Mapping of the Spatial Distribution Pattern of Health Care Facilities in Bauchi Metropolis, Using Geographic Information System, Bauchi State, Nigeria.

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Abstract

The research problem under consideration in this study focuses on the lack of accurate map and a robust spatial database of health facilities that exist in Bauchi metropolis. This can certainly assist policy maker make informed decision for the overall benefit of the public. The major objectives include creation of a spatial database of healthcare facilities and analyzing the distribution pattern of the facilities using ARC GIS 3.2 and micro software. Method used include geocoding of the healthcare facilities spatial and attribute query as well as average nearest neighbor index. The result include the cartographic display of 62 healthcare facilities, clustered pattern of the health facilities and robust spatial database of the existing healthcare facilities. Thus, it has been concluded that the existing healthcare facilities in some few areas at the detriment of other areas. More, so the spatial database developed will enable decision makers to improve future planning of the healthcare facilities. Finally, it has been recommended that both private and public healthcare providers should adopt affective use of spatial database for easy planning and improves access to general public.

Key words: GIS, GPS, Geocoding, map and Digital.

Introduction

Maps are produced by the combined efforts of many professionals using a variety of technologies. Mapping is the creation of a map. A map is a record of locations of objects in a geographic space. Maps are designed to illustrate specific and detailed

features of a particular area, most especially used to illustrate the geography of an area. Maps attempt to represent various things, like political boundaries, physical features, roads, topography, population, climates, natural resources, and economic activities. Modern technology of digital mapping process is an effective and efficient way of mapping. The process utilizes spatial data in numeric form rather than in graphical or analog form to compile and produce maps or plans using information in a digital format (Abubakar and Alhasan, 2017).

Digital mapping has now become an indispensable tool in solving many environmental-based problems. The method used for producing digital maps is dependent on the level of details required, the use to which the map will be put into and the sourced data. Digital mapping operations help organizations achieve significant analytical and operational advantage. Location intelligence is empowering even non-Geographic Information Systems (GIS) experts to gain the advantage of using location to make more insightful everyday decisions. However, the locational pattern of any facility, (Medical facilities inclusive) can determine the level of its utility. From the locational pattern, the spatial distribution of any facility could be determined. (Nduke, 2001)

The closer a health facility is to the people, the greater its utility and benefits. This can be connected to how they are distributed over the space in both urban and rural areas.

The spatial distribution of health facilities is of great importance to planners. Their inequitable distribution over space is of concern and has brought about the issue of provision and effective utilization of the facilities. It is believed that it is highly available in the urban areas and, the number and quality of health facility in a country or region is one common measure of that area's prosperity and quality of life (Rizyada, 2012). Health facilities include all public, private, non-governmental and community-based. Health facility is defined as a static facility in which general health services are offered. Health posts can be counted as static facilities, but because they are generally small with minimal supplies, they may need to be disaggregated for interpretation purposes (WHO, 2010). In addition, health facilities refer to the physical structures and supporting equipment established for the provision of health services. It usually involves a structure with facilities for different health service needs, equipment such as cold chain facilities for storage, management and use in the provision of health services to the population (Shrestha, 2010).

Accurate health information is the cornerstone of effective decision-making and reliable assessment of disease, burden and resource needs. Health mapping utilizes the technology of Geographic Information Systems to add value to information for public health planning and decision making. Geographical Information Systems (GIS). Provides useful techniques regarding capturing, maintaining and analyzing spatial data. Geographic Information System (GIS) has the potential to access the patterns of health clinics and to identify geographic regions that are in need of health clinic access. GIS is currently recognized as a set of strategic and analytic tools for public health, so the design and

implementation of an information system for health clinic distribution with GIS capacity should be considered.

Statement of the Problem

In Bauchi metropolis, various kinds of public and private health facilities exist; however, lack of map showing the distribution pattern of the facilities in the study area has made it very difficult for people to see at a glance how these facilities are spread and no spatial database exists listing such facilities. This lack of baseline data is a major hurdle in linking of spatially referenced health-facility information with their catchment areas. This has necessitated the need to have an accurate map and robust GIS database that will provide end-users and health policy-makers with information to assist in making better and more accurate decisions regarding the distribution of health care services in Bauchi metropolis.

Aim of the study

This study is aimed at mapping of the spatial distribution of health care facilities for both the public and private sectors in Bauchi metropolis.

Objectives of the study

This study can be accomplished through the following objectives
  i.   To produce a map showing the locations of healthcare facilities
  ii.   To create a GIS database of the existing healthcare facilities
  iii. To examine the spatial distribution of the existing healthcare facilities
  iv.   To determine the index for spatial dispersion of healthcare facilities.

Significance of the Study

To locate the position and the data base of the healthcare centre in Bauchi metropolis using GIS.

Scope and Limitation of the Study

This study is particularly limited to Bauchi metropolis. Hence the information required and used were obtained within the scope. A total number of sixty two healthcare training was mapped out using geographic Information System (GIS)
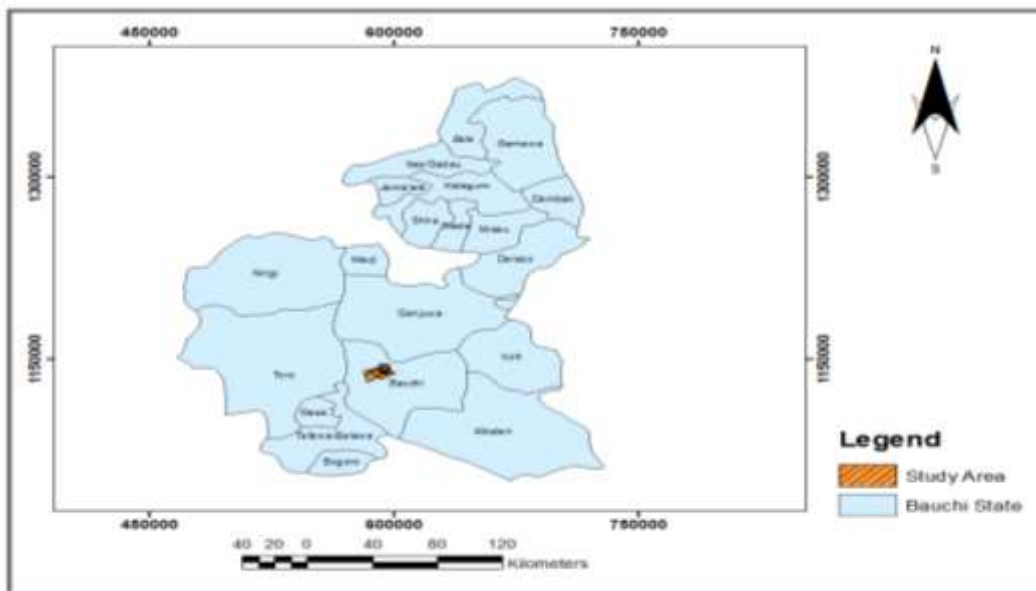
Study Area

The study area is Bauchi metropolis of Bauchi state. It is located within the longitude 09^0 46' to 09^0 54' E and Latitude 10^0 15' to 10^0 23' N. Bauchi town lies on the watershed of many watercourses flowing away from the town in all directions. There is much exposed rock and in many cases it is closed to the surface creating drainage problems. Bauchi town is strategically placed on the junction of the Jos–Bauchi–Gombe and Jos–Bauchi–Maiduguri trunk "A" roads. The improvement of Bauchi–Dass road to the south and

Bauchi–Ningi road to the North has increased the importance of the state as a distribution centre in addition to its traditional position as an administrative center. Bauchi's population as at two decades ago was about Three Hundred Thousand (300,000). (National Population Commission, 2006).
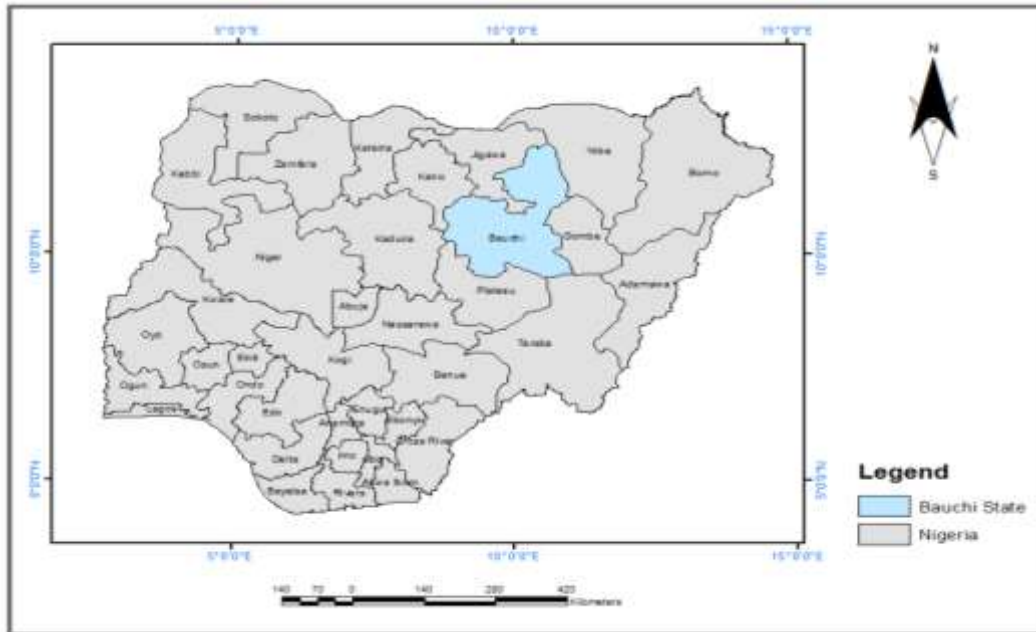
Figure 1. Administrative Map of Nigeria showing Bauchi State in blue.
Source: Bauchi state Min. of Land and Survey

Figure 2. Administrative Map of Bauchi State showing the study area.
Source: Bauchi state Ministry of Land and Survey

METHODOLOGY

This focuses on the fundamental methods and procedure adopted in this research. This section can be referred to as the overall configuration of a piece of research work. Therefore, the input and output specifics used in the work are explained below.
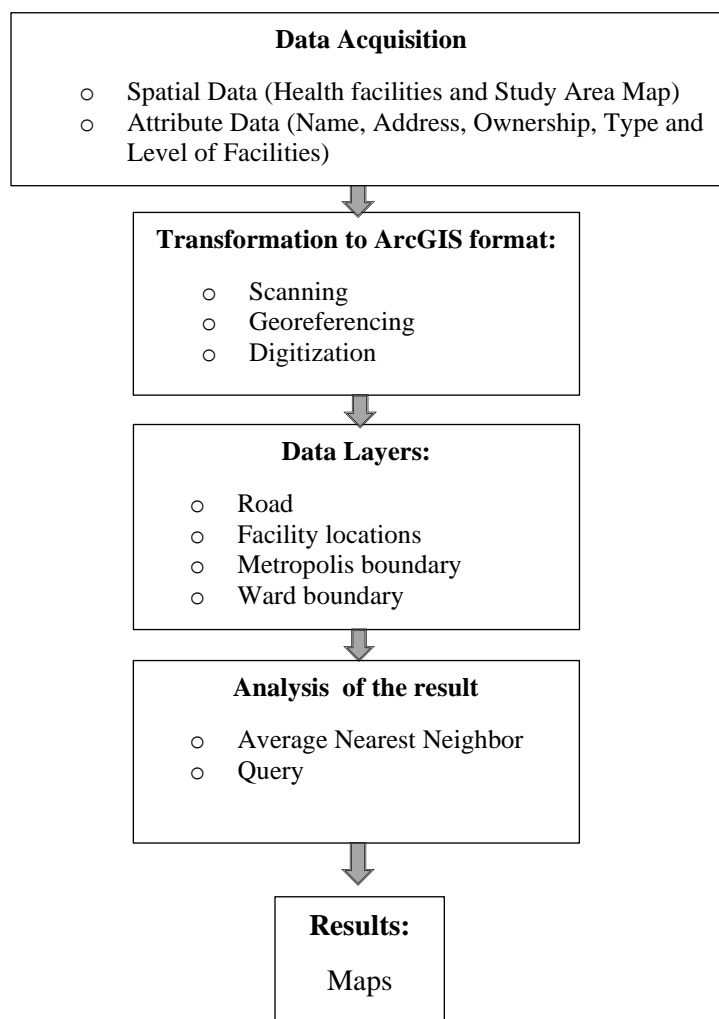
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┌─────────────────────────────────────────────────────┐
│                 Data Acquisition                     │
│                                                       │
│   o  Spatial Data (Health facilities and Study        │
│      Area Map)                                        │
│   o  Attribute Data (Name, Address, Ownership,        │
│      Type and Level of Facilities)                    │
└─────────────────────────────────────────────────────┘
                          ↓
        ┌──────────────────────────────────────┐
        │   Transformation to ArcGIS format:    │
        │                                        │
        │        o  Scanning                     │
        │        o  Georeferencing               │
        │        o  Digitization                 │
        └──────────────────────────────────────┘
                          ↓
        ┌──────────────────────────────────────┐
        │            Data Layers:                │
        │                                        │
        │   o  Road                              │
        │   o  Facility locations                │
        │   o  Metropolis boundary               │
        │   o  Ward boundary                     │
        └──────────────────────────────────────┘
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        ┌──────────────────────────────────────┐
        │        Analysis  of the result         │
        │                                        │
        │   o  Average Nearest Neighbor          │
        │   o  Query                             │
        └──────────────────────────────────────┘
                          ↓
              ┌────────────────────┐
              │      Results:       │
              │       Maps          │
              └────────────────────┘
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Figure 3. Flow Chart

Data Acquisition

The data collected was in two categories; Primary data and Secondary data source

Primary Data Source

S/n	Data	Sources	Characteristic
1	Spatial Data Point Data (x,y)	Field Survey	UTM WGS84 zone 32 North. X,Y,Z coordinates, Year of acquisition Dec., 2018.

	Attributes Data		
1			
	Name, Address, Ownership, Type and Level of the facilities	Health facility owners/staff	Textual, Date of acquisition April, 2019

Table 1
Secondary Data Source
This was the data that already existed from various outlined sources.
Table 2

S/n	Data	Sources	Characteristics
	S p a t i a l D a t a		
1	Administrative Map of Nigeria, Map of Bauchi State, Map of Ward	Ministry of Land and Survey	Date; 2010, scale 1:500 000 Date:2012, Scale 1:500 000 Date:2004, Scale1:25,000
2	Satellite Imagery (GeoEye)	Bauchi Geographic Information System (BAGIS)	Date of acquisition: March 2013 Spatial Resolution: 50 cm Scale: 1:2500

Equipment
Hardware
  i.   Garmin GPSMAP 76c receiver
  ii.   A0 Scanner
  iii. Hp Laptop Centrino, 750GB HDD, 4GB RAM, 2.1GHZ,
  iv.   HP F4200 DeskJet Printer
Software
        i.   ArcGIS 10.4.1
        ii.   Excel 2010
        iii. Micro software
Data processing
This consist of the following;
  i.   Scanning
  ii.   Geo-referencing
  iii. Digitazation
  iv.   Statistical testing

Scanning
The paper maps have to be first converted into a digital format usable by the computer. This is a critical step as the quality of the analog document must be preserved in transition to the computer domain.

Geo-referencing
The processing of the spatial data includes geo-referencing, on-screen digitization, and map visualization. The analogue maps of Nigeria, Bauchi State and Ward were imported into ArcGIS environment. The projected reference system, WGS 84, UTM zone 32N was defined. The next operation was geo-referencing which involved the aligning of geographic data.

Digitization
The digitizing process started by creating a layer in ArcCatalogue. The features on the image were geometrically represented as polyline and polygon. The layer created with the same reference system was added to the ArcMap environment where the sketch tool was used as a pencil to trace the road and ward.

Creation of the Database
A vector representation scheme of the health care facilities (points) was adopted as primitives. The schema was created using fields which are; Facility name, Category, Ownership, and x and Y coordinates of the health care facilities. All the necessary information for each health facility was entered into its layer's attribute table. This was done by adding the required number of fields (columns) to the table and entering the data for all the health centers in their corresponding records (rows).

Physical Modeling
The physical data model showed all table structure including column name, column data type, column constraints, and relationships between tables.
The steps for the physical data model design were as follows:

Table 3. Physical data modeling for Health care facilities

Attribute	Data type	Width
Facility Name	Text	20
Address	Text	15
Facility type	Text	10
Facility Level	Text	10
Ownership	Text	10
Ward Name	Text	10
x- coordinate	Integer	**10**
y- coordinate	Integer	**10**

RESULTS AND DISCUSSION
The Table 4 shows the various columns of information about the health facilities. Column one shows the serial number while column two shows the Facility name, column three shows the ID, column four shows the Facility level, column five shows the facility type

column, six shows the ownership, and column seven and eight show the spatial data x, y coordinates obtained from the health facility. The final output result of mapping and spatial distribution of health facilities in the study area with the database is presented below. The design of the database was based on the data that was collected and was initially stored in one table for both spatial and non-spatial. But because of the existing repeating field, normalization was carried out to eliminate the repeating group (Table 4.1) below

Table 4. Normalized Attribute and location of health facilities

Facility

S/No	Facility Name	ID	Facility Level	Facility Type	Ownership	X	Y
1	Doya Maternal Child Health	100	Primary HealthCare Center	Maternity	Public	593258	1140414
2	Bayan Fada Maternal and Child Health Clinic	101	Primary HealthCare Center	Maternity	Public	592870	1140261
3	Fada Primary Health Clinic	102	Primary HealthCare Center	Clinic	Public	592847	1139777
4	Primary Health Center Kofar Dumi	103	Primary HealthCare Center	Clinic	Public	593605	1138518
5	Kofar Dumi Primary Health Clinic	104	Primary HealthCare Center	Clinic	Public	593870	1139624
6	Kofar Dumi Maternity	105	Primary HealthCare Center	Maternity	Public	593410	1138894
7	Railway Clinic	106	Primary HealthCare Center	Clinic	Others	592797	1137965
8	Unguwan Mahaukata Dispensary	107	Primary HealthCare Center	Dispensary	Public	592939	1138429
9	Kandahar Maternity And Health Clinic	108	Primary HealthCare Center	Maternity	Public	593843	1139624
10	Under Five Clinic	109	Primary HealthCare Center	Clinic	Public	592106	1138742
11	Federal Lowcost Primary Health Center	110	Primary HealthCare Center	Clinic	Others	591100	1137541
12	Family Planning Clinic	111	Primary HealthCare Center	Clinic	Private	592380	1138108
13	Darussalam Health centre	112	Primary HealthCare Center	Clinic	Private	591825	1137915
14	Kainuwa Clinic	113	Primary HealthCare Center	Clinic	Public	591461	1137790
15	Yelwa Clinics and Maternity	114	Primary HealthCare Center	Maternity	Private	586826	1135610
16	Poly Medical Center	115	Primary HealthCare Center	Health Center	Others	584323	1134006
17	Yelwa Cocin Clinic	116	Primary HealthCare Center	Clinic	Private	586735	1135546
18	Keffi Clinic	117	Primary HealthCare Center	Clinic	Private	585855	1134406
19	Maternity Clinic	118	Primary HealthCare Center	Maternity	Public	586818	1134953
20	Yelwa Domiciliary	119	Primary HealthCare Center	Maternity	Public	587592	1136656
21	Primary Health Care Inkil	120	Primary HealthCare Center	Clinic	Others	597792	1138916
22	Ibrahim Bako Model Primary Health Center	121	Primary HealthCare Center	Clinic	Public	596788	1139748
23	Gudum Primary Health Center	122	Primary HealthCare Center	Clinic	Public	593510	1135430
24	Al Almin Health Clinic and Maternity Inkil	123	Primary HealthCare Center	Maternity	Private	596953	1139665
25	Turum Primary Health Center	124	Primary HealthCare Center	Clinic	Public	595352	1144151
26	Maternity Child Health Center Tirwun	125	Primary HealthCare Center	Maternity	Public	595352	1144151
27	Dumi Health Clinic	126	Primary HealthCare Center	Clinic	Public	593687	1135258
28	Gudun Hausawa Primary Health Center	127	Primary HealthCare Center	Clinic	Public	595403	1136801
29	Sabo Clinic	128	Primary HealthCare Center	Clinic	Private	592393	1141985
30	State Low Cost Primary Health Center	129	Primary HealthCare Center	Clinic	Public	590521	1140510
31	Ni'ima Consultant Hospital	130	Tertiary HealthCare Center	Hospital	Private	589116	1138552
32	Amsad Clinic	131	Primary HealthCare Center	Clinic	Private	590639	1138924
33	Al Wadata Clinic	132	Primary HealthCare Center	Clinic	Private	589534	1140302
34	Albishir Clinic	133	Primary HealthCare Center	Clinic	Private	586798	1139712
35	City Clinic	134	Primary HealthCare Center	Clinic	Private	590512	1139894
36	Police Health Clinic	135	Primary HealthCare Center	Clinic	Public	590625	1140727
37	Apple Clinic And Maternity	136	Primary HealthCare Center	Maternity	Private	587165	1139483
38	School Of Armour Clinic	137	Primary HealthCare Center	Clinic	Public	590875	1144813
39	Reemee Medicare Nig. LTD	138	Secondary HealthCare Center	Health Center	Private	589953	1140218
40	Phalycon Hospital	139	Primary HealthCare Center	Hospital	Private	589294	1140841
41	Abubakar Tafawa Balewa Teaching Hospital	140	Tertiary HealthCare Center	Hospital	Public	591041	1141225
42	Zango Primary Health Clinic	141	Primary HealthCare Center	Clinic	Public	591388	1136798
43	33 Artillery Brigade Medical Centre	142	Primary HealthCare Center	Clinic	Public	589422	1141214
44	Federal Lowcost Primary Health Center	143	Primary HealthCare Center	Clinic	Public	590714	1137258
45	Zango Maternal and Child Health Care	144	Primary HealthCare Center	Clinic	Public	591336	1136795
46	Dawaki Primary Health Center	145	Primary HealthCare Center	Clinic	Public	593151	1141031
47	Bauchi Urban Maternity Center	146	Primary HealthCare Center	Maternity	Public	592704	1141718
48	Fomwarn Health Center	147	Primary HealthCare Center	Clinic	Private	593863	1141719
49	Bauchi Specialist Hospital	148	Secondary HealthCare Center	Hospital	Public	592212	1140706
50	Maijama'a Clinics	149	Primary HealthCare Center	Clinic	Private	591605	1140714
51	Comprehensive Health Center Tashan Babiye	150	Primary HealthCare Center	Clinic	Public	592221	1140717
52	The People's Clinic	151	Primary HealthCare Center	Clinic	Private	591756	1140871
53	Kobi Dispensary	152	Primary HealthCare Center	Dispensary	Public	591782	1140272
54	Rimin Jahun Dispensary	153	Primary HealthCare Center	Dispensary	Public	591572	1138956
55	Bauchi Medical Clinic and Maternity	154	Primary HealthCare Center	Maternity	Others	591143	1139490
56	Al Ameen Hospital	155	Primary HealthCare Center	Hospital	Private	591114	1139336
57	Maternal Child Health Nutrition Nassarawa Jahun	156	Primary HealthCare Center	Clinic	Public	591078	1139105
58	Shifa Royal Hospital	157	Secondary HealthCare Center	Hospital	Private	591265	1139750
59	Wuntin Dada Model Primary Health Center	158	Primary HealthCare Center	Clinic	Public	584297	1140193
60	Makkah Specialist Eye Hospital	159	Tertiary HealthCare Center	Hospital	Private	591695	1140335
61	Lusqi Dispensary	160	Primary HealthCare Center	Clinic	Private	588834	1135002

Figure 4 Digitized Map showing Locations of Health Facilities
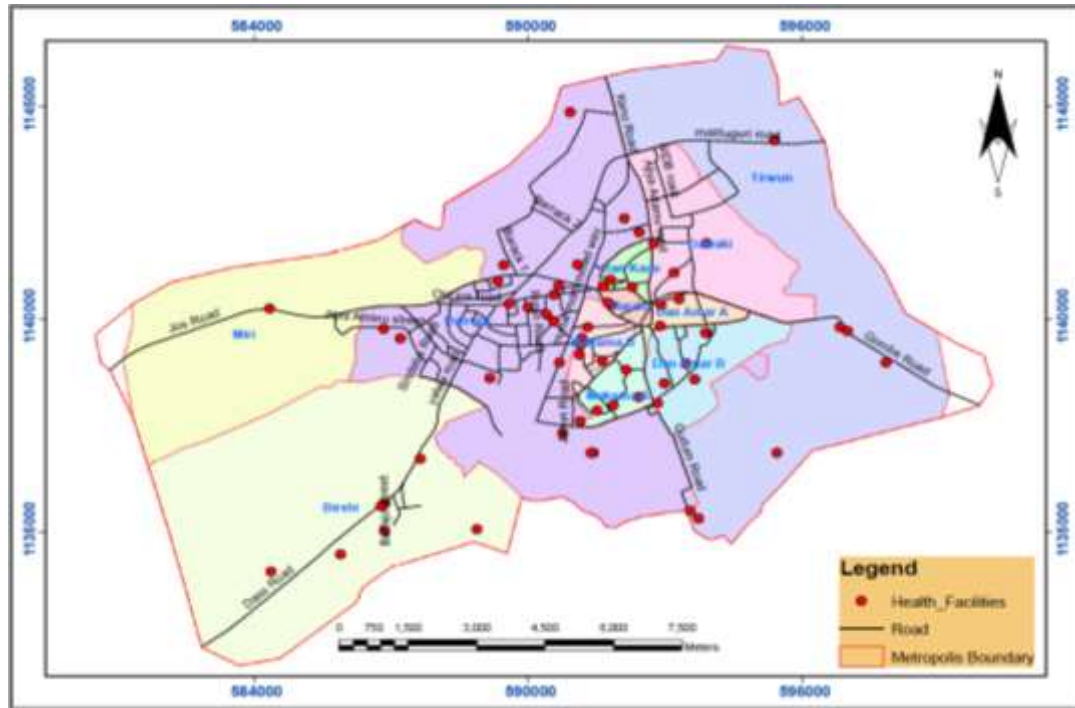

Table 4 shows a summary of the health care facilities distribution by Ward. Majority of the health facilities, (57 out of a total of 62) are primary facilities. For example, Tiwun has 8 Health Facilities of which all are in the primary category. Similarly, in Dan'iya ward, of the 19 Health Facilities 15 are primary health facilities. In fact 91.9% of the Health Facilities in Bauchi metropolis are primary, meaning health centers, health clinics, maternities and dispensaries.

Table 5 The summary of health facilities distribution in each these areas.

S/NO	Ward Name	Shape_Area_km2	Facility_ Count
1	Miri	22.12	1
2	Dan Kade	1.10	3
3	DanAmar A	1.26	3
4	Tirwun	35.70	8
5	Hardo	0.66	2
6	DanAmarB	4.67	6
7	Dan Iya	36.23	19
8	Birshi	33.42	7
9	Makama A	2.25	5
10	Makama B	1.82	5
11	Dawaki	8.71	3
	Total	**148**	**62**

Table 6 Database of Health Facilities

Table 6 above shows the Database of the healthcare facilities. A vector representation scheme of the health care facilities (points) was adopted as primitives. The schema was created using 8 fields which are; Facility name, Address, Facility Level, Facility type, Ownership, Ward, and x and Y coordinates of the health care facilities. This constitutes the database as shown in table 6. An important aspect of database is the ability to retrieve, manipulate, store, analyze and update and query for decision making. It is faster and convenient than copying from hardcopy files or from the word document that cannot be queried. Another advantage of query is the ability to exposed information that may probably go unnoticed if checked manually using naked eyes. The database is made up of sixty two (62) locations of health facilities. The spatial database can be queried from the attribute table. Also, attribute table can be queried using query builder icon. All these functions mentioned above were tested on the database and found to be working properly. The ability of spatial database creation linked with the attribute data can be analyzed and queried.

Figure 5 "Ownership"= "Private" (Spatial query for privately owned health facilities in the study area)

Figure 6 "Ownership"= "Public" (Spatial query for public owned health facilities in the study area)

CONCLUSION AND RECOMMENDATIONS
Conclusion
In conclusion, mapping and spatial distribution of health facilities has proven to support health system development and has become an increasingly important mechanism. It is essential for managers, planners and practitioners from both governmental and nongovernmental organizations, as well as for researchers and academics.

Recommendations
This study has unveiled the current condition and information on the locations of health facilities in Bauchi metropolis. Therefore, the following recommendations are drawn:
   i)   There is need for both private and public healthcare providers to adopt the effective use of database for easy accessibility to general public.
   ii)   Relevant governmental agencies as well as NGOs can make use of this map and database for subsequent intervention and allocation of healthcare facilities.
   iii) For the clustered pattern identified, the area deprived of such facilities can be allocated with some health facilities within their catchment area.
   iv)   The use of geographic information system should be encouraged by government in all its agencies as well as private bodies.

REFERENCES

Abubakar,T. and Alhasan, I. (2017): Mapping and Evaluation of Polling Units for Optimum Election Process in Damaturu Metropolis, Yobe State Nigeria. *American Scientific Research Journal for Engineering, Technology, and Sciences* (ASRJETS) ISSN (Print) 2313-4410, ISSN (Online) 2313-4402 © Global Society of Scientific Research and Researchers http://asrjetsjournal.org/

Alabi M. O. (2015), Towards Sustainable Distribution of Health Centers Using GIS: A Case Study from Nigeria. *American Journal of Tropical Medicine & Public Health*. 2011;1(3):130-136.

Aliyu, A., Shahidah M. A., Aliyu R.M (2013) Mapping and Spatial Distribution of post Primary School in Yola North Local Government Area of Adamawa State Nigeria.

Revisited." Surveys in Mathematics and Its Application. 2: 91112.

Detmer D E. (2003): Building the national health information infrastructure for personal health, health care services, public health, and research. BMC Medical Informatics and Decision Making, 2003, 3:1

Idowu, T. O. Edan, J. D. and Damuya, S. T. (2013):''Estimation of the Quantity of Surface Runoff to Determine Appropriate Location and Size of Drainage Structures in Jimeta Metropolis, Adamawa State, Nigeria. *Journal of Geography and Earth Science* 1(1); June 2013 pp. 19-29

Oloyede-Kosoko S.A.O (2007): *Lecture notes on remote sensing for* Post Graduate Diploma in Geographic Information System, Surveying and Geoinformatics, Federal School of Survey Oyo (unpublished)

Lawrence, N., Kleinschmidt, I. and Sharp, B. L. (2006): Spatial Analysis Mapping of Malaria risk in Malawi using point-referencing prevalence of infection data. *International Journal of Health Geographics* 2006, 5:41 doi: 10.1186/1476-072X-5-41 http:/www.Ij-healthgeographics.com/content/5/1/41

Ndukwe, K.N (2001) Digital Technology in Surveying and Size of Drainage structures in Jimeta metropolis, Adamawa state, Journal of Avenbli, wwwsciencedomain.orbenin City BSSS Pp 131-17172

Ritzyada, (2012). Mapping Health facilities studyMode.com2013

Sheikh, M. A. (2013): Spatial Distribution of Health Facilities in Islamabad, Pakistan, independent consultancy, kirachi, Pakistan.

Shrestha, J. (2010). Evaluation of Access to primary healthcare: A case study of Yogyakarta, Indonesia. *Social Science and Medicine*, 42:801–816.Study from Nigeria. *American Journal of tropical medicine & public health.* 2(1) 22-24.

WHO, (2010). Monitoring the building blocks of health systems: a handbook of indicators and their measurement strategies, Geneva: WHO. Online available http://www.who.int/healthinfo/systems/WHO_MBHSS_2010_full_web.pdf