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Analysis of Spatial Distribution Pattern of Boreholes in Geidam Town, Yobe State, Nigeria.

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ABSTRACT: The research accesses the spatial distribution pattern of boreholes in Geidam town. The researchers aim at providing information that will serve as a guide for boreholes distribution planning to the policy makers of the town. The geometrical data of the boreholes were generated using hand held Global Positioning System Garmin 76CSx receiver, and the attribute data were generated through office records, site inspection and oral interview. The geometrical data, attribute data, and satellite imagery of the study area were use as input data in ArcGIS 10.3 software. Digital map and spatial distribution pattern of the facilities were produced. The attribute data were linked with the spatial data to enable the researchers examine the spatial distribution of the boreholes which in turn revealed their spatial pattern. All the analysis was performed in ArcMap environment using spatial analyst and proximity tools available in the software. The findings revealed that there are Twenty Seven (27) boreholes located in the three (3) wards of the study area, of which 15 boreholes (56.6%) are located at Hausari ward, 6 (22.2%) at Asheikri ward, and 6 (22.2%) at Kolori ward. Out of the 27 boreholes in the study area, 22 (81.5%) are owned by Government, while the remaining 5 (18.5%) are owned by Non Governmental Organizations (NGOs). Also analysis was carried out to ascertain the status, power source, functionality, etc. of the boreholes within the study area. The creation of zones of interest also known as Buffering was carried out to determine the boreholes distribution patterns within 250m, and 500m radius from each other, and nearest neighbor index (Rn) was computed. The point pattern analysis revealed that the spatial distribution pattern of the boreholes is Random. The study revealed that resident can get borehole water at a distance of less than 500 meters fro their homes. It is clear that the policy implementation in the study area is not properly guided by GIS technique; it is recommended that, the use of GIS tecnology in planing, management and decision making on water facilities should be encouraged for optimal distribution of water facilities for efficient discharge to the community.

Key words: GIS, ArcGIS Satellite Imagery, Geometrical Data, Attribute Data, Borehole.

I. INTRODUCTION

Water is indispensable for life and it is also indispensable for economic activities. Supply of water is problematic globally since being a constant resource; the demand has increased. Much of urban Africa is confronted by inadequate water supply. In Africa, water crisis is predicted that by the year 2020, 75% of the continent's population will be water stressed (Joyce, et al., 2010). Population increase reduces per capita water availability and that conflict or cooperation may result as different water users, compete for the basic resource (Revenga, Johnson & Echeverria, 2001). Hence there is popular saying that "water sustains life", good quality drinking water is primarily sourced from rainfall or from surface water such as streams, rivers, springs and lakes. Where these do not exist or where they exist in quantities that cannot adequately support the dependent populations, ground water sources are exploited in the form of wells, and boreholes to provide this vital body requirement. This is why water has and continues to be the centre of ancient and present civilizations (Shaibu-Imodagbe, 2011). A borehole by definition is large water holes that are used by most of the major water companies or an organization to get water for domestic used, on the other hand a borehole is simply a deep narrow well usually driven by an electric pump that taps into the ground stores of water held in permeable rock known as aquifer, so that a water borehole can provide constant supply of water for purely outdoor use method we can also provide clean, pure potable and drinking water for indoor use and consumption. (Petrowiki, 2015).

A borehole is a narrow shaft bored in the ground, either vertically or horizontally. A borehole may be constructed for many different purposes, including extraction of water, other liquids (such as petroleum) or gases (such as natural gas), as part of the geotechnical investigation, environmental site assessment, mineral exploration, temperature measurement, as a pilot hole for installing piers or underground utilities, for geothermal installations, or for underground storage of unwanted substances, e.g. in carbon capture and storage.

According to the National Water Supply Policy (NWSP), estimated the minimum water requirement for rural areas is 30 gallons per person per day, while for small towns the estimated minimum water requirement is 50 gallons per person per day. In urban areas the category that Geidam falls, the minimum water requirement per person per day is 150 gallons. Drawing from this standard, and considering water yield potentiality of the various water supply facilities options, it is estimated than an average of 250 persons can be served by a hand pump borehole, while an average of 1500 persons can be served by a motorized borehole. Similarly an average of 2000 people can be served by a reticulated motorized borehole.

According to Joshi & Fawcett (2011), women being the main collectors of water it is often their lives that change the most dramatically." Thus the scarcity of water leading to erratic water availability implies that females spend more time in water collection activities. If the water supply issue is addressed in many countries, it would be available closer to their homes; women will have additional time freed for other activities and decision making. Women are further subjected to walking to isolated water points or find private places to go to the toilet, hence are at risk from sexual harassment (Water Aid, 2006).

Cost of buying water; Poor communities without access to water supplies (piped water, boreholes and shallow wells), particularly in urban areas, often have no option but to spend money they can hardly afford buying water from expensive water vendors who can get their water from unaccountable sources (UNEP, 2004).

Shortage of water is a big problem in many cities (Janakarajan, 2002). Water is sometimes turned on only a couple of times a day for about a half an hour each time. People with money have special storage tanks to collect water during those times, which in turn allows them to have water around the clock. People without storage tanks collect water in cans, jugs and buckets and often have to take bucket baths when the water is not turned on. Erratic water adaptation strategies also involve the use of storage containers to store water to ensure availability when needed for use. Most people globally have resulted to storing water because of its scarce nature (Kimaniet al., 2007).

According to Madulu (2003), about 31% of households in Tanzania have access to clean water supply within 15 minutes distance. Water scarcity forces people, especially rural dwellers who are the majority, to travel long distances fetching water from unknown sources which are often contaminated and not good for human consumption. Moreover many areas of the dry central part of the country have scarce water that even for personal hygiene cannot be easily found. Women and children bear the responsibility of fetching water, they spend a lot of time fetching water for domestic consumption. This is exhausting and dangerous chore that limit them to participate in other productive activities and learning for girls (URT, 2002a; Solomon, 2001; Biswaset al., 2004; Madulu 2003; UNICEF and WHO, 2005). The scarcity of the precious water resource for livelihood forces people, especially rural communities, to invest their own efforts in developing their own water sources as one of the coping mechanisms. These sources are often contaminated and not managed properly. Rural people invest considerable energy and finances in supporting household-owned water supply facilities such as shallow wells, dug wells, rain water, harvesting and household water treatment methods (Madulu, 2003; UNICEF and WHO, 2005). The outcomes of using water from unknown sourced are generally health problems, which have economic impacts to the household, especially the rural and urban poor communities (SIDA, 2004).

Another challenging issue with the Nigerian water supply sector is the traditional way in which citizens view the provision of water supply and services. The provision of water is traditionally regarded as a social responsibility of government. Consequently, the costs of water infrastructure and service delivery is usually met largely from government allocations and aids, rather than from water tariffs and charges, thus leading to the long standing practice of fixing water rates far below the full cost of service provision (Odigie and Fajemirokon, 2005).

According to the Water Act of 1993, the Ministry of Water Resources is given power to regulate water-related issues such as pumping or use of commercial scale or construction, licenses of water, storage, maintenance, operation, repair of any borehole or hydraulic works, e.t.c. the minister also has the responsibility to define places from which water can be taken or use and also fix times of actual envisaged water shortage, amount of water which may be taken by any person. He also prohibits temporarily or permanently the taken or use of water that is hazardous to health, revokes the right to use water where such right override public interest, require to be examined or license any drilling operations, regulate, place, depth, manner of construction of borehole or well. In the discharge of his duties, minister is to ensure the provision for adequate water supply that is suitable for animals, irrigation, agriculture, domestic and non-domestic use, generation of hydro electric energy, navigation and recreation, drainage, safe disposal of sewage, prevention from pollution, prevention from flooding, soil erosion, reclamation of land, protection of the environment etc. (Adoga, 2006)

Currently, access to drinking water in Nigeria is generally low, with urban areas having a higher proportion than those in the rural areas who have access. In this study access to drinking water refers to the proportion of the population that uses drinking water from improved sources, such as household connections, public stand pipes, boreholes, protected wells and springs (WSMP, 2008). Based on NBS (2006) survey report of the six geopolitical zones in Nigeria, improved water coverage ranged from 73.5% to 30.7%, with the South West zone having the highest coverage of improved water source (73.5%) and the North East zone has the lowest coverage (30.7%). In a study by Water Aid (2006), in Nigeria, it was indicated that there was strong political influence in the provision of water points as the allocation of government boreholes and other improved water supply projects are mainly left to the inclination of political leaders and state patronage.

This research work focus on the location analysis of boreholes in Geidam town, the headquarters of Geidam Local Government Area of Yobe State. The study is triggered because of the rapid increase in human and housing population in the town and from observation it seems there may be some problems as regard to location and distribution of boreholes in the town. In the word of Christeller (1993) in Albert, Adams and Gold (1973), there is some ordering principles unrecognized that governs the distribution of things and phenomena. Only when proper investigation is made that one can explain what is where and why, a question that geography holds since the epoch of Eratosthenes, since the beginning of geography.

Borehole is a source of water for domestic use and it served as major source of water for the residents of Geidam town. Inspire of the reasonable number of these facilities provided within the town, there has been complain of water shortage for domestic use by the residents. Therefore, there is need to know if these boreholes are efficiently distributed among the residents population. Also records of boreholes are made on paper records (analogue) that constitute inadequate information on the water facilities. Usually names and address of the water facilities are obtained in such records and lack information on automated map of the study area, spatial locations, and database for public potable water facilities. There is also the need to produce an automated record that will surmount the challenges facing the study area and indeed to create a system that will constitute the spatial and attribute data of the boreholes, so that it can ease future planning and decision-making by the administrators particularly water board and Ministry of water resources.

1.1 Study Area

The study area is Geidam Local Government Area of Yobe State, located in the North East Geopolitical Zone of Nigeria. Geidam Local Government is one of the seventeen local government's areas of the state with its headquarters area in the town of Geidam. The Local Government Area has an area of four thousand, three hundred and fifty seven square kilometers (4,357 km^2) and a population of about One hundred and fifty five thousand and seven hundred and fourty (155,740) people as at 2006 census. It is bounded to the north by Yunusari Local Government, to the south by Tarmuwa Local Government Area, and to the west by Bursari Local Government's Area of Yobe State, while to the East it is bounded by Mobar Local Government Area of Borno State. The study site is Geidam town, the headquaters of Geidam Local Government area, located at latitude 12º 53′ 49″N, longitude 11º 55′ 49″E and 289m altitude. The town has an estimated population of forty one thousand, three hundred and sixty seven (41,367) people as at 2006 census. The climate of the area can be described under Sahel Savannah which often characterized with short wet season that last for four months and long dry season of about eight months. The wet season occurs between August and September, with mean annual rainfall of 350-500mm. The temperature is fairly consistent, and

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the hottest months are March, April, and May with temperature ranges from 35ºc-40ºc. The vegetation cover in Geidam is directly related to environmental factors such as soil, rainfall, and human intervention. The entire area fall within the Sahel Savannah; short grasses, thorny shrubs and trees are found dotted around. The study site is pluralistic in ethnic composition. Agriculture is the main occupation of the people, mainly crop production, livestock keeping. Inhabitants are mostly public servants, businessmen, and farmers. Map of Yobe State showing the seventeen local government areas is shown in figure 1.

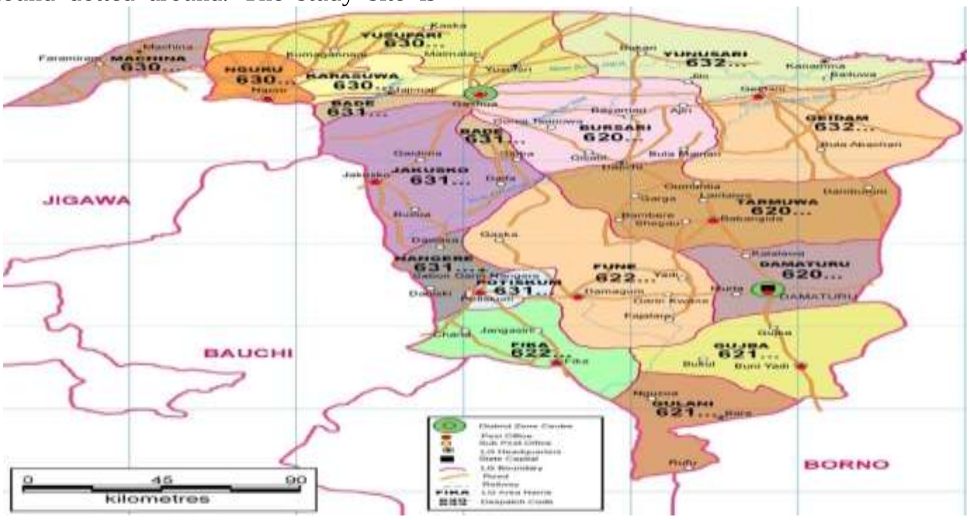

Figure 1: Map of Yobe State

Source: Ministry of Land and Housing, Damaturu

II. METHODOLOGY

In this study a reconnaissance survey was carried out in order to identify and document the number of boreholes in the study area. This provided the researchers with the knowledge of the study area and guide on the nature of data required and preparation for the field work. Street maps of Geidam town at a scale of 1:2000 and Quickbird imagery of 2016 at 2.5 meter resolution were acquired from the Yobe State Ministry of Land and Housing. These data were integrated in order to produce the updated street map of the study area. Some attribute data of the boreholes was acquired from the Yobe state Ministry of water resources, a ministry responsible for registering and regulating the activities of boreholes in the state. From the data, boreholes names, ownership, functionality, and area (street) of their location were identified. This served as a guide for verification and acquisition of the Geometrical data using hand held Global Positioning System (GPS) receiver.

The obtained street map was scanned, imported into ArcMap environment of ArcGIS 10.3 and then georeferenced using map to image georeferencing method. The Quickbird image 2016 of the study area was used as a slave image for the georeferencing. The georeferenced maps were also rectified and then given same coordinate system with the image.

Shapefiles were created in ArcCatalog environment of the ArcGIS 10.3 software with same coordinate system with that of the image and maps. The shapefiles were later imported into the ArcMap environment and used to digitized the street map and landuse map separately.

A simple checklist was used to source the detailed information on the boreholes, and their coordinates were obtained using hand held GPS (Garmin 76CSx) receiver.

The attribute data obtained from the ministry of water resources and field visitation were used to create a simple database in Microsoft Excel (2007). Columns were used as field to store information on filling station which was saved in the project folder. The data was later exported to ArcMap environment of ArcGIS 10.3 software. The numbers boreholes in each ward were determined. To map out the boreholes, different symbolization was used. In addition tables and charts created in Microsoft Excel were used to present the inventoried data. Buffer and proximity analysis were carried out in ArcMap, in order to compare location of the boreholes. Different queries were performed to obtain the desire results.

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Buffer of 250 meters was created on the boreholes to enable the researcher know the settlements that falls within the buffer zone. The selected features were highlighted and layer was created from the selected features. Another query was performed to show the location of settlements those are within 500 meters from the boreholes.

The point pattern of the water facilities and the average nearest neighbor were also determined in ArcMap environment. Average Nearest Neighbor (ANN) Tools were used to calculate the distance between each feature and its nearest neighbor, then compute the average for all nearest neighbor distances and then compares the computed average distances to periodic ones that will be obtain if the points were randomly inside a circle within the same area.

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III. RESULTS AND DISCUSSION

3.1 Inventory of Boreholes by Wards

The finding revealed that there are Twenty Seven (27) boreholes at the time of the study. These boreholes are located at the three wards in the study area (Table 1). However, the boreholes are not equally distributed between the wards as can be observed from the table. Hausari ward has the highest number of boreholes (15), followed by Asheikri wards and Kolori ward with (6) each respectively, Hausari ward account for more than half of the boreholes in the area (representing 55.6%). This result is not surprising because Hausari ward because it is the widest in terms of settlements, it has the highest population and is along the major that linked the town and the state capital.

s/n	Ward	No. of boreholes	percentage
1	Hausari	15	55.6%
2	Asheikri	6	22.2%
3	Kolori	6	22.2%

Table 1: Distribution of Boreholes by Wards

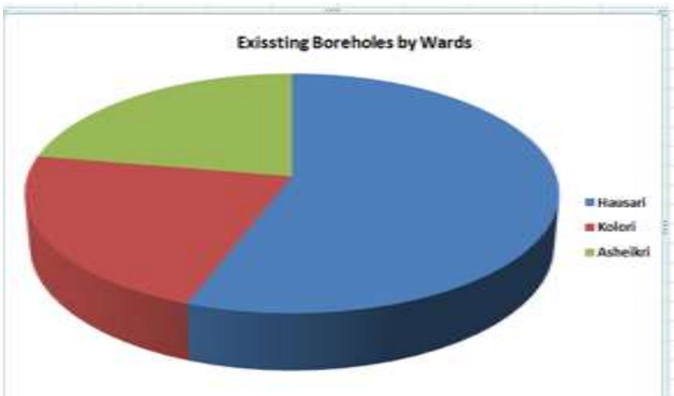

Figure 2: Existing Boreholes

Five (5) boreholes (18.5%) use generators as source of power, while 8 (29.6%) use solar and 14 (51.9%) use electricity respectively (figure 3). Twenty six (26) boreholes (92.3%) use overhead tanks (OH Tank) as medium of storage, while 1 (3.7%) used surface tank (S Tank) to store water (figure 4). Twenty six (26) boreholes (92.3%) are fenced, while only 1 (3.7%) is not (figure 5). Twenty two (22) boreholes (81.5%) are owned by Government, while Non Governmental organizations (NGOs) owned 5 boreholes (18.5%) in the study area (figure 6). All the 27 boreholes (100%) in the study area are fully functioning (figure 7).

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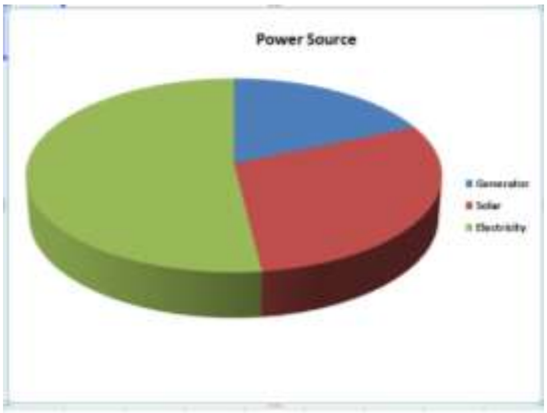

Figure 3: Power Source

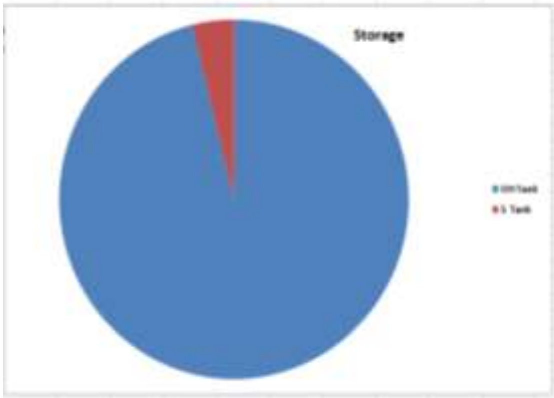

Figure 4: Storage System

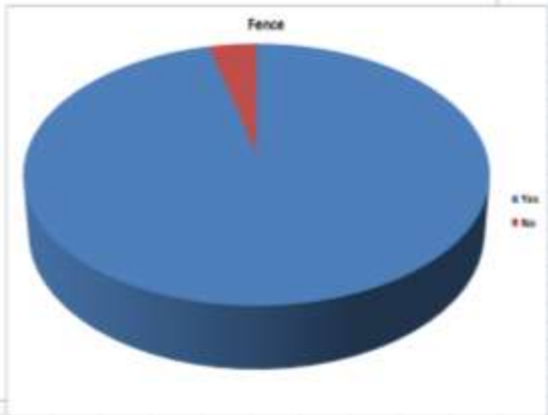

Figure 5: Fence Status

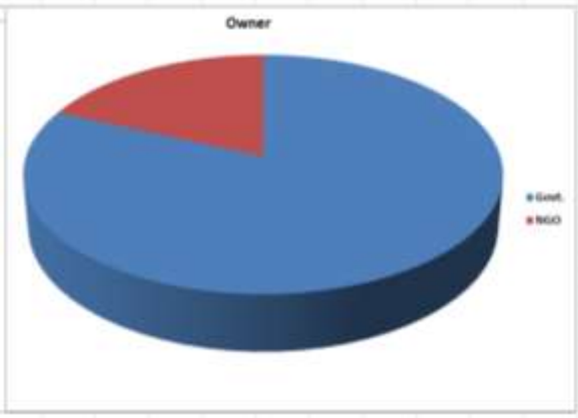

Figure 6: Ownership of Boreholes

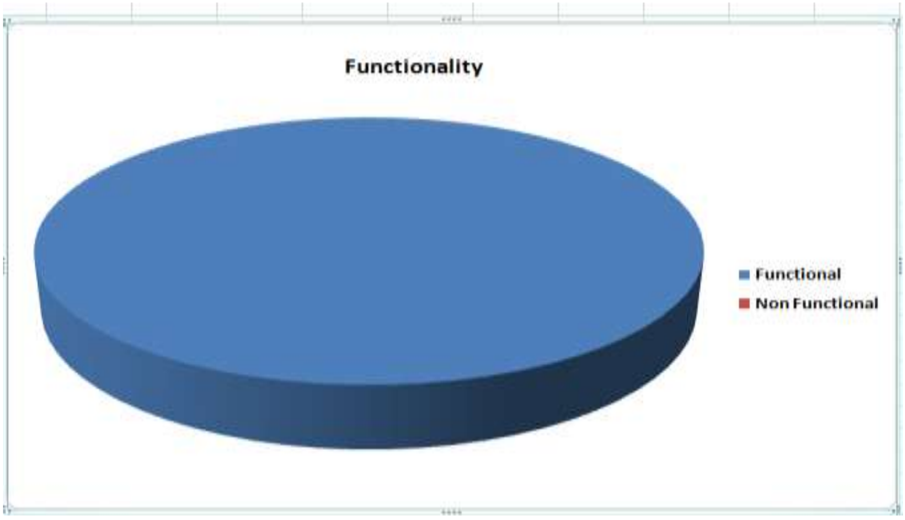

Figure 7: Functionality of Boreholes

3.2 Map of the Study Area

Map of the study area showing the location of boreholes was produced as shown in the figure 8, their spatial pattern is shown in Table 2 and Table 3..

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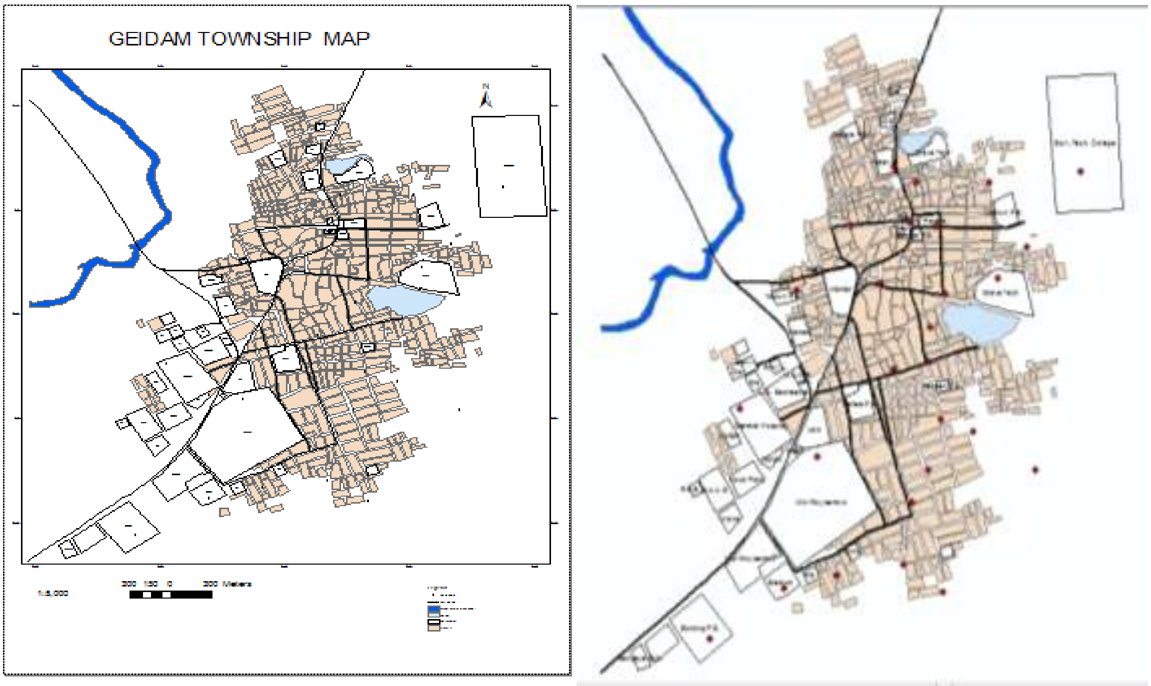

Layout View Data View

Figure 8: Map of Geidam Town

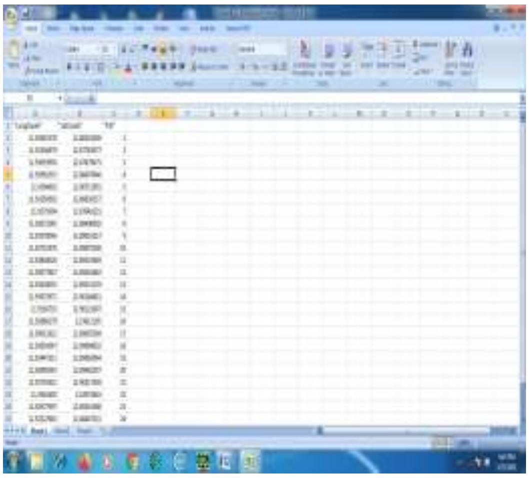

Table 2: Geometrical Data
Source: Field Work, 2021

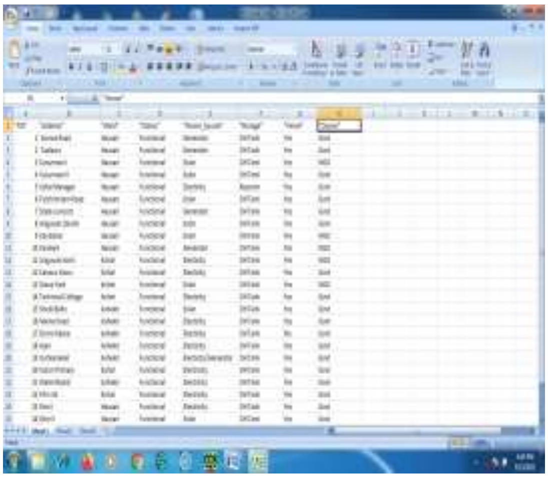

Table 3: Attribute Data
Source: Field Work, 2021.

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3.3 Point pattern analysis

This can also be called dot map. It was use to display the distribution of boreholes events as data locations visual inspection of spatial clusters, and analyzing the facilities distribution pattern. The point pattern of the boreholes in Geidam town and their average nearest neighbor summary are shown in figure 9 and figure 10, respectively.

Figure 9: Point Pattern

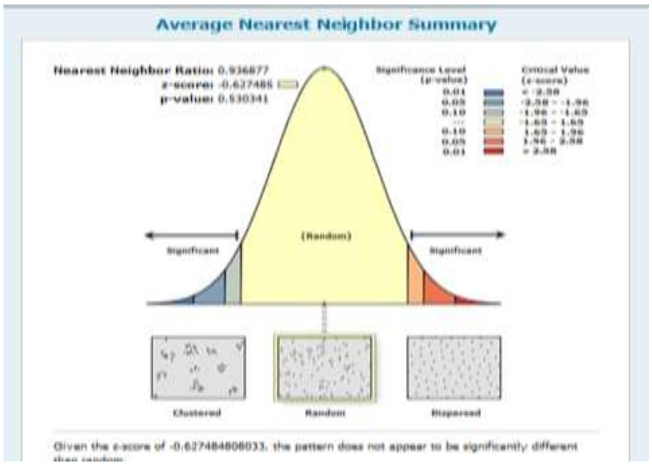

Figure 10: Average Nearest Neighbor Summary

Given that the Z-score of -0.627484808033, the pattern does not appear to be significantly different than random.

Average Nearest Neighbor (ANN) Tools were used to calculate the distance between each feature and its nearest neighbor, then compute the average for all nearest neighbor distances and then compares the computed average distances to periodic ones that will be obtain if the points were randomly inside a circle within the same area.

The result in the HTM output result under the result in the ANN tools shows that the boreholes are clustered. The numeric output in the ANN tool indicates that the boreholes are random. The result indicates statistically significant random distribution pattern. The result shows the nearest neighbor ratio of 0.936877, the Z-Score of -0.627485, and P value of 0.530341. Z-Scores are standard deviation and can be plotted on a normal curve as shown in figure. The smaller the number, the further down on the tail of the normal curve the Z-Score falls.

3.4 Buffer analysis

The buffer analysis was used to analyze the distances and to suggest future locations of water facilities. Essentially, buffer analysis is tool to which has been used to find regions that are directly connected to a specified object and useful for finding regions of space that are nearest to each of a set of irregularly distributed sample locations. The observed mean distance was found to 360.3818 meters, while the expected mean distance is 384.6631 meters (figure 11).

Average Nearest Neighbor Summary	
Observed Mean Distance:	360.3818 Meters
Expected Mean Distance:	384.6631 Meters
Nearest Neighbor Ratio:	0.936877
z-score:	-0.627485
p-value:	0.530341

Figure 11: Average Nearest Neighbor Summary

The accessibility of water facilty was determined by carrying out buffer of 250 meters and 500 meters (0.5 km) radius separate and combined. The result revealed that the spatial distribution pattern is random. The 250 meters buffer, 500 meters buffer, and combined buffer are shown in figure 12, figure 13, and figure 14, respectively.

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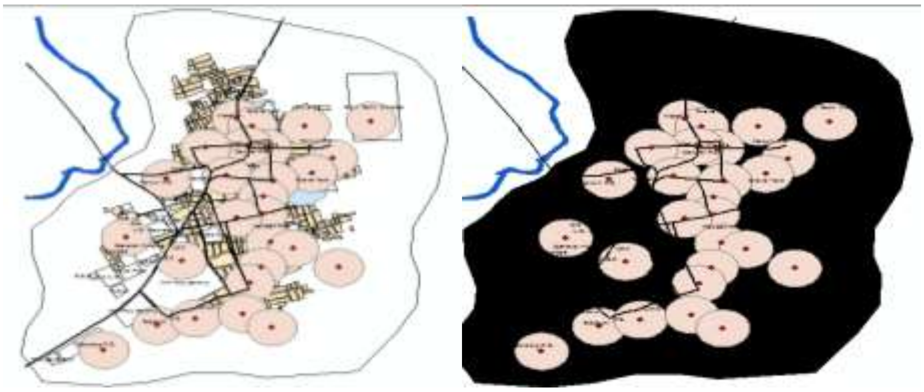

Figure11: 250m Buffer

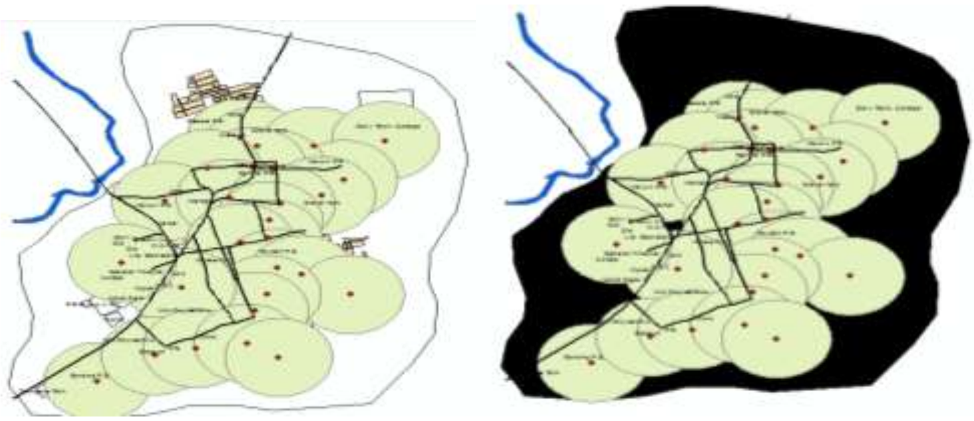

Figure 12: 5000m (0.5km) Buffer

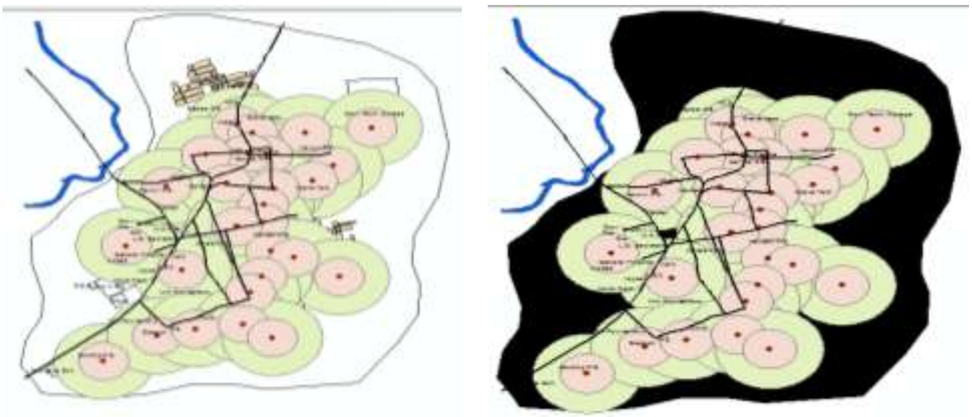

Figure 13: 250m and 5000m (0.5km) Buffer (Combined)

IV. CONCLUSION

In this study, the spatial distribution patten of boreholes in Geidam town was sucessfully generated from satellite imagery, geometrical and attribute data using ArcGIS software. The most important feature of image based measurement is that none of the objects are being touched during measurement. However, with the emerging of modern technology such as Geoinformatics, this non-contact measurement can be used to produce the spatial distribution of facilities. The satellite imagery, geometrical and attribute data were used as input data in ArcGIS software.

The analysis of the results was carried out based on locations and attributes of the facilities. The facilities were seen to be randomly distributed. The accessibility of water facilty was determined by carrying out buffer of 250 meters and 500 meters (0.5 km) radius. The result revealed that the spatial distribution pattern is radom and there are very few dark areas that does not need urgent attention of the Government. The observed mean distance was found to 360.3818 meters, while the expected mean distance is 384.6631 meters, this revealed that, residents can get borehole water at a distance of less than 00 meters from their homes.

The potentials of GIS technology in database design and creation has also been demonstrated and found to be more efficient than the manual approach. GIS is also a key in evaluating water facilities planning through providing spatial relationship information.

Finally it is recommended that, the use of GIS tecnology in planing, management and decision making on water facilities should be encouraged for optimal distribution of water facilities for efficient discharge to the whole community.

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