government Area with the Neighboring LGAs
 Source: Bauchi State Ministry of Land and Survey (2015).

Table 1: Types and Sources of Data

S/N	Types of data	Sources of data	Purpose
1.	Administrative map of Bauchi LGA	Bauchi states Ministry of Land and Survey	This was scanned, geo-referenced and digitized to serve as the base map.
2.	Road Network of the LGA	Bauchi States Ministry of Works and Transport	This was used for network analysis to determine travel distance of communities to access healthcare services
3.	List and Coordinate points of the health care centers	List of public healthcare facility centers were obtained from the state hospital management board while their coordinate points were captured using hand held(GPS)	This was imported and integrated into GIS environment for analysis
4.	Population census data (1991 & 2006)	National Population Commission(NPC)	Was used to determine changes in population size for projection.

2.2Types and Sources of Data

There are various types and sources of data used for this study as presented in Table 1.

2.3Field Survey

The locations of all the healthcare facilities in form of latitudes and longitudes were obtained using the Global Positioning System (GPS,

Garmin 76 map model). Then the coordinates of the healthcare facilities were converted into four decimal places in Excel and imported into ArcGIS environment.

2.4 GIS Methods

Several GIS methods were adopted to analyze both the spatial and the non-spatial data, and the WHO (1997) Criteria for location of healthcare facilities in developing nations were incorporated in the analysis. The coordinates of the healthcare facilities were imported from Excel as point data into the ArcGIS environment and integrated with other datasets (road data, population and boundary data) which were prepared in a GIS format for the analysis. The population data at ward level were used as

In addition, the Average Nearest Neighbor Analysis was carried out to determine the spatial pattern of distribution of the facilities in Bauchi. The Average Nearest Neighbor Analysis attempts to measure the distributions of geographic phenomena to establish whether they are clustered, random or regular. The nearest neighbor formula gives a result between 0 and 2.15 where clustering occurs. When $R_n = 0$, random distributions occur, where there is no pattern at all, $R_n = 1.0$. The usual pattern for settlement is random with a tendency for clustering or regularity, and regular patterns are perfectly uniform with an $R_n = 2.15$, which means that each place is equidistant.

Accessibility to healthcare facilities in Bauchi was determined for each of the wards in the Local Government Area. In order to achieve that, each ward polygon was converted to a point in ArcGIS10.1 software, and then positioned at the center of ward boundary. The Network dataset was built using the road network. The distance to each healthcare facility along the road network was then calculated using OD Cost Matrix tool of Network Analyst, then the travel time was determined.

2.5 Criteria for the GIS Analysis

In order to propose optimum locations for additional healthcare facilities in the area, the WHO (1997) Criteria for location of healthcare facilities in developing nations were adopted.

The criteria are:

centroids for the analysis. The Map of Bauchi was scanned, georeferenced and digitized to create shape files of the study area, which are compatible with GIS environment.

Then, attribute database for the locations of the healthcare facilities in Bauchi was created in GIS environment, all necessary information like the names of the healthcare facilities, coordinates, wards, type of facilities and ownership of each health center were entered into its attribute table. The attribute database was then used to form queries for the analysis.

a. Proximity and Accessibility

According to World Health Organization (1997), the criteria for citing new healthcare centre based on proximity are as follows:

- i. The health centre should not be more than 4km from residential areas.
- ii. The health centre should be of distance not more than 20m from the major road.
- iii. There should be easy accessibility to source of water which should not be more than 250m from health the centre.

b. Population Size

The condition based on the size of population for setting new health centre is that: An area with a population of 500 people should have access to at least one (1) health centre.

These criteria were then used to carry out multi criteria evaluation (MCE) of suitability analysis and desired locations are depicted.

3.0 RESULTS AND DISCUSSION

A total of 78 public healthcare facilities were identified in Bauchi LGA. Fourteen (14) of which are Primary Health Centers, 14 maternity centers, 34 dispensaries, 6 health centers, 6 health clinics, and 3 maternal & child health clinics.

Figure 3 revealed that there is gross inequality in the distribution of healthcare facilities in the area, with a Nearest Neighbor Ratio of 0.858643 as can be seen in Figure 4. This confirms the high level of disparity in the provision of healthcare facilities within Bauchi local government area, resulting to a situation where some of the wards within the area are underserved with very few or no healthcare facilities. The reasons for the

unfair distribution of healthcare facilities in the area of study needs to be studied in order to have a holistic understanding of the geographical, political, social and economic factors that have resulted into the pattern of the distribution in the area. Although, inequality in the distribution in

healthcare facilities is common problem in developing nations (Amer, 2007; Kara and Egresi, 2013) like Nigeria, there are peculiar locational factors which need to be studied and understood to guide policy formulation and implementation in areas of interest.

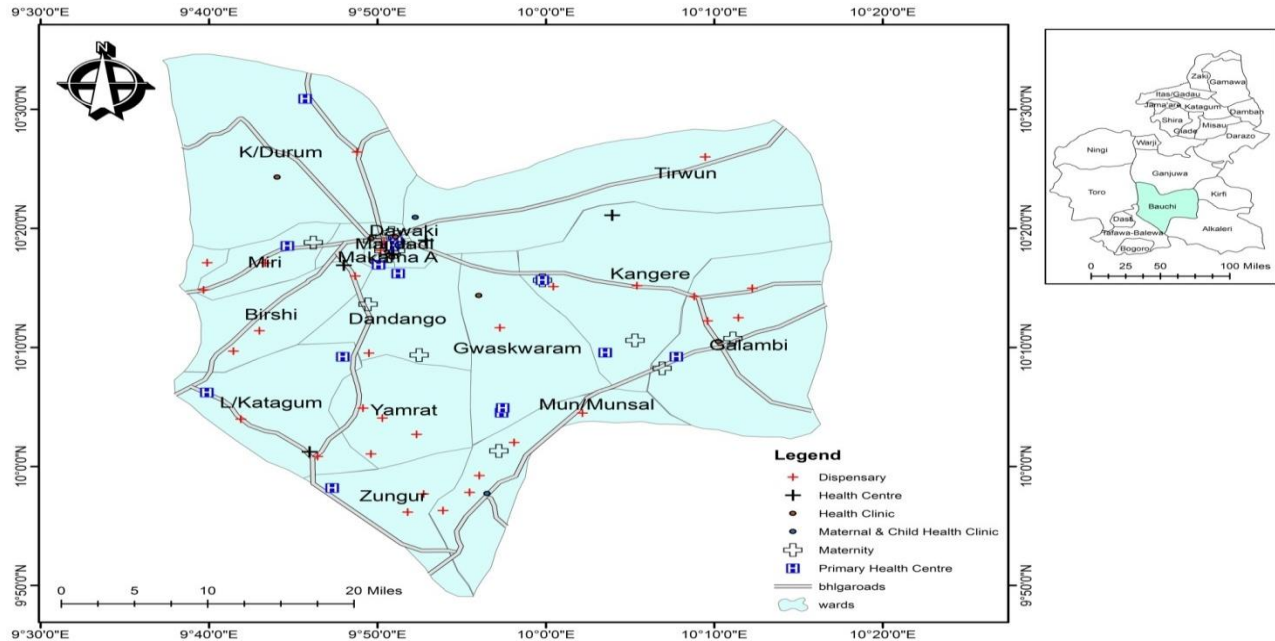


Figure 3: Map of Bauchi LGA showing distribution of healthcare facilities.

Result of the Average Nearest Neighbor analysis can be seen in Figure 4 below.

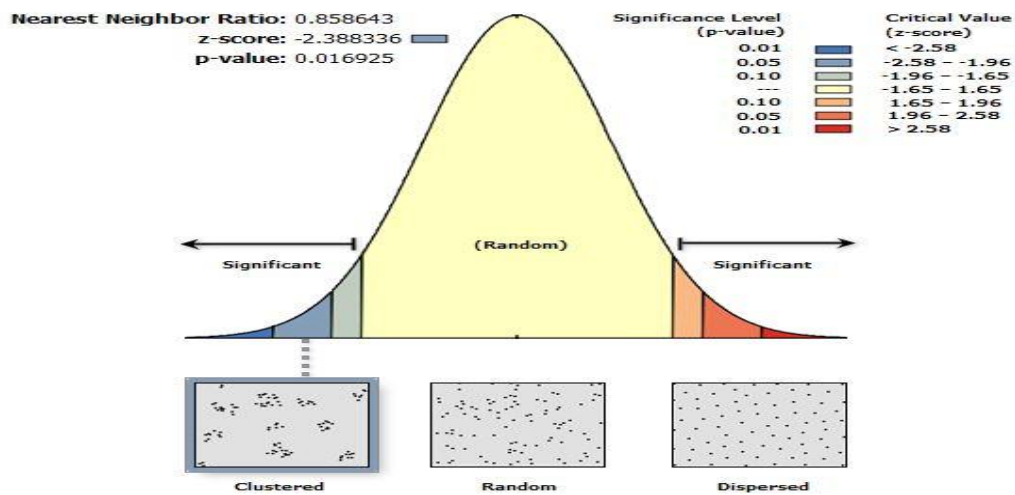


Figure 4: Results of Average nearest Neighbor Analysis.

Figure 5 shows a clear picture of the inequality in the distribution healthcare facilities (HCF) where some wards have more facilities than others. For instance, each of the wards with lower population like Mun/munsal (10, 461), Galambi (11, 218) and Kangere (16, 414) has 7 health centers, constituting about 27% of the total healthcare facilities in the area. Whereas, each of the wards with higher population like Majidadi (37, 675), Hardo (31,587) and Makama-B (29,374) has only 1 health center, accounting for only about 3% of the total healthcare facilities in the area. This suggests that majority of the healthcare facilities are concentrated in certain wards irrespective of their population. This is similar to the findings of Adewoyin et al. (2016) which showed that the functional Primary Health Centres in Ife East of Osun State are not evenly distributed but clustered mainly in the urban area.

The disparity in the distribution of healthcare facilities will go a long way to affect access to the facilities in view of the fact that the

level of access to healthcare facilities in an area is a function of the degree of fairness in spatial distribution of the facilities (Inyang, 1994). Disparities in the geographic accessibility to healthcare may be due to the location/distribution of the population and the spatial arrangement of the healthcare delivery system within an area or region (Yerramilli and Fonseca, 2014).

Figure 6 shows the results of the network analysis, where the network analyst tool in ArcGIS was used to create OD cost matrix and service areas. The wards were used as origins while the healthcare facilities as destinations. The nearest healthcare facility and the distances from the facility to each of the wards were estimated and summarized as minimum, maximum and average total distances. This is presented in Table 2.

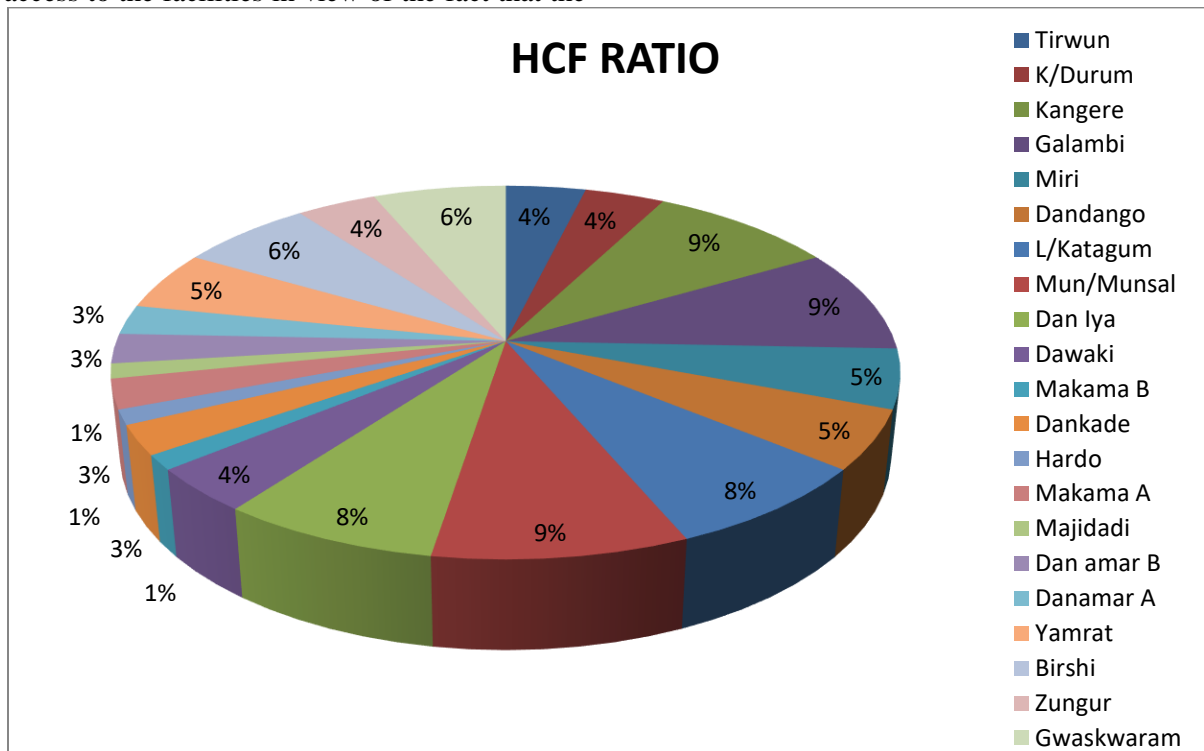


Figure 5: Chart showing percentage of HCF per electoral wards of Bauchi LGA.

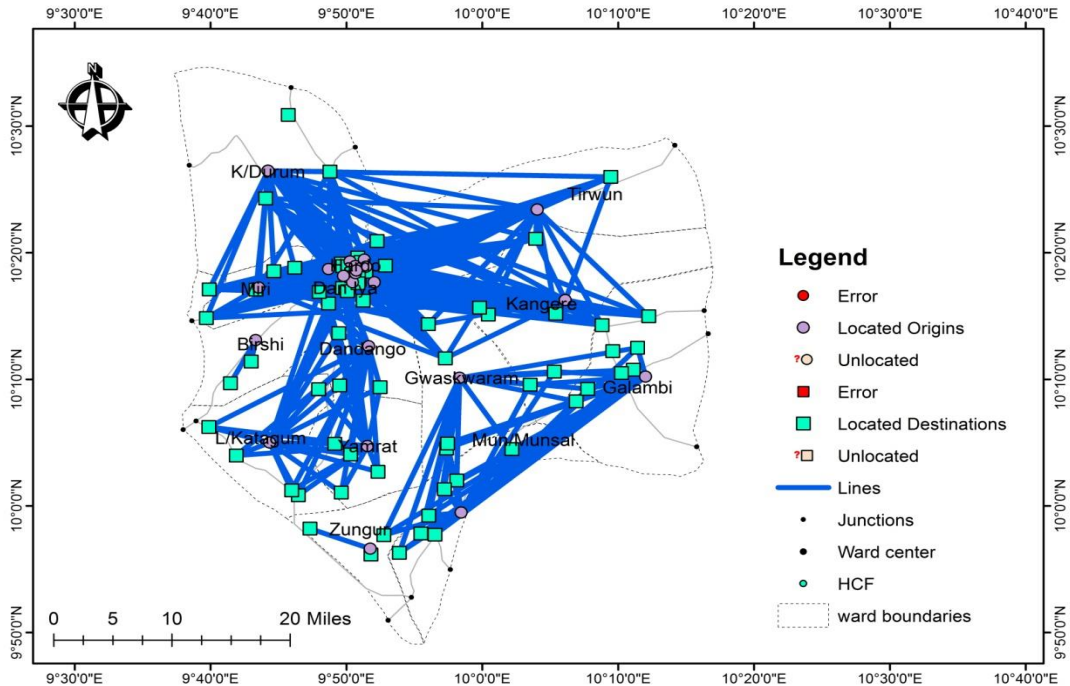


Figure 6: Map of Bauchi showing accessibility to HCF using OD Cost Matrix.

Results of the network analysis as shown Table 2 indicate that the minimum distance to the nearest facility is **136m** and the maximum distance is **67, 983m**. A close look at the distances revealed that some of the healthcare facilities are more accessible than others. For instance, communities in Tirwun, Daniya and K/Dorum have serious problem accessing the nearest health facility as they have to travel a distance of 60-67km to access some of these facilities. This is worrisome, because health centre should not be more than 4km from residential areas (WHO, 1997). Moreover, a distance of 5km, which is equivalent to one hour walking, is considered to be the maximum radius for Primary Health Center (Ranga, 1993).

Furthermore, the case of communities in Gwaskwarom and Yamrat is extremely despicable as they lack good road network to access the available healthcare facilities. This is in conformity with the findings of CIET (2010) which reported that low utilization of health facilities in parts of Bauchi results mainly from distance and lack of appropriate transport to the health facilities. Disparities in the geographic accessibility to healthcare may be due the characteristics of the transportation infrastructure

relative to spatial arrangement of the healthcare delivery system within a region (Yerramilli and Fonseca, 2014).

Table 2: OD cost matrix analysis of healthcare facilities in Bauchi LGA

S/N	Electoral Ward name	Minimum Distance to the nearest HCF in (Meters)	Maximum Distance to the nearest HCF in (Meters)	Average Distance to the nearest HCF in (Meters)
1	Miri	637	7, 879	4, 258
2	L/Katagum	3, 007	7, 324	5, 166
3	Zungur	266	41, 381	10, 214
4	Makama-A	91.49	41, 206	10, 219
5	Yamrat	486	26, 041	12, 413
6	Gwaskwarom	2, 213	23, 362	13,544
7	Dan amar-A	136	39, 971	10, 531
8	Birshi	723	42, 295	10, 724
9	Majidadi	86	43, 072	10, 900
10	Dan amar-B	538	43, 423	11,435
11	Dankade	175	41, 041	11, 649
12	Hardo	1, 836	45, 125	12, 271
13	Dawaki	482	25, 419	13, 126
14	Makama-B	2, 222	39, 007	14, 577
15	Galambi	2, 462	34, 429	15, 247
16	Mun/Munsal	465	55, 464	19, 903
17	Dandango	4, 215	38, 098	20, 982
18	Kangere	970	42, 568	21, 761
19	K/Durum	3, 301	60, 052	27, 699
20	Daniya	1, 122	66, 928	30, 555
21	Tirwun	2, 007	67, 983	33, 299

In addition, results of the analysis as presented in Table 3 shows that all the electoral wards are highly underserved as far as the standard healthcare service delivery is concerned. This is because none of the wards has the number of required healthcare facilities to meet the demand of the population as stipulated by the WHO (1997) Criteria for the location of healthcare facilities. For instance, Dankade and Makama-A wards, each with a population of over 43, 000, has only two healthcare facilities available in each of them. This is highly undesirable, as the minimum required by each of the two wards is 86 healthcare facilities. A similar trend of unfair distribution of healthcare facilities was observed in the other wards, for example, communities in Makama-B, Hardo and Majidadi wards are only served by the only one health center available in each of them. This is in agreement with the findings

of Ujoh and Kwaghsende (2014) where inequality in the distribution of primary health centres in the 23 LGAs of Benue State in northcentral Nigeria was observed.

In addition, Figure 7 shows the current situation regarding the pattern of the distribution of healthcare facilities in Bauchi. It can be seen that only few places adhered to the WHO (1997) Criteria in the provision of healthcare facilities based on proximity to the population, that is, only the healthcare facilities that fall within the 4km buffer are properly located, while the ones outside the buffer zone are not properly located. As such, the optimum locations for healthcare facilities in Bauchi is proposed in Figure 8, which shows that additional healthcare facilities are required to meet up the WHO (1997) criteria for the location of healthcare facilities in developing nations.

Table 3: Required number of HCF in each ward of Bauchi LGA.

S/N	Ward Name	Population	Present Number of HCF	Required HCF
1	Tirwun	17, 054	3	34
2	K/Durum	11, 514	3	23
3	Kangere	16, 414	7	32
4	Galambi	11, 218	7	22
5	Miri	13, 944	4	27
6	Dandango	12, 948	4	25
7	L/Katagum	32, 978	6	65
8	Mun/Munsal	10, 461	7	20
9	Dan Iya	43, 583	6	87
10	Dawaki	27, 932	3	55
11	Makama-B	29, 374	1	58
12	Dankade	43, 983	2	87
13	Hardo	31, 587	1	63
14	Makama-A	43, 403	2	86
15	Majidadi	37, 675	1	75
16	Dan amar-A	29, 461	2	58
17	Dan amar-B	22, 607	2	45
18	Yamrat	5, 324	4	10
19	Birshi	31, 878	5	63
20	Zungur	12, 449	3	24
21	Gwaskwaram	7, 934	5	15

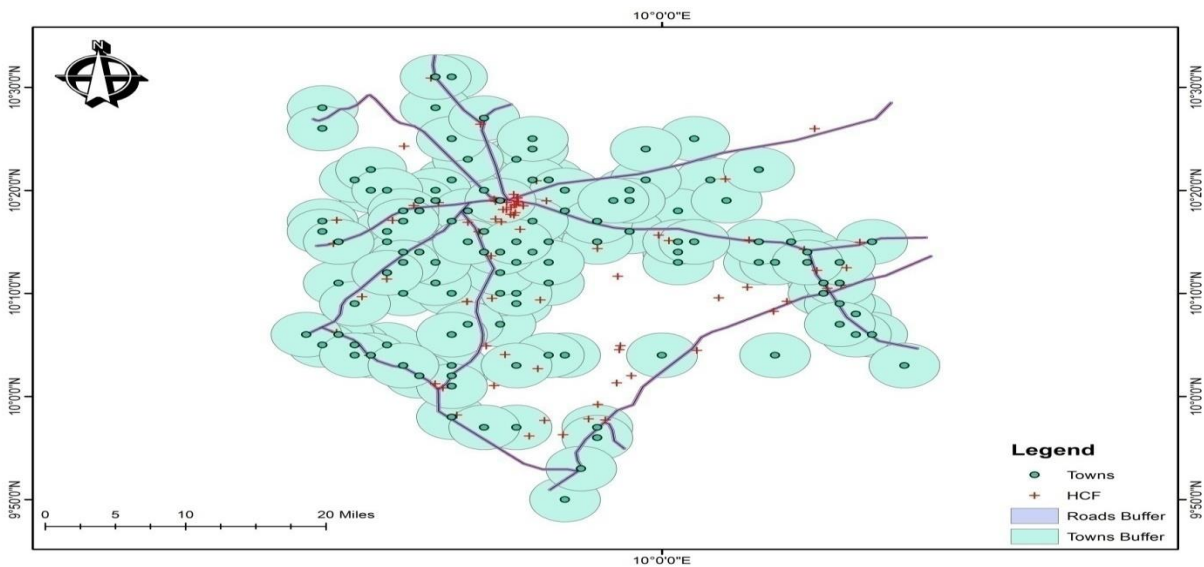


Figure 7: Buffer analysis showing the present locations of HCF in Bauchi LGA.

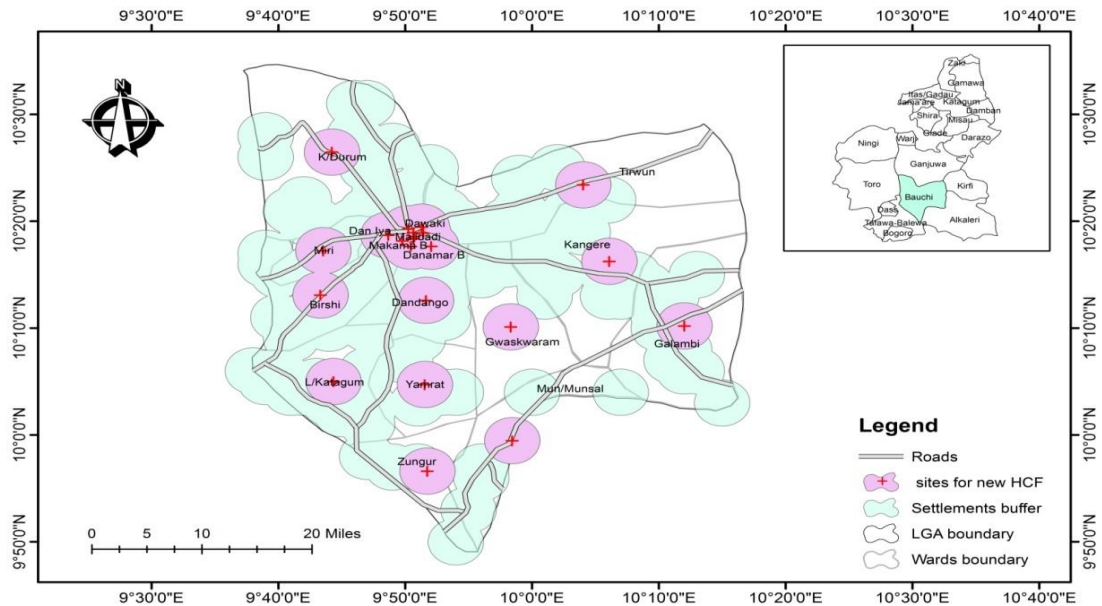


Figure 8: Map showing proposed locations for additional HCF in Bauchi LGA.

4.0 CONCLUSIONS

This study employed GIS techniques to analyze accessibility to healthcare facilities in Bauchi local government area of northeastern Nigeria. Findings revealed inequality in the distribution of healthcare facilities in the area, where some wards like (Majidadi, Hardo and Makama-B) are found to be underserved with fewer healthcare facilities than Kangere Galambi and Mun/Munsal wards, while some wards are completely not served. The spatial distribution of the healthcare facilities has affected accessibility to the facilities in the area. Therefore, some people in Tirwun, Daniya and K/Durum wards have to travel a very long distance (about 60-67km) in order to access the nearest healthcare facility.

4.1 Recommendations

Based on the findings of this study it is therefore recommended that Bauchi State Government should:

- i. Distribute the healthcare facilities in the area proportional to the density of population of the electoral wards.
- ii. Locate new healthcare centers not more than 4km from residential areas at a distance of not more than 20m from the major road.
- iii. Provide good roads network in the area to facilitate access to the nearest available healthcare facility.

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