



## Geospatial Analysis of Primary Health Care Facilities in Ribadu and Gurin Districts of Fufore Local Government Area of Adamawa State, Nigeria

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### ABSTRACT

The Study analyses Geospatial distribution of primary health care facilities in Ribadu and Gurin districts of Fufore local government area of Adamawa state, Nigeria. To accomplish the task, the Differential Global Positioning System (DGPS) equipment was used to acquire the spatial data of 24 primary health care facilities available within the two districts and their attribute information were obtained through a designed questionnaire. Having obtained the spatial and attribute data, the satellite images covering the entire local government area was downloaded via the Google Earth at 4,800 x 4,800 pixels with a scaling of 1%. The downloaded images were then imported in to ArcGIS 10.3, geo-referenced and extracted to produce a base map of the study area. The base map so produced was digitized by using the Editor tool of ArcGIS 10.3 to create a digital map of the study area where database creation, raster calculations, various spatial analysis and queries were carried out. The result of a Nearest Neighbor Analysis (NNA) indicates that the Primary health care facilities within the study area are spread out over a wide area and are 87.7% adequate. Although buffer analysis of 4km radius given by World Health Organization (WHO) as standard distance from one health care facility to another indicates that some few settlements will have to move more than 4km to access health care facilities. However it was also found that most of the primary health care facilities lack adequate health personnel and equipment and only one private clinic has a medical doctor among the entire 24 primary health care facilities within the study area. It is recommended that; government and stake holders in health sector should build more primary health care facilities in some parts of the study area to meet the WHO's standard maximum distance of 4km radius from one health care facility to another, recruit qualified medical doctors and health attendants and provide more equipment in those facilities so as to meet the demand of the populace.

**Key Words:** Spatial data, Attribute data, Satellite images, Downloading, Analysis

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### I. INTRODUCTION:

Health can be defined as the general condition of the body or mind, especially in terms of the presence or absence of illness, injuries or impairments. The World Health Organization (WHO) defined it as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." Among the most important service provided by the Government of both developed and developing nations as the productivity level of anyone is dependent on its state of health. According to Federal Ministry of Health (FMOH) (2010), the health of the people does not only contributes to better quality of life but also essential for sustained economic and social development of the country. The provision of adequate and equitable basic health care facilities is becoming increasingly difficult due to rapid population growth, rising poverty levels and lack of available resources.

The provision of health facilities in Nigeria is a concurrent responsibility of the three tiers of Government in the country. However, because Nigeria operates a mixed economy, private providers of medical health care have visible role to play in health care delivery. The federal government role is mostly limited coordinating the affairs of the University Teaching Hospitals, Federal Medical Centers (tertiary health care)

while the state Government manages the various general hospitals (secondary health care) and the local government focuses on Dispensaries (primary health care) which are regulated by the Federal government. The total expenditure on health care is 4.6% of GDP while the percentages of Federal government expenditure on health care is about 15% (Wikipedia, 2009). Thus health is known to be an important resource in the process in economic development, thereby making expenditure on health a productive investment.

Primary healthcare, by its nature is best delivered by local governments. In Nigeria, local governments exist at the pleasure of state governments. The big interest of state government is to appropriate funds due to local governments and to use arbitrary appointments to build up and strengthen their political bases at the grassroots. Appropriation of local government resources is made easy for the state governments because they run the joint accounts they have with local governments. There have been cases where local governments have complained, and it has been shown that the state government appropriated the funds of the local government, but nothing came of it. State governments know that they can do this with impunity. If the local government is too independently minded, it is simply dissolved and replaced by the governor's chosen loyalists, without any election.

State governments exercise the power to dissolve local governments and supervise the election of new ones. The Constitution provides that local governments be run by elected officials, but an editorial of This Day newspaper (16 March, 2012, page 15) lamented the revelation of Kabiru Gaya, the Chairman of the Senate Committee on state and Local Government, that out of the 774 local governments in Nigeria, 540 are run by Caretaker Committees 'who are in effect the hand-chosen cronies of state governors. Most state governors would not go into an election without first dissolving the local governments and positioning their agents as caretaker chairmen who would ensure their victory.

Under these circumstances, implementation of anything by local governments becomes a big problem. Primary Health Care (PHC) is caught up in this political mess. The National Primary Health Care Development Agency is doing a good job, but the political instability at the local government level is making it difficult to make PHC become the culture of the people at the grassroots level.

The World Health Organization (WHO) in its report has recommended that implementation of PHC is more necessary now than ever before. The Health Schematic Group of Vision 20, 2020 recognized that the lack of political stability at the local government level was an impediment to the establishment of PHC, and recommended that, if government cannot be stabilized at this level, the responsibility should be assumed at the state or even the federal level.

GIS (Geographic Information System) is a valuable to assist health research planning, monitoring and evaluating health systems. It has been used by several scholars to combine different data and generate information required for decision making in health management. The World Health Organization (2004), describes GIS as "an excellent means of analyzing epidemiological data, revealing trends, dependencies and interrelationship that would be more difficult to discover using traditional tabular approach".

While several studies have reported many aspects of the Nigerian health care system, no work has been done in the aspect disease tracking, and Management Information System (MIS) techniques to meet the need of the Nigerian populace in the modern era, practically, no attention is given to the surveillance system. Hence a major shortcoming of the Nigerian health care system is the absence of adequate MIS system to track disease outbreaks, mass chemical poisoning, etc.

The ability to locate health facilities and identify their capabilities in terms of services hours of operation and their sparse distribution has been underscored due to lack of proper mapping facilities. Unlike in the developed world where all health facilities are of equal standard, in the developing world is different. Therefore, to those needing medical help would be wondering as to which health care facility to attend, therefore, questions may arise as to those available health facility operate 24 hours, do they have pharmacy/pharmacist, are they adequate and has functional laboratories for the purpose of blood transfusion and examination of pathogens, do they have beds? First objective of this project is to provide the ability to check this information on a computer, either online or not to achieve even more details on health facilities in a single visual map.

The two districts under study, Ribadu and Gurin districts have two political wards each, making a total number of four political wards within the study area. Ribadu district has Ribadu and Fufore wards while Gurin district has Gurin and Beti wards. The four wards have a total number of twenty four (24) Primary Health Care Facility (PHCF) distributed all over the towns and villages within the study area. The PHCF built include Primary Health Care Centers (PHCC) usually located in the major towns and they serve as center where drugs and medical equipment are distributed to Primary Health Centers (PHC) and Health Post (HP) located in towns and villages respectively. Another PHCF available are a government and a private Maternity Health Centers (MHC) located in Fufore and Chigari towns respectively. The 2022 projected total population of the two districts amounts to 146,255 (NPC, 2022). Therefore the geospatial analysis of the distribution of the PHCF were done base on the distribution of the health facilities in the four political wards of the study area. The breakdown of the number of PHCF in each political ward are as follows:

i. Ribadu ward = 7 ii. Fufore ward = 3iii. Gurin ward = 7 iv. Beti ward = 7

***Statement of the Problem:***

Health care in Nigeria is prone to so many problems which are attributed to the fact that health services are in great demand but accessibility to health services is very low. Emergency health cases and accidents due to increase in population, insecurity, insurgency, immigration and disaster are becoming a major concern. Inability to find adequate health facilities with doctors, nurses and health attendants together with equipment is a great challenge and also these health facilities are inadequate and unequally distributed. However this study would provide Management Information System (MIS) by analyzing the pattern of health care facilities distribution, equipment and personnel availability and accessibility within the study area and display the results on computer screen just at a click of a button.

***Research Questions:***

1. Are the primary health care facilities adequate within the study area? 2. Are the primary health care facilities fully equipped and have sufficient and qualified personnel? 3. Are the primary health care facilities equally distributed based on the population of the study area?

***Significance of the Study:***

The final results of the research would be an automated system where all necessary information regarding health facilities within the study area would be displayed on a screen, just at a click of a button and in the comfort of an office. The research would therefore be of significance in planning the management of health facilities in the study area by the government and stake holders in the health sector at large. The system would also assist the general public in locating the best health facilities within their neighborhood in terms of equipment and qualified personnel at a glance

***Aim:***

The aim of this research project is to analyze the geospatial distribution of primary health care facilities in Ribadu and Gurin districts of Fufore local government area of Adamawa state, Nigeria.

***Objectives:***

- i. To produce administrative map of the study area from satellite image.
- ii. To obtain spatial and attribute data of all PHCF within the study area using DGPS equipment and a designed questionnaire respectively.
- iii. To create a base map and a digital map of the study area from satellite image.
- vi. To create attribute database and link with spatial data
- v. To carryout geospatial analysis and test run the efficacy of the system by queries.

***Justification of the Study:***

Planning of management strategies is a key issue in the delivery of health system, a good management design is not just desirable but a consistent development that need to pass through one step to the other. The continuous increase in the demand for the health facilities in Nigeria is as a result of population growth bearing in mind that the competitive environment in which these services are provided. Health system therefore needs a more effective and efficient approach to improve availability of appropriate information in decision making, productivity of all staff, new and improved working facilities, expand the existing structures, improve the standard of services offered.

***Scope of the Research:***

This research was limited to geospatial analysis of Primary health care facilities within Ribadu and Gurin districts of Fufore Local Government Area only. It did not cover the whole of Fufore local government area due to time frame and limited funding.

***Motivation of the Research***

The ability of using digital mapping techniques to see the spatial distribution and database creation to locate and infer details of health facilities in the study area is possible. The satellite imagery of the study area was downloaded geo-referenced and digitized. Spatial data of each health facility was obtained from the X, Y coordinates, distances were inferred and the details provided in the database was accessed by user. The nearest neighbor analysis was carried out in order to determine the distribution pattern of the health facilities in Ribadu and Gurin districts, the study area.

## II. Study Area

The study area Ribadu and Gurin districts are two out of the seven districts of Fufore local government area of Adamawa State located in North-Eastern part of Nigeria. Other districts are Karlahi, Yadim, Daware, Malabu and Mayoinne. The local government area lies between latitude  $08^{\circ} 45'$  and  $09^{\circ} 35'$  N and longitude  $12^{\circ} 15'$  and  $13^{\circ} 15'$  E. It has a total land mass of about 3,666sqkm (Musa and Tukur, 2009). The local government has 2022 projected total population of 371,255 (NPC, 2022). The area is regarded as low lying with about 80% of the entire area being at less than 300m above sea level, while remaining 20% are hills and mountains (Fadama II, 2008). However Ribadu district has 2022 projected population of 57,949 and Gurin district has 2022 projected population of 88,306, therefore the 2022 projected total population of the two districts stood at 146,255 (NPC, 2022). The two districts are located such that they have a common boundary and are centrally located in the local government area (Fufore). The districts are bounded with Daware and Karlahi districts on the North and South respectively, Cameroon on the East and Yola South on the West. The administrative map of the study area is presented in figure 1 below.

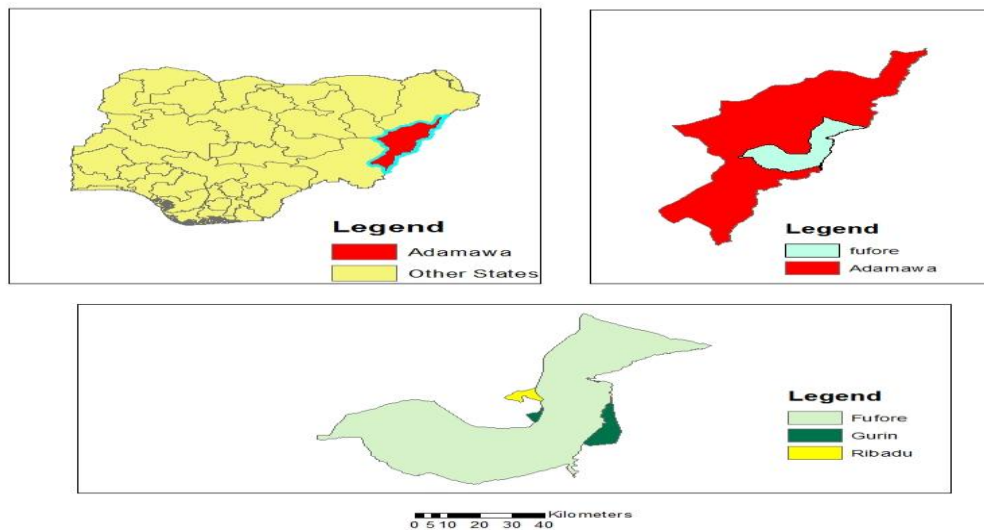


Figure 1: Administrative map of Nigeria showing Adamawa state, Fufore Local Government, Area Ribadu and Gurin Districts, the study area. Sources: Google Earth, 2022.

## III. MATERIALS AND METHODS

The materials/equipment used for the research include; i. The Hard ware and ii. The Software. i. The hard ware include; a. Differential Global Positioning System (DGPS) Promac-3 b. One HP Laptop altech G61 with 2.00 GB RAM & 250 GB Hard disk plus 500GB external hard disk storage capacity c. One HP printer P1102 series and d. One HP 1310 photocopier. ii. The software include; a. ArcGIS 10.3 b. Google Earth c. Microsoft Excel 2013 d. Microsoft Word 2013 and e. CorelDraw X3. There are two types of data acquired for the research, these are; spatial data and non - spatial data. The spatial data are X,Y coordinates of all the Primary Health Care Facilities (PHCF) within the study area and topographic maps and satellite images covering the study area. The non-spatial data otherwise known as the attribute data were information obtained from the department of health, Fufore Local Government Secretariat and through interviews administered on the officials of the various PHCF based on a designed questionnaire. The attribute information obtained include; the category of PHCF, ownership type, number of doctors in each health facility, health attendants, availability of laboratory, blood bank, number of beds etc. The sources of data is classified in to primary and secondary sources of data. The primary sources of data are Adamawa State Ministry of Land and Survey, Yola and Google Earth where analog topographic maps and satellite images covering the study area were respectively obtained. The secondary sources of data is a direct survey field work and administration of interviews where the X,Y coordinates of all the PHCF within the study area and their attribute data were respectively obtained.

For the method of executing the research, there are four political wards within Ribadu and Gurin districts, the study area with total number of 24 PHCF. The geospatial analysis of the distribution of the PHCF was carried out based on the distribution of PHCF in the four political wards namely; Ribadu, Fufore, Gurin and

Beti. Office reconnaissance survey was firstly carried out where the topographic maps covering the study area were obtained from the Adamawa State Ministry of Land and Survey, Yola which served as a guide in locating all towns and villages that have PHCF within the study area. It was also during office reconnaissance, the satellite images covering the entire Fufore Local Government Area (L.G.A.) was downloaded via Google Earth at 4,800 x 4,800 pixels with a scaling of 1% and creation of administrative maps of the study area were also done. The administrative map of the study area was created through the latest GIS shape file of Nigeria administrative levels namely, state, local and ward boundary map downloaded from IGISMAP. The data is available in Geographic Coordinate System (GCS), a datum at WGS84. The data downloaded was then imported into the ArcGIS 10.3 environment to produce the administrative map showing Nigeria, Adamawa, Fufore L.G.A., Ribadu and Gurin districts the study area. Different colors were used to signify the administrative areas, scales were inserted accordingly and was exported as map as presented in figure 1. Field reconnaissance survey was then carried out where the health department of Fufore local government secretariat was visited and all relevant information regarding the distribution of PHCF within the four political wards in terms of their locations, categories, ownership type, services rendered, accessibility etc. were obtained. Having carried out office and field reconnaissance survey, survey field work was followed. The field work involved obtaining the spatial data that is X,Y coordinates and attribute data of all 24 primary health care facilities available within the study area. The spatial data were obtained using DGPS Promac-3 equipment and the attribute data were obtained by administering interviews on the officials of the various PHCF based on a designed questionnaire. Both the spatial and attribute data were obtained simultaneously.

#### **IV. DATA PROCESSING**

Prior to processing of the field data, the base map of the study area was created. To create the base map of the study area, the satellite image covering the entire Fufore L.G.A. earlier downloaded from Google Earth at 4,800 x 4,800 pixels with a scaling of 1% was saved in a computer folder. To facilitate geo-referencing, which is a process of registering the downloaded image with geographic information so that ArcGIS can place the image in its appropriate real world location, four corner points of the image in the Google Earth environment were selected and place mark symbol was used to mark selected points on the image. The marked image was saved as a Keyhole Markup Language (KML) file. The two files (satellite image and KML file) were imported to ArcGIS 10.3 environment. The data frame was subjected to the UTM coordinates systems. Spatial conversion tool of ArcGIS 10.3 was used to convert the KML file from Google Earth to a shape file. The image was then geo-referenced and the boundary of the two districts Ribadu and Gurin was clipped and saved as a shape file named "Base Map" as presented in figure 3. After creating the base map of the study area, digitization was the next step, it is the process of converting imagery in to a digital format and the generation of a structured dataset called topological dataset on which spatial operation are performed to produce useful information. On screen digitizing was adopted and different layers of features were generated using ArcGIS 10.3 software. This involves the formulation of health facility table in MS-Excel spread sheet, which was converted to database and was exported to GIS environment to produce point map to show the spatial distribution and pattern of distribution both public and private PHCF in the two districts. Also, the various wards and existing roads were digitized to produce the digital map of the study area showing spatial distribution and pattern of distribution of health facilities. The digital map of the study area is presented in figure 4.

Having created the base map and digital maps of the study area, the next step was creation of the data base. Data base is the process of creating a generic data structure in the computer system to facilitate ease of data exchange and series of analysis. This is the major stage as it is the heart of GIS. To create the data base for the research, the attribute and spatial data acquired from the field were entered in to a spread sheet using Microsoft excel and were imported in to ArcGIS 10.3 to create attribute and spatial data bases which are then linked together to form a relational database from where spatial analyses were carried out. The entity relationship diagram for the data base creation is presented in figure 2 below.

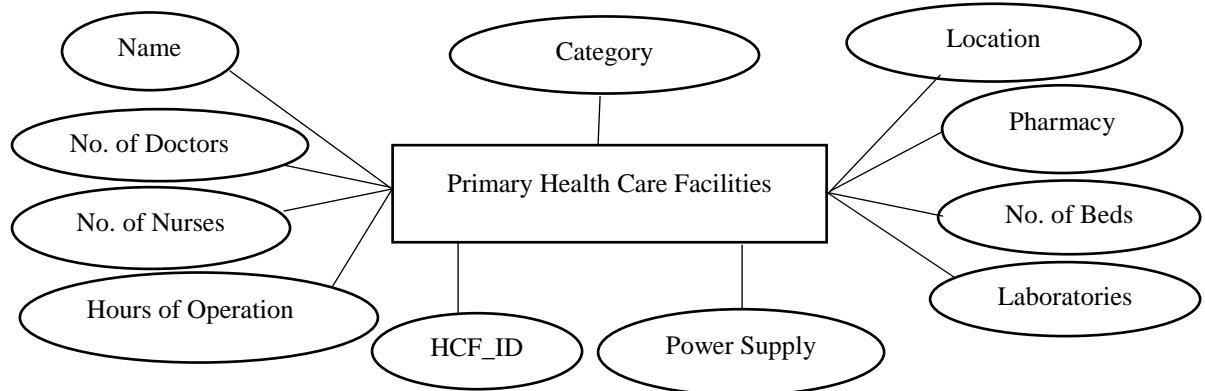


Figure 2: Entity Relationship Diagram

Spatial analysis was performed on the data obtained. The locational data (X, Y coordinates) of the health facilities were used to determine the distance from each point to its nearest neighbor and the distances were used to determine the distribution pattern of the health facilities using the Nearest Neighbor Analysis (NNA) statistical tool in ArcGIS 10.3. Population analysis was also performed in ArcGIS to determine the population distribution of the study area based on a projected population of 2022. The population distribution was determined which provided the relationship in population of all settlements within the study area. Spatial queries were made to retrieve the information stored in the database pertaining to certain analytically defined attributes within the database to answer spatially related questions and to test run the accuracy and efficacy of the system. This operation involved the link between the database and the map. It involves the retrieval of information stored in the database using Structured Query Language (SQL). An example of such queries are presented in figures 11 – 13.

## V. RESULTS PRESENTATION AND DISCUSSION

The results of the study are basically in the form maps, tables and chart as presented below: A total of 24 health facilities whose coordinates were obtained using differential Global Positioning System (DGPS) at Gurin and Ribadu Districts of Fufore LGA. comprising of 4 wards were mapped and their coordinates inputted in ArcGIS 10.3 Environment for various spatial analysis. Figure 3 is the base map of the study area created from the satellite imagery of the study area downloaded via Google Earth at 4,800 x 4,800 pixels which was digitized to form a digital map of the study area. Figure 4 shows the extracted digital version of the satellite imagery of the study area. The map clearly shows settlements, healthcare facilities, roads and boundaries with their respective locations. The map provides a glance view of the 2 districts and healthcare facilities domiciled in the area. Table 1 shows the political wards and number of health care facilities in each ward. Table 2 is the list of primary health care facilities in each political ward. The statistical distribution (in percentage) of the health facilities in the study area was depicted in by Pie Chart in figure 5, the chart shows that Gurin, Ribadu and Beti wards have the highest and equal number of healthcare facilities with 29% and the least is Fufore ward with 13%. The health facilities and their locations within the study area is presented in table 3

The distributional pattern of healthcare facilities in the 2 districts were analyzed using the Average Nearest Neighborhood. The analysis uses the distance between each point and its closest neighboring point to determine if point pattern is clustered, random or dispersed. If the average distance is less than the average for a hypothetical random distribution, the distribution of the features being analyzed are considered clustered, however, if the average distance is greater than a hypothetical random distribution, the features are considered dispersed as shown in figure 6 and the observed Mean Distance of 3740.2253m and Expected Mean Distance of 3126.4080m were obtained as presented in Average Nearest Neighbor Summary table 4. The Observed Mean Distance being greater than the Expected Mean Distance with Nearest Neighbor Ratio of 1.196333m, it is logical to conclude that the health facilities are dispersed within the study area. This implies that health facilities in the study area are spread out over a wide area. The reason for the dispersed distribution is due to the wide spread of settlements over the study area.

Proximity Analysis is an analytical technique used to determine the relationship between a desired point and its neighbors. Buffer analysis was used for identifying areas surrounding geographic features, which in this case healthcare facilities. Distance buffer of 4km was generated around existing healthcare facilities in the study area to subject the locations of healthcare facility in relation to others to the standard distance given by the World Health Organization. In figure 7, the distance buffer analysis of 4km radius indicated that Vamni, Lesbeti, Jammare, Pateri and Farang-farang settlements will have to move more than 4km to access a healthcare facility.

Distribution of population has a key role to play in deciding eligibility of healthcare facility in a given settlement. Table 5 shows the 2022 projected population of the settlements within the study area. The National Primary Healthcare Development Agency (NPHCDA) has given population criteria as minimum standard for establishment of Primary Health Care in Nigeria. For Health Post (HP) (category A) an estimated coverage population of 500 people, Primary Health Clinic (PHC) (Category B), 2,000 – 5000 people and Primary Health Care Centre (PHCC) (Category C), 10,000 - 20,000 people. Therefore, figure 8 shows the population distribution showing service delivery area (category A) of population of at least 500, figure 9 shows the population distribution showing service delivery area (category B) of population of 5000 and above, figure 10 shows the population distribution showing service delivery area (category C) of population above 10,000. Therefore the results of figures 8,9 and 10 depicts that 20 settlements are eligible for Health Post (HP), 4 settlements are eligible for Primary Health Clinic (PHC) and 4 settlements are eligible for Primary Health Care Center (PHCC).

The database created is made up of 24 primary health facilities and one attribute table containing the records of the health facilities. The spatial database was queried from the attribute table or using the identity icon. Also, the attribute table was queried using the query builder icon. All these functions mentioned above were tested on the database and found to be working properly. An important aspect of database is the ability to retrieve data promptly and accurately using query. It is much easier, faster and much more convenient than copying from hard copy paper files or even from word documents that cannot be queried. In testing the efficacies of the database, query operations were performed. The query of health care facilities with beds more than 10 (Figure 11) indicates that 5 out of 24 health facilities have bed spaces more than 10. And query of Health care facilities with no Doctor as presented in figure 12 showed that 23 out of 24 health care facilities have no Doctor. Also query of Health care facilities with nurses greater than or equal to 3 as indicated in figure 13 shows that 10 out of 24 healthcare facilities have 3 nurses or above. Table 6 shows the adequacy of health care personnel and facilities per political ward. From the table it is clear that all the 23 government owned health facilities do not have a medical Doctor and there was only one medical Doctor in a private health facility located in Beti ward, and other facilities like laboratories, pharmacies, blood banks and bed spaces are in adequate.

**Findings**

- i. From the distance buffer analysis of 4km radius given by World Health Organization as standard distance from one healthcare facility to another, indicated that Vamni, Les-beti, Jammare, Pateri and Farang-farang settlements will have to move more than 4km to access a healthcare facility.
- ii. The result of the analysis performed shows that there should be a total of 28 Health facilities that will adequately suffice for population of the study area. In comparison, there are 24 healthcare facilities in the study area, therefore, based on WHO standard, healthcare facilities are 87.7 percent adequate.
- iii. Result from the geodatabase query indicated that, all the 23 Government primary healthcare facilities have no Doctors; only 41.7% of healthcare facilities in the study area have at least 3 healthcare attendants. Additionally, only 20.8% of healthcare facilities in the study area have bed space more than 10.
- iv. The database created and tested provide the ability to retrieve up-to-date-data promptly and accurately using query, such as location of hospitals in relation to others, number of hours each health facility in the study area operates, number of doctors, Nurses, Health attendants and beds, information on laboratories, blood banks etc.

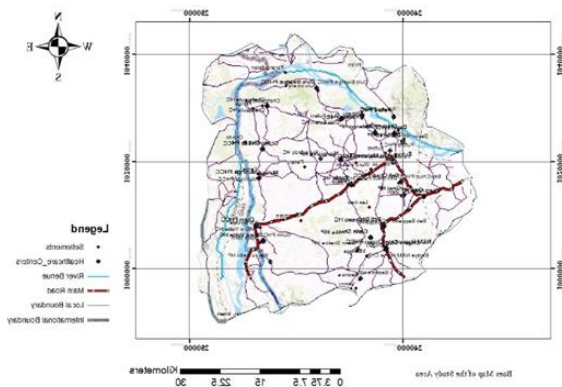


Figure 3: Base Map of the Study Area

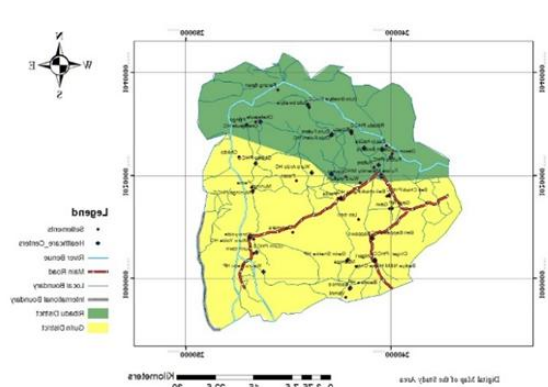


Figure 4: Digital Map of the Study Area

Table 1: Political Wards and Number of Health Facilities in Each Ward

S/N	Ward	Government	Private	Total
1.	Ribadu	7	0	7
2.	Fufore	3	0	3
3.	Gurin	7	0	7
4.	Beti	6	1	7

Table 2: List of Primary Health Care Facilities in each Political Ward

**RIBADU WARD**

- |   |  |
|---|--|
| 1. Ribadu Primary Health Care Center (PHCC)       | 2. Dasin Primary Health Care Center (PHCC) |
| 3. Dulo Bwatiye Primary Health Care Center (PHCC) | 4. Dulo Fulani Primary Health Center (PHC) |
| 5. Chafajaule Primary Health Center (PHC)         | 6. Wafango Health Post (HP)                |
| 7. Dason Health Post (HP)                         |  |

**FUFORE WARD**

- |                                       |   |
|---------------------------------------|---|
| 1. Fufore Primary Health Center (PHC) | 2. Fufore Maternity Health Center (MHC) |
| 3. Njangjanre Health Post (HP)        |   |

**GURIN WARD**

- |  |  |
|--|--|
| 1. Gurin Primary Health Care Center (PHCC)   | 2. Muninga Primary Health Care Center (PHCC) |
| 3. Chikito Primary Health Care Center (PHCC) | 4. Parda Primary Health Center (PHC)         |
| 5. Wuro Yolde Primary Health Center (PHC)    | 6. Wuro Ardo Primary Health Center (PHC)     |
| 7. Wauru Nelbi Health Post (HP)              |  |

**BETI WARD**

- |  |   |
|--|---|
| 1. Chigari Primary Health Care Center (PHCC) (BN&MH) | 2. Badiya Nursing & Maternity Home Chigari  |
| 3. Beli Chiuti Primary Health Care Center (PHCC)     | 4. Beti Bappawo Primary Health Center (PHC) |
| 5. Garin Shekke Health Post (HP)                     | 6. Baomse Health Post (HP)                  |
| 7. Gawi Health Post (HP)                             |   |

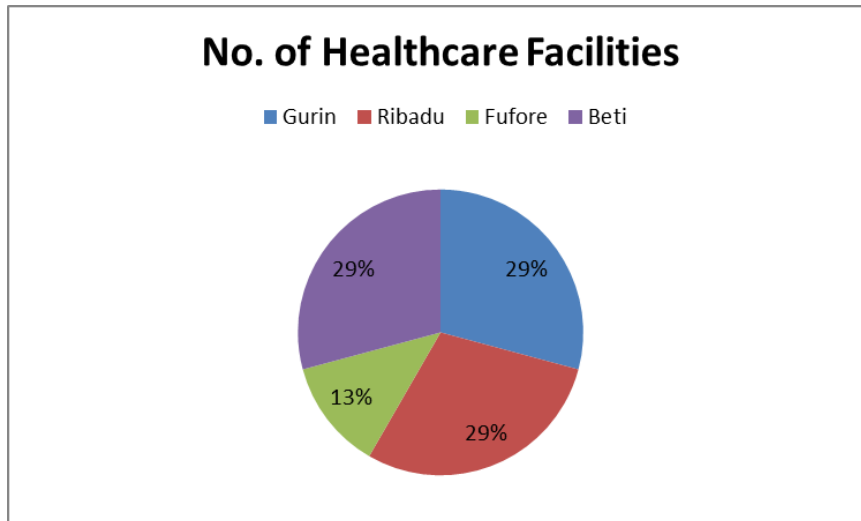


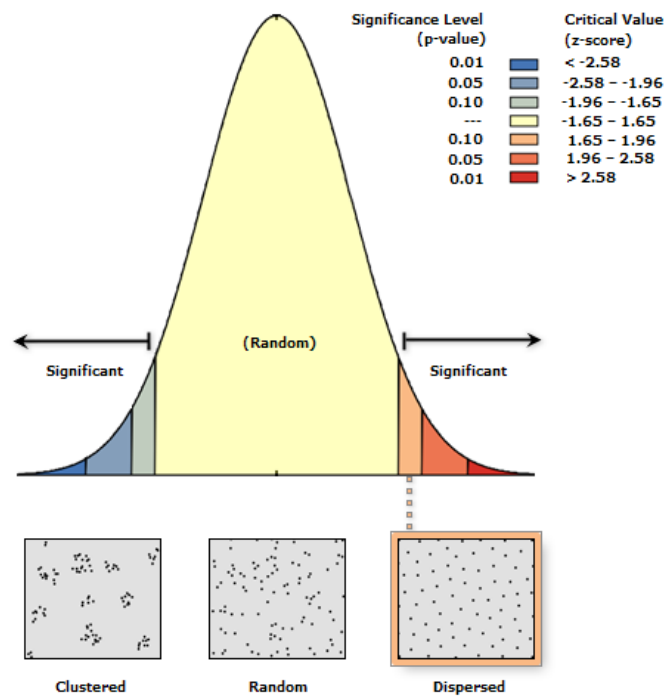
Figure 5: Pie Chart of the Distribution of Health care facilities per ward

Table 3: Health Facilities and their Locations within the Study Area

S/No.	Name of Facility	Easting (m)	Northing (m)	Height (m)
1.	Ribadu Primary Health Care Center	247709.102	1028607.004	201.001
2.	Dasin Primary Health Care Center	241645.401	1025103.112	169.712
3.	Dulo Bwatiye Primary Health Care Center	256159.211	1033744.011	1181.214
4.	Dulo Fulani Primary Health Center	251477.110	1027955.910	181.249
5.	Chafajaule Primary Health Center	265462.100	1030521.612	187.407
6.	Wafango Health Post	245244.314	1025344.012	187.290
7.	Dason Health Post	240031.610	1023619.010	219.004



8. Fufore Primary Health Center	242414.724	1022052.197	179. 322
9. Fufore Maternity Health Center	241893.110	1019818.220172.	644
10. Njangjanre Health Post	251663.410	1020245.333211.213	
11. Gurin Primary Health Care Center	266210.073	1005133.467200.106	
12. Muninga Primary Health Care Center	266944.008	1016909.330203.113	
13. Chikito Primary Health Care Center	266353.701	1022340.601198.220	
14. Parde Primary Health Center	249719.055	1015660.411196.337	
15. Wuro Yolde Primary Health Center	267486.800	1007933.041202.143	
16. Wuro Ardo Primary Health Center	255399.669	1020604.050197.435	
17. Wauru Nelbi Health Post	264844.6701001304.480184.335		
18. Chigari Primary Health Care Center	243136.290	1003610.901192.481	
19. Badiya Nursing & Maternity Home Chigari	243132.008	1003491.470191.271	
20. Beli Chiuti Primary Health Care Center	240330.0131016115.098179.880		
21. Beti Bappawo Primary Health Center	243600.068	1007791.497195.837	
22. Garin Shekke Health Post	248369.8621003632.154184.602		
23. Baomse Health Post	247893.611998181.726195.810		
24. Gawi Health Post	239912.0221013609.313202.150		



Given the z-score of 1.84005141292, there is a less than 10% likelihood that this disperse pattern could be the result of random chance.

Figure 6: Nearest Neighbor Analysis

Table 4: Average nearest Neighbor Summary  
**Average Nearest Neighbor Summary**

<b>Observed Mean Distance:</b>	3740.2253 Meters
<b>Expected Mean Distance:</b>	3126.4080 Meters
<b>Nearest Neighbor Ratio:</b>	1.196333
<b>z-score:</b>	1.840051
<b>p-value:</b>	0.065761

**Dataset Information**

<b>Input Feature Class:</b>	Healthcare_Centers
<b>Distance Method:</b>	EUCLIDEAN
<b>Study Area:</b>	938344983.199345
<b>Selection Set:</b>	False

Table 5: 2022 Projected Population of the Settlements within the Study Area

Settlement	Population	
<b>RIBADU WARD</b>		
1. Ribadu town	6,500	2. Chafajaule 3,220
3. Dasin Hausa	10,343	4. Dulo Bwatiye 3,630
5. Dulo Fulani	4,683	6. Wafango 1,100
7. Dason	1,100	8. Filingo 543
9. Farang Farang	463	
<b>TOTAL <u>31,582</u></b>		
<b>FUFURE WARD</b>		
1. Fufore town	23,851	2. Njangjanre 1,200
3. Solomsi	674	4. Wuro Mallum 642
<b>TOTAL <u>26,367</u></b>		
<b>GURIN WARD</b>		
1. Gurin town	22,872	2. Muninga 9,237
3. Chikito	9,237	4. Parada 6,380
5. Wuro-Yolde	3,977	6. Wauru Nelbi 3,977
7. Wuro-Ardo	3,148	8. Fema 534
9. Jammare	653	10. Pateri 564
<b>TOTAL <u>60,579</u></b>		
<b>BETI WARD</b>		
1. Chigari	10,844	2. Beti Bappawo 3,967
3. Beli Chiuti	3,219	4. Gawi 1,985
5. Garin Shekke	3,749	6. Baomse 2,046
7. Les Beti	589	8. Mbamga 674
9. Vamni	654	
<b>TOTAL <u>27,727</u></b>		
<b>GRAND TOTAL <u>146,255</u></b>		

Source: National Population Commission, Federal Secretariat, Yola.

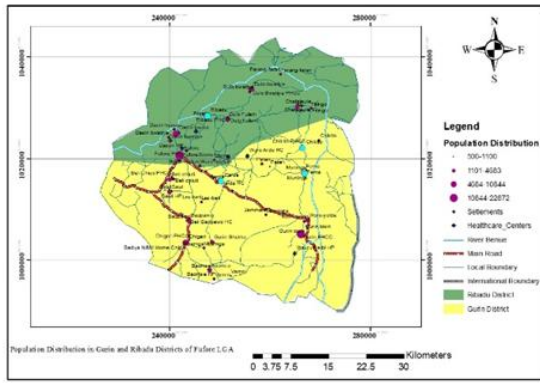


Figure 7: Distance Analysis of 4Km Buffer.

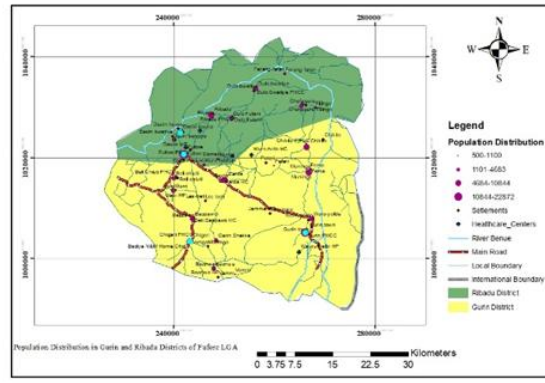


Figure 8: Population Distribution Showing Service Delivery Area (Category A) of Population of at Least 500

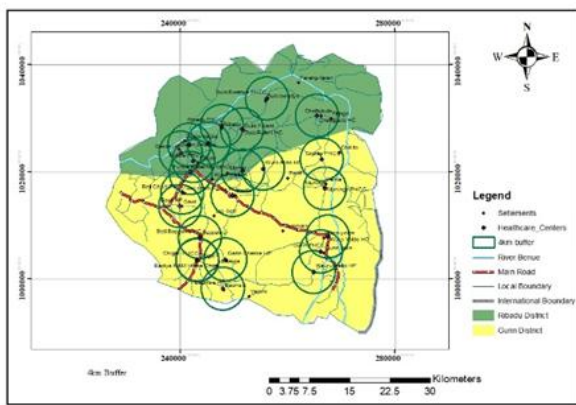


Figure 9: Population Distribution Showing Service Delivery Area (Category B) of Population 5000 and Above.

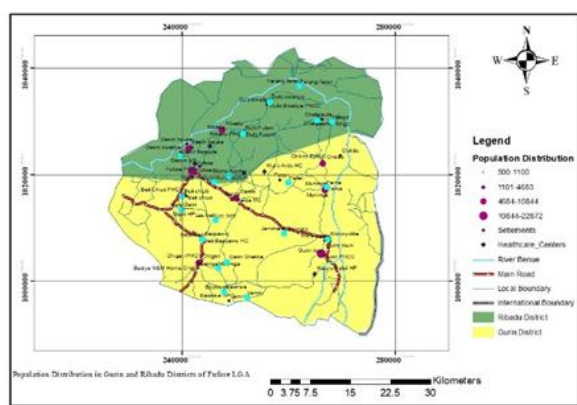


Figure 10: Population Distribution Showing Service Delivery Area (Category C) of population above 10,000.

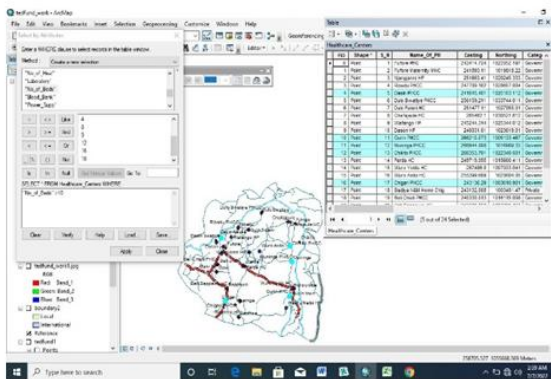


Figure 11: Query of Health Facilities with Beds More than 10

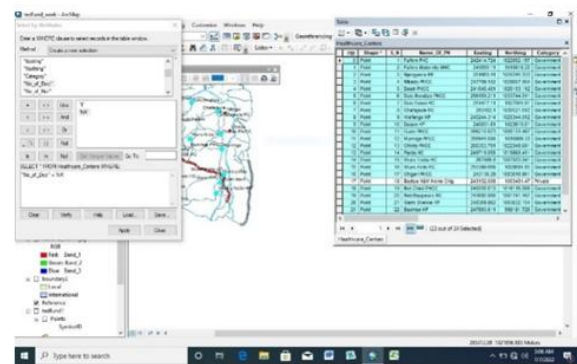


Figure 12: Query of Health Facilities with no Doctors

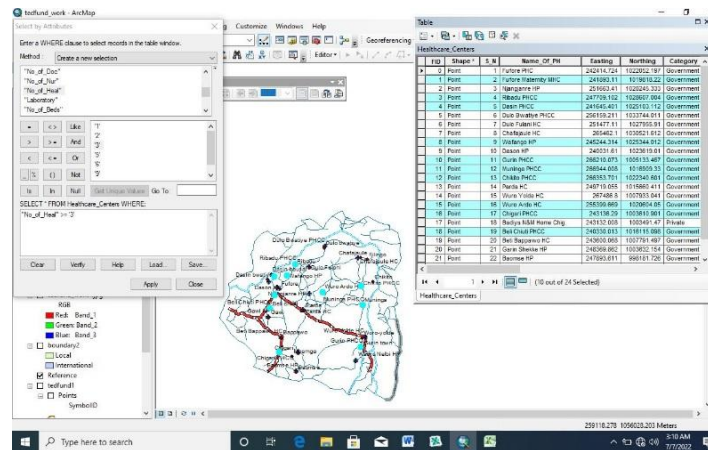


Figure 13: Query of Health Facilities with Number of Nurses Greater than or Equal to 3

Table 6: Adequacy of HealthCare Personnel and Facilities per Political Ward

S/N	Ward	Doctors	Nurses	H/Attend	Pharmacy	Labs	Blood Bank	Bed Spaces
1.	Ribadu00	203	3	3		41		
2.	Fufore	0		2		7	11	114
3.	Gurin002433348							
4.	Beti	1		012		3	3	34

## VI. SUMMARY

The geospatial analysis of Primary Health Care Facilities (PHCF) in Ribadu and Gurin districts was carried out by firstly conducting office and field reconnaissance survey. During office reconnaissance survey, topographical maps covering the study area were obtained and used as a guide in locating twenty four (24) PHCF distributed over the study area. The satellite images of the study area was also downloaded via Google Earth at 4,800 x 4,800 pixels with scaling of 1% during the office reconnaissance survey. All relevant information regarding the distribution of the PHCF in four political wards of the study area in terms of their locations, categories, ownership type, services rendered, accessibility etc. were obtained from health department of Fufore local government secretariat during field reconnaissance survey.

There are two types of data obtained for the research, The Spatial and non - spatial data. The spatial data are the X,Y coordinates of all 24 PHCF within the study area which were obtained using DGPS equipment and topographical maps and satellite imageries covering the study area obtained from the ministry of land and survey Yola and Google Earth respectively. The non – Spatial data also known as attribute data were information on each health facility such as ownership type, number of doctors, nurses, health attendants, bed spaces, availability of laboratory, pharmacy, blood bank, power supply etc. were obtained through social interview administered on the officials of the various PHCF based on a designed questionnaire.

Having obtained the spatial and non – spatial data for the research, the base map of the study area was created in the ArcGIS 10.3 from the downloaded satellite imageries of the study area. The base map so produced was converted to a digital format through a process known as digitization. On screen digitization was adopted where different layers of features were generated using ArcGIS 10.3. The four political wards and existing roads were digitized as well to produce the digital map of the study area showing spatial and pattern of distribution of health facilities across the study area as presented in figure 4.

The spatial and attribute data obtained from the field were entered in to a spread sheet in Microsoft Excel and were imported in to ArcGIS 10.3 software where spatial and attribute data bases were created and linked together to form a relational data base from where spatial analysis and queries were carried out. The spatial analysis conducted include Nearest Neighbor Analysis (NNA) which determined the spatial distribution pattern of the primary health care facilities across the study area and 4km buffer analysis which identified the proximity of the health care facilities within 4km radius. Other spatial analysis conducted is population distribution analysis which determined the eligibility of health facility in a given settlement. Queries were also made to retrieve the information stored in the data base to answer spatially related questions and to test run the efficacy and accuracy of the system using Structured Query Language (SQL) as presented in figures 11, 12 and 13.

## VII. CONCLUSION

The study on the distribution of primary health care facilities in Ribadu and Gurin districts of Fufore Local Government Area has been conducted successfully. Total number of 24 health facilities was found to have been distributed over the 4 political wards of the study area. Various analysis were carried out and queries were made to retrieve the information stored in the data base to answer spatially related questions. The statistical distribution (in percentage) of the health facilities depicted by pie chart shows that Ribadu, Gurin and Beti wards have the highest and equal number of health facilities with 29% and the least is Fufore ward with only 13%. The average Nearest Neighborhood analysis indicates that the health facilities are dispersed within the study area and are 87.7% adequate based on WHO standard, however, buffer analysis of 4km radius conducted indicates that settlements like Vamni, Les-beti, Jammare, Pateri and Farang-Farang will have to move more than 4km to access a health care facility which is against the standard maximum distance of 4km given by the WHO. The study also revealed that out of 24 health facilities available within the study area only 1 is private the rest 23 are owned by government and there was only 1 doctor in all the 24 health care facilities and other health personnel and equipment are seriously inadequate.

## VIII. Recommendations

Having successfully completed the study, the following recommendations has been made; 1. Government should employ at least one Doctor in each Primary Health Care Center (PHCC) and more health personnel such as nurses, midwives, health attendants etc. in all health facilities available within the study area. 2. Government and non-governmental organizations should build more health facilities in settlements that are not within the proximity radius of 4km to health facilities such as Vamni, Les-beti, Jammare, Pateri and Farang-Farang settlements. 3. Government, private individuals and stake holders in the health sector should generously supply health equipment and drugs such as blood bank, power sources, beds, refrigerators, water sources, labs reagents, kits etc. in all the health facilities within the study area. 4. Private individuals should build private health facilities in major towns of the study area to supplement government owned health facilities.

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