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GEOSPATIAL DOCUMENTATION AND GEO-DATABASE DEVELOPMENTS FOR HEALTH FACILITIES IN BIRNIN KEBBI METROPOLIS, KEBBI STATE, NIGERIA

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Abstract:
This study investigates the spatial pattern, distribution, and concentration of health facilities in Birnin Kebbi metropolis by creating a geospatial database using high order technology equivalent of the map in the field of Geography for visual representation. The categories of health facilities are Hospitals, Clinics, Maternity centers, and Dispensaries vis-à-vis their population was captured and mapped. The results of the analysis show a total of 24 health facilities in Birnin Kebbi Metropolis, eight (8) are privately owned, four (4) registered with State Ministry for Health and four (4) not registered and Sixteen (16) are publicly owned. In addition, there are three (3) secondary health care centers, the Federal Medical Center, four (4) Primary Health Centers, four (4) Post Primary Health Centers and four (4) Clinics. Our findings revealed the disproportionate distribution of health care facilities in Birnin Kebbi metropolis. The underlying reasons for this remain poorly known. A further study which will map healthcare facilities in relation to population distribution is therefore recommended. Because the identification and mapping of health facilities vis-à-vis the geospatial database creation will help decision makers plan and take a decision with complete confidence using maps.

Keywords: GIS; hospital; clinics; health past; database; spatial analysis

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1. Introduction

Decision making in government establishment has faced a lot of challenges due to the use of inappropriate decision support information, there are many decision support systems (DSS) in use by public officials in many of government parastatals but none of it utilize the geospatial technologies (Budge et al., 2006) consequence which make government infrastructure inaccessible for the majority of the populace, because the infrastructures are localized in one area rather than be evenly distributed within the metropolis. Geographic information system (GIS) has now become an essential tool in solving many spatial based problems by using its location intelligence to produce a spatial database that can be subjected to spatial queries. The information produce can serve as a reliable and more insightful guide for decision information for decision maker (Church 2002), and this makes GIS an indispensable spatial decision support system (SDSS).

Geographical Information System provides a spatial information via analyses and visualization of data from specific geographic locations, to create a realistic view of the real-world perspective of the data. This provides a guide for decision making, for example, a spatiotemporal map showing the distribution of health care facilities, and identify areas of prevalent diseases, pest breeding grounds, and population distribution. (Burrough, 2001). In addition, GIS is useful in almost every facet of our daily lives, from earth science and other physical sciences to finance and management, Evaluation of health facilities, doctor-to-patient ratio, and location of health services. All these can be shown using GIS which reduces the difficulties involved in locating health care facilities other problems relating to health care and disease prevention which ranges from soil contamination, air pollution, to disease-carrying vectors etc. Many researchers including (Gething et al., 2007 and 2007; Fleischer et al., 2014) have used geospatial analysis to investigate the spatiotemporal prevalent of health hazards. Health hazards within the environment can be analyzed by modeling their spatial distributions for record and decision purposes (Mushonga et al., 2017).

Early GIS applications in environmental health analyses incorporate GIS techniques into the study of human health and the spread of diseases. The most notable early application of maps in health care is the use of a hand-drawn map by Dr. John Snow in London in the mid-1850's to analyze the spatial location of deaths caused by cholera. The output information reveals that most of the deaths are clustered around the Broad Street water pump. When the pump handle was removed, the cholera outbreak receded, though some scholars would argue that the epidemic was already on the decline (Green, 2012). Conversely, Leukemia in relation to nuclear facilities in England (Openshaw et al., 1988), laid the foundation for the extensive body of research on the GIS-based analysis of spatial disease clusters. Other early studies include McMaster's (1988): GIS assessment of community vulnerability to hazardous materials. Later Wartenberg (1992); Wartenberg et al. (1993) applied GIS to characterize populations living near high-voltage transmission lines. The GIS has been used in vector-borne

disease studies to determine the associations between environmental features and vector concentrations (Glass et al., 1994).

From much recent studies, including (Ye et al., 2017; Macharia et al., 2017; Tadesse et al., 2018), GIS is used to map out vector-borne and zoonotic diseases such as Lyme disease, viral meningitis, Hantavirus, Dengue Fever, Yellow Fever, and Rabies, among others. Earlier, Ghosh (2011), used GIS to analyze the association of urban environment features that facilitated viral activities of West Nile Virus (WNV) and compared the spatial association between WNV infected mosquito pools and human cases with heterogeneous urban characteristics in Minnesota USA between 2002 and 2007. His results showed that WNV is considerably higher in areas close to swamps, parks, and water discharge sites.

The World Health Organization (WHO, 1997) specified criteria for health care planning for third world countries. It recommends that each service area should cover about 4km catchment area with a population of 60,000 for primary health care to have adequate and equality of access to health care centers, in line with WHO (1997). The accessibility of health infrastructure in the study area has suffered a great setback as the use of GIS as decision support information is still not included in their routine in managing public health thus there is a need to empower the decision maker in the health sector with use of GIS as a spatial decision support system in their health management in other to enhance the accessibly of health facility, it was on this note that this research is aiming to creating a geospatial documentation of health facilities in Birnin-Kebbi metropolis of Kebbi state Nigeria, however, the set of objectives in actualize the stated aim including identifying, document, mapped, and analyses the spatial pattern of healthcare facilities the study area.

2. Study Area

The Study area is Birnin Kebbi the capital city of Kebbi state, the state that was carved out and created from part of Sokoto State in 1991, the headquarter of Birnin Kebbi local government area and also the seat of Gwandu Emirate is located in Northwestern Nigeria. It is geographically defined within latitude 12^0 24′ 00″ and 12^0 30′ 30″ North and longitude 4^0 10′ 0″ and 4^0 15′ 30″ East (Fig. 1). It lies along Sokoto River at the intersection of roads from, Jega and Bunza bonded in the east by the Gwandu LGA, to the west by Arewa Dandi Local government and the Kalgo and Argungu local government areas to the south and north respectively (See fig 1). The climate of the area is local steppe which falls within Koppen-Geigers BSh tropical Continental climatic. The average annual temperature ranges between 28.4^0 C to 37^0 C, with the mean annual rainfall is about 807mm with some local variations. The study area is part Sokoto basin of an elongated sedimentary basin underlying which is characterized by gently rolling to undulating relief features, the soils are the vertisols. Which comprises of heavy, cracking clayed soils with more than 35% clay have shrinking and swelling properties, the elevation around varies from about 225 meters to 238 meters above sea level.

The Birnin Kebbi landscape is mostly dominated by floodplains of Rima and Shella rivers which are located in the north and south-east of the town respectively. The study area falls within the northern Guinea savannah zone which is mostly described by heterogeneous mixture of vegetation, with few medium height trees the population of Birnin Kebbi was estimated to be about 125,594 peoples according to 2006 population census, the area comprises of multiple ethnic groups, major among who are Kabawas, Fulanis, Zabarmawas, Dakarkaris, with Islam as the major religion, due the nature of the area i.e. the two fertile Fadama lands; the Shella and Rima rivers fadama. Shella river fadama is situated approximately 3km south east of the town and averages about 1.5km width the people of the area are predominant fadama farmer with rice as the major agricultural product as well as other crops.

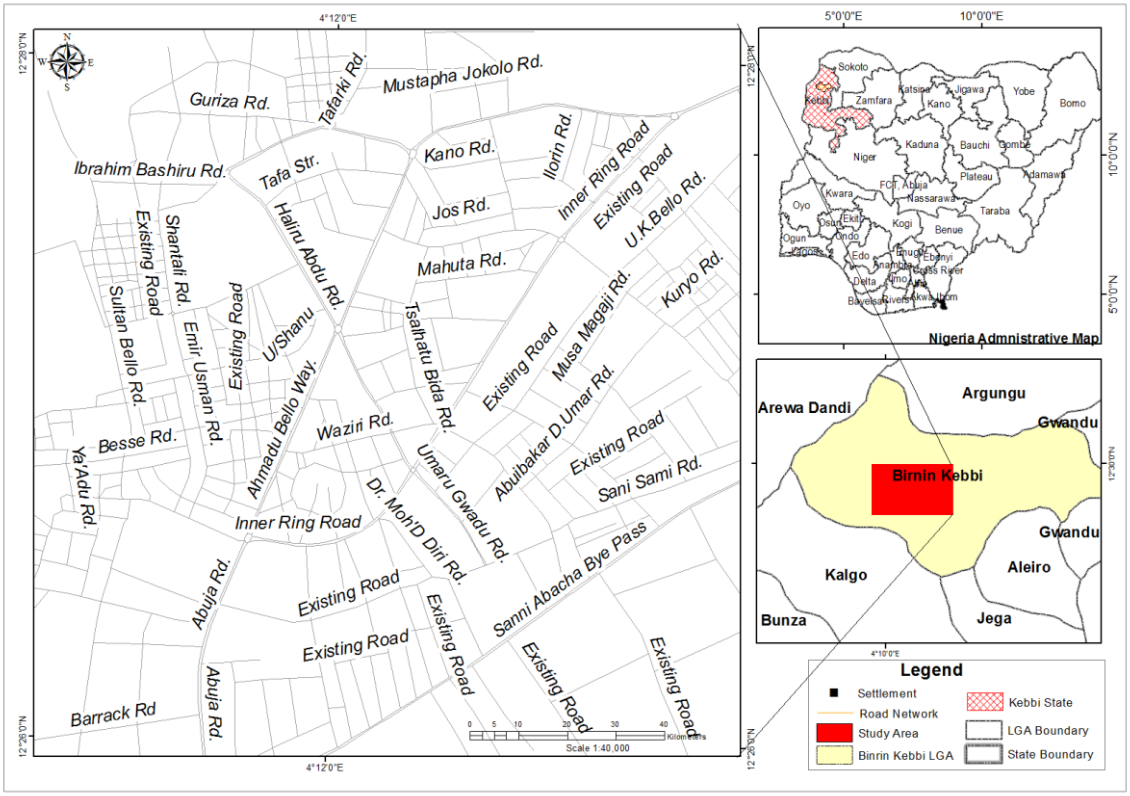

Figure 1: The Study Area

3. Materials and Methods

The data used for this study is basically on health infrastructures in the study area. Therefore, the source of data includes data from the reconnaissance survey to the study area and data obtained from the organization charged with a governmental portfolio in charge of the collection of relevant information concerning health infrastructures (State ministry of health) in the study area. Also, the map of the study area was extracted from IKONOS imagery from Google Earth Pro and georeferenced using ArcGIS 10.6 software. The remotely sensed data from Google Earth Pro is useful due to its high spatial resolution as well as ability to permit geographic analysis from the extracted

data. Other ancillary data used in this study were extracted from existing base maps, textbooks, journals and several other publications based on health facilities. A schematic summary of the data used, and other characteristics and sources are listed in Table 3.1 below.

Table 1: Data and Sources of Data for the Study

s/n	Data	Scale and Resolution	Data Source	Date Acquired
1.	Birnin Kebbi Imagery	1meters Eye altitude of 6 km	Google Earth	2017
2.	Birnin Kebbi base Map	1:25,000	Federal Survey Gazetteer map	
3.	Thematic Digital Street Level map of Birnin Kebbi town		Terrain Details Associates Ltd. Lagos	2018
4.	List of health facilities in Birnin Kebbi		Kebbi State Ministry of Health	2018
5	Spatial location of health facilities in Birnin Kebbi		Author field work	2018
6	Various literature materials relating to health facilities mapping	Not Applicable	Internet journal and textbooks	2018
7	GPS	0.5 m accuracy	Garmin	2009

3.1. Research Approach

The overall methodology used for this study in creating a geospatial documentation of health facilities in the study area involved the reconnaissance survey of all health facilities location and their respective attributes. as presented in Table 2., this was overlaid on the updated base map of the study area (i.e the updated road network names) in the GIS environment to generate a spatial database, and mapped the spatial distribution of health infrastructure, which could be query to obtained a spatial information that could serve as a document and guide for health infrastructures management in the study, the entire methodological framework used for this study is depicted in Figure. 3.1.

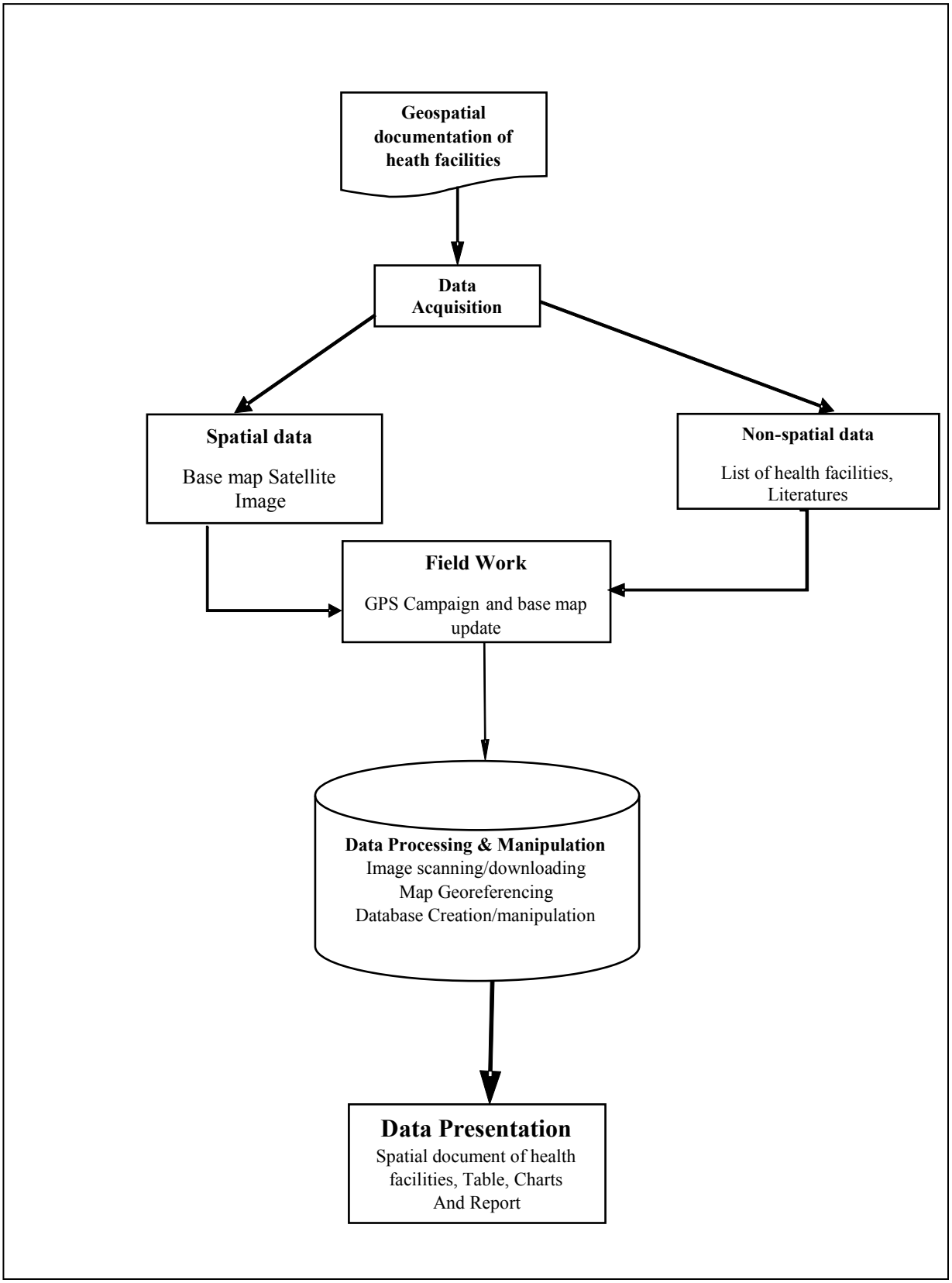

Figure 2: Research methodology flowchart

Table 2: GPS Coordinates of Health Facilities in Birnin Kebbi Metropolis

S/n	Longitude	Latitude	Elevation	Name	Classification	Ownership
1	4.21286	12.4646	229	Hafsat Eye Centre	Secondary	Public
2	4.22113	12.46263	233	Bayi-Salma	Clinic	Private
3	4.22091	12.45231	227	V V F	Secondary	Public
4	4.20049	12.4368	233	D D G Medical Centre	Clinic	Private
5	4.18896	12.43404	232	Federal Medical Centre	Secondary	Public
6	4.17723	12.43286	244	MRS Army Barrack	Hospital	Public
7	4.20353	12.44685	235	Godiya Clinic	Clinic	Private
8	4.19951	12.45424	235	MCH Nassarawa	PHC	Public
9	4.19951	12.45493	235	Sir Yahaya Memorial Hospital	Secondary	Public
10	4.19952	12.45387	235	El - Shifa Clinic	Clinic	Private
11	4.19947	12.45606	238	Malaria Control Unit	Health Post	Public
12	4.19914	12.45714	238	Police Cottage Hospital	Hospital	Public
13	4.19456	12.45108	242	Alfa Clinic	Clinic	Private
14	4.16988	12.44326	243	Badariya Primary Health Centre	PHC	Public
15	4.18884	12.44681	246	Mayo Foundation Clinic	Clinic	Private
16	4.18956	12.45651	246	Makerar Gandu Health Post	Health Post	Public
17	4.18742	12.46176	241	IlelaYari Health Post	Health Post	Public
18	4.19179	12.46507	238	Gamagira	Health Post	Public
19	4.19303	12.47202	211	Takalau	PHC	Public
20	4.20732	12.45883	240	Ezekiel Clinic	Clinic	Private
21	4.21755	12.4527	235	Matafaz Clinic	Clinic	Private
22	4.23262	12.47382	228	Shagari Quarters	Health Post	Public
23	4.24369	12.47654	225	Gwadangwaji	PHC	Public
24	4.22986	12.46572	235	Federal Polytechnic Medical Centre	Hospital	Public

Source: Author, (2018).

3.2. Data Analysis

In the analysis of the data in this study, four techniques were employed: Symbology, Proximity analysis (Buffer), Nearest Neighbor analysis, ArcGIS 10.4 software was used principally for mapping and geospatial computations of the health facilities itemized above. The spatial database of the above was created and mapped as points data relative to the specific location. The facilities were symbolized base on two parameter which is: ownership (Public & Private), the classification (PHC, Hospital, Clinic, Health Post & secondary), which is a set of conversions rules. Or encoding systems that defined how geographic information is represented on the map. Symbology comes in different forms e.g. character maker symbol, graduated colors. graduated symbols, dot density, proportional symbols, bar and pie chart and customs symbols, in this study character maker symbol was employed, The Proximity analysis is often referred to as buffer analysis, the toolset determines the proximity of features by creating a buffer around the feature in other to determine, its accessibility.

The Average Nearest Neighbor analysis was achieved using spatial Statistics extension, this is to derive the distance between two health facilities centroid its nearest tool measures the distance between each feature centroid and its nearest neighbor's centroid location. It then averages all these nearest neighbor distances. If the average distance is less than the average for a hypothetical random distribution, the distribution of the features being analyzed is considered clustered. If the average distance is greater than a hypothetical random distribution, the average nearest

neighbor ratio is calculated as the observed average distance divided by the expected average distance (with expected average distance being based on a hypothetical random distribution with the same number of features covering the same total area).

4. Results and Discussions

4.1. Spatial Location of Health facilities

The background understanding of this study shows that the health facilities services area should cover about 4km catchment area with a population of 60,000 for primary health care this assertion was centered on the WHO recommendations on the accessibility of basic health need of human being, the spatial location of each facility was a result of ground truthing i.e the use GPS to geocode the location of each health facilities and then created a spatial database in ArcGIS environment. There are 24 health facilities in the study area eight (8) of it are privately owned while sixteen (16) are publicly owned, there five classes of health facilities identified in the study area (Table 3). The variability of health facilities is further illustrated in figure 3.

Table 3: Summary of health facilities classes in Birnin Kebbi

Health Facilities Classes	Public	Private	Total
Health Post	5	0	5
Clinic	0	8	8
Hospital	3	0	3
PHC	4	0	4
Secondary	4	0	4
Total	**16**	**8**	**24**

Source: Author, (2018).

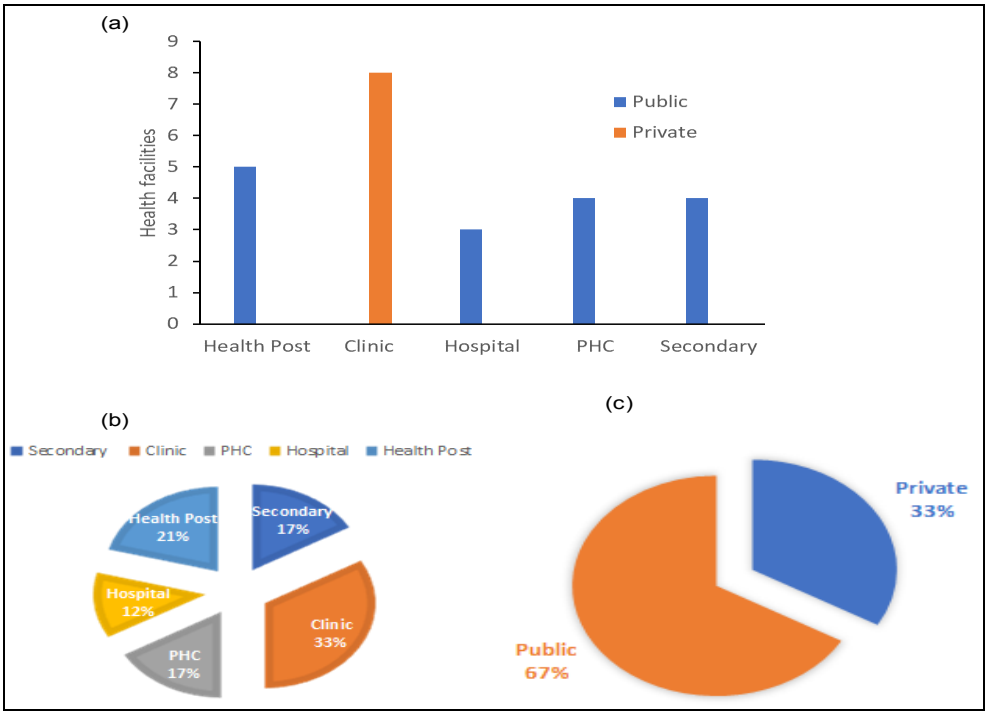

Figure 3: Variability of health facilities in Birnin kebbi Metropolis

4.2. Spatial Pattern of Health facilities

Birnin kebbi has an areal extent of 31.0694km^2., the spatial pattern is to analyse the distribution of health facilities within the stated area, this was achieved through the pattern analysis of spatial statistics toolbox of ArcGIS software, The results revealed that the observed mean distance between the health facilities is 707.4 meters as opposed to the expected mean distance of 568.9 meters as proposed by the ArcGIS software. The ArcGIS software also revealed that the pattern of the health facilities in the study area is dispersed with Z-scores of 2.2817 that is there is less than 5% probability that this dispersed pattern could be because of random chance. The summary of this nearest neighbor analysis is shown in figure 6 below. The location of health facilities in Birnin Kebbi showed marked spatial variability (Figure 5, 6 & 7).

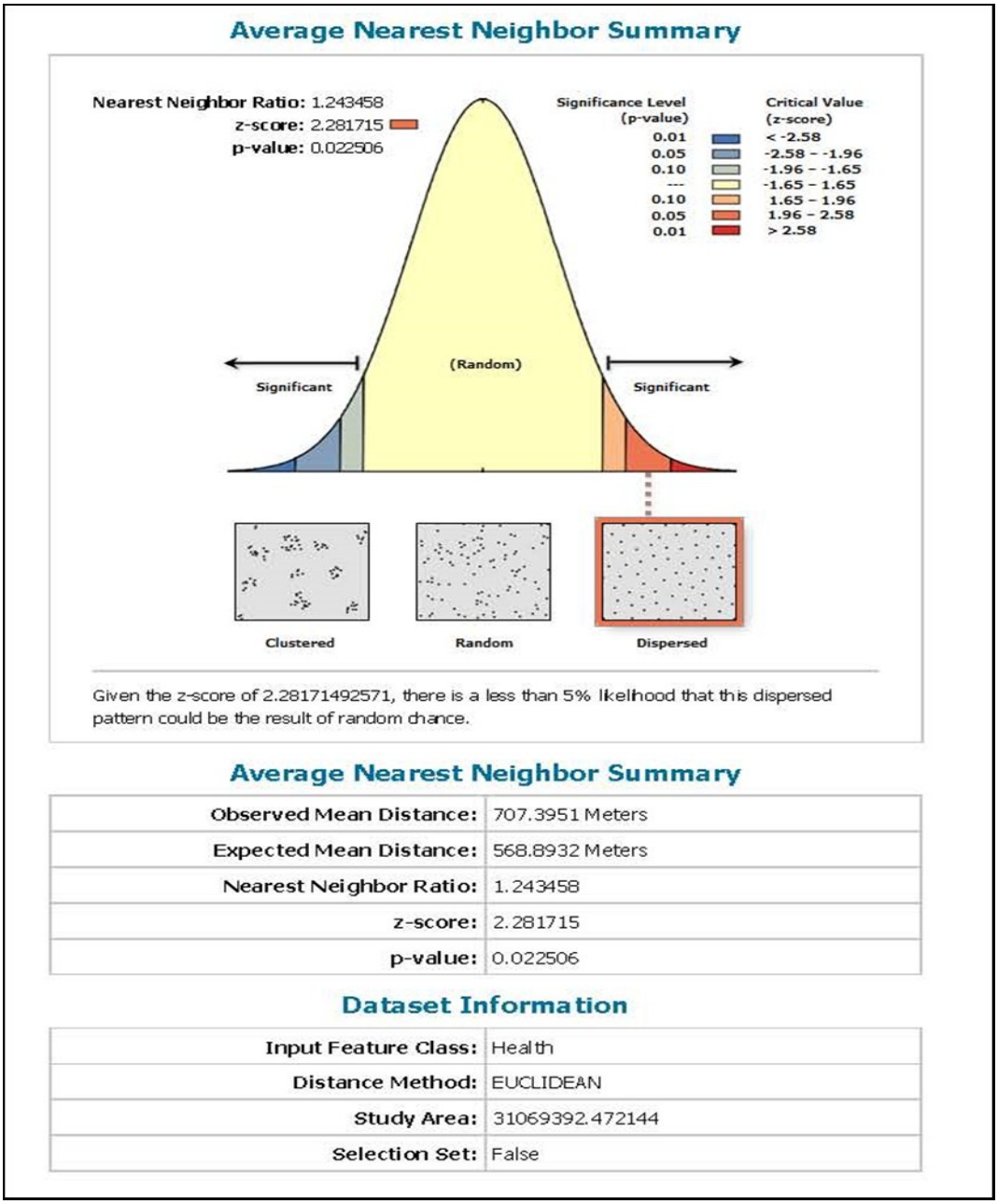

Figure 4: Spatial pattern analysis of Health facilities in Birnin Kebbi

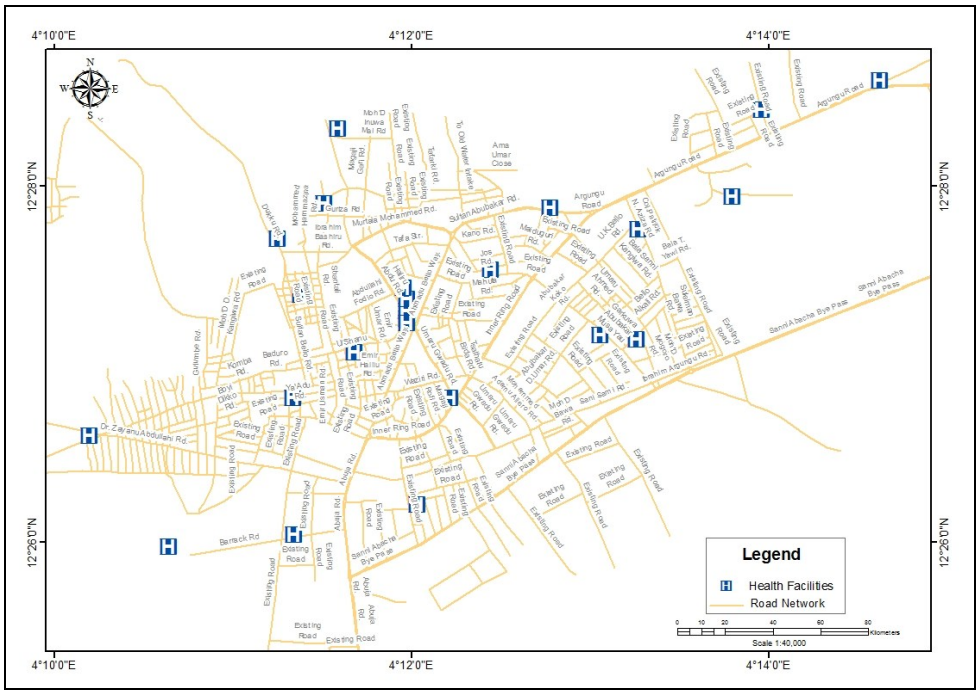

Figure 5: Spatial Locations of Health facilities in Birnin Kebbi

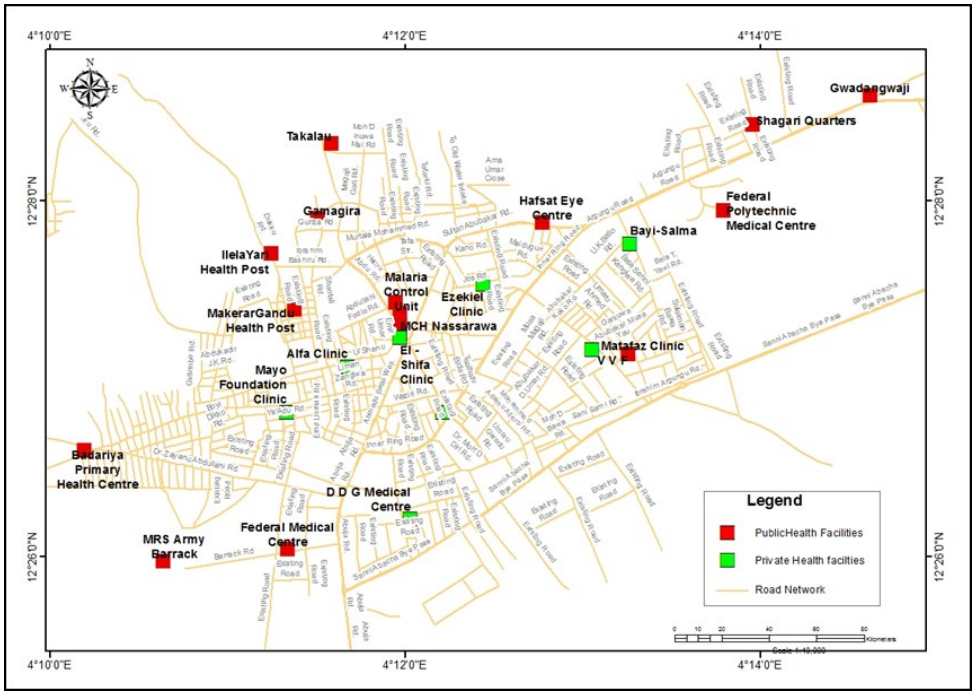

Figure 6: The spatial pattern of Public and Private Health facilities in Birnin Kebbi

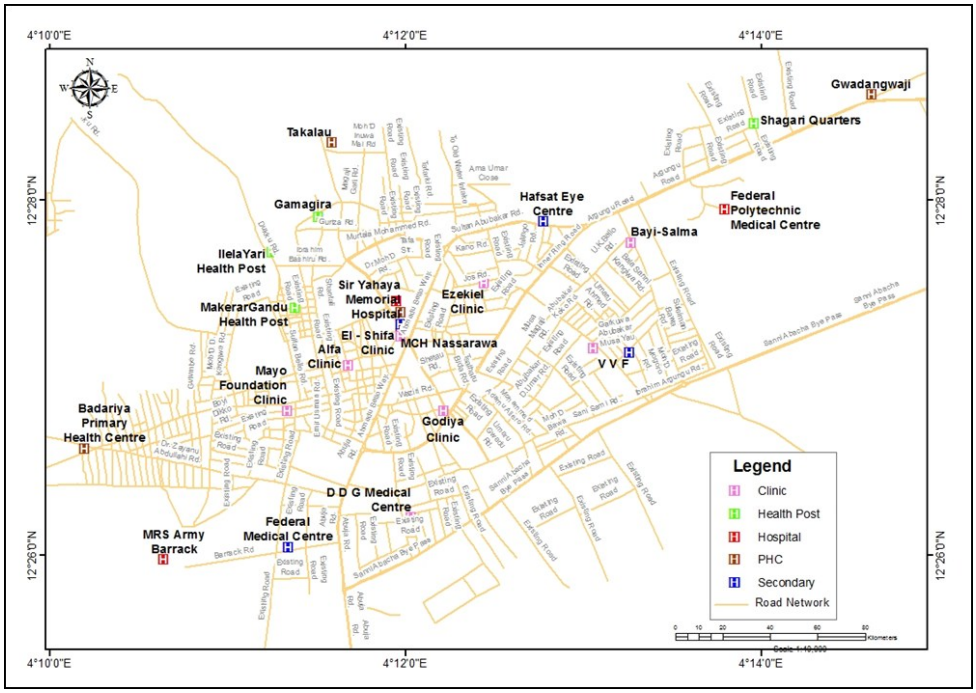

Figure 7: Classification of Health facilities in Birnin Kebbi

4.3 Accessibility to Health facilities

Investigating health facilities accessibility is the most elusive definition of accessibility of a given facilities in relation to location and how easy it is to get there. Defining accessibility to health centers is one of the important tasks for decision makers. The ideal representation of reality for health facilities in Birnin Kebbi town is centered on the following:

- Distance to the nearest healthcare facilities
- Density of healthcare facilities
- A combined health care accessibility indicator for both classified facilities

Buffer analysis was used to check the distance to the nearest of health facilities in the study area which is to either the facilities are near, moderate distance, and long-distance classes for an analysis. A buffer of 1 kilometer (1km) was created around each facilities as shown in Figures 8 and 9. The outcome show that health facilities is accessible within a kilometer radius (i.e. one cannot move a kilometer without a health facilities in the study area) This will aid in health facility location planning where planners can determine the number of health facilities within a specified distance of any of the above described points, the density of health facilities indicated the volume of patient which each facilities are cater for, the spatial density analysis tool of ArcGIS software was used in the case, the output as display in figure 8 indicated the area where the more health facilities is required because the facilities are over stretch i.e. the deep blue section which decrease as it the color failed because it was symbolized with graduated color.

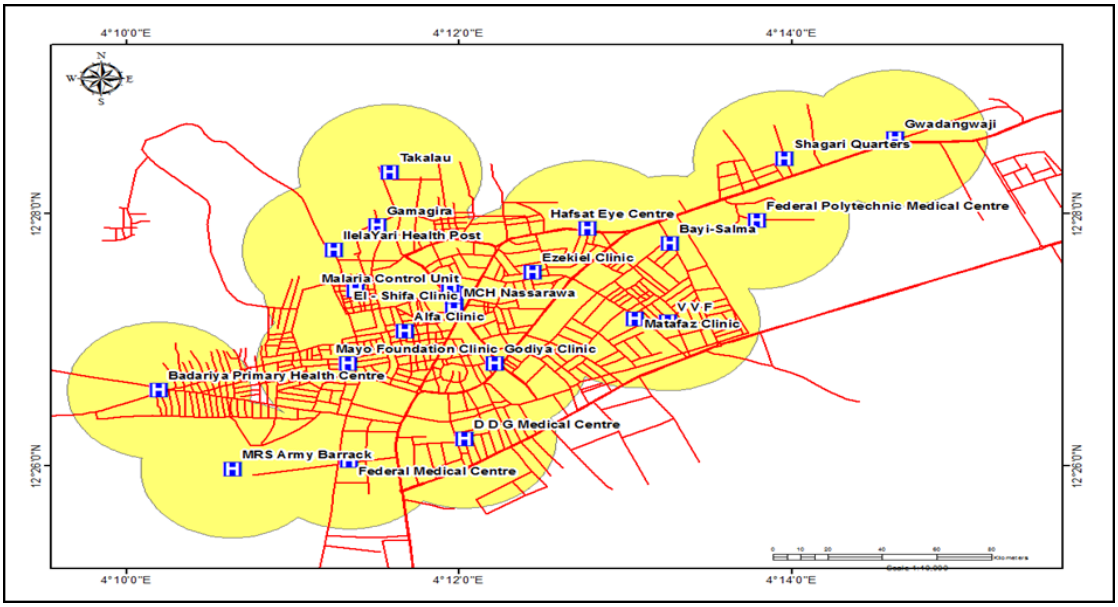

Figure 8: One-kilometer buffer analysis: Proximity to Health facilities in Birnin Kebbi

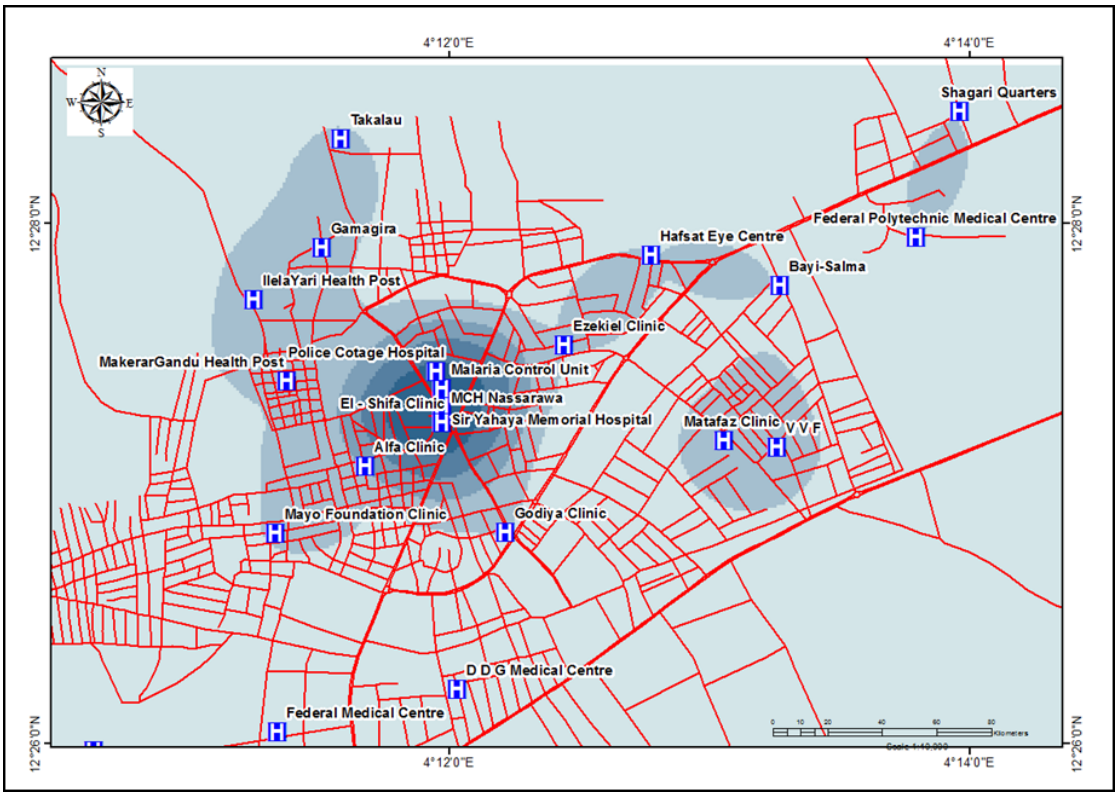

Figure 9: The density of health facilities in Birnin Kebbi

4.4. Spatial database of health facilities

Spatial data types store the spatial attributes that allow the visualization data on a map. Many databases automatically include spatial data types. Others require some configuration or an installation to use a spatial data type. It integrate the spatial and non-spatial attribute of the area of interest together to give out a spatial information as required, in this study the spatial data set consists of the basic information of the health facilities in the study area as shown in figure 9 below, the database is relational data

type. The following sections list all the databases ArcGIS supports, what spatial data types are supported in each, and what, if any, configuration is needed to use a spatial data type in each database which make it more flexible and accepting modification(i.e. it can accommodate more information)

This spatial database can be queried to identify where each feature belong base on the major categories considered (Ownership and Classification) this can be done using structured query language (SQL) is a set of defined expressions and syntax used to query and manipulate data in relational database management systems (RDBMS). The result of the query is shown in figure 10 and 11 respectively for the main categories of the health facilities in the study area, it also the basis on which symbolization of the health facilities are base.

5. Summary and Conclusion

The geo-spatial Documentation and Geo-database Developments for Health Facilities in Birnin Kebbi Metropolis was carried out to assess the spatial distribution of health care facilities. The study revealed that:

- The was a total of 24 Hospital in Birnin Kebbi metropolis, seven (8) are privately owned and sixteen are government owned, which gives (60%) of the health care to the public sector.
- The nearest neighbor ratio revealed a dispersed pattern of health facilities in Birnin Kebbi metropolis.
- The ownership of these facilities is spread among Public, private, Local Government and organizations.
- The result of the kernel density shows more concentration of health facilities in Nasarawa part of Birnin Kebbi metropolis
- The buffer analysis indicates no gap spaces in the location of Health facilities within the metropolis. This shows that the health facilities in Birnin Kebbi metropolis meet the required one-kilometer radius (1km) of the WHO health facilities planning standard.

In conclusion, this study shows the location of public and private health facilities is within World Health Organization Specification and planning standard in terms of spread and standards in relation to population density locational efficiency and needs of both the rural and urban population. However, more studies are required to facilitate the process of planning monitoring and the deliverance of proper and efficient health facilities over broader spatial and temporal scales.

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