Groundwater Database for Sustainable Water Development within the Federal Polytechnic Ado Ekiti, Southwestern Nigeria

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ABSTRACT

As a result of the rapid population growth, industrial activities, and climate change which has been a major global concern, human consumption and water demand continue to increase. In an attempt to achieve the target for the Millennium Development Goals (MDGs) concerning reducing populations without access to safe drinking water, developing countries require extra efforts to achieve this target. This project is aimed at assessing and generating the spatial distribution of boreholes and hand-dug wells within Federal Polytechnic, Ado-Ekiti using Remote Sensing and Geographic Information Systems (GIS). The spatial distribution of the boreholes and hand-dug wells was determined using a hand-held GPS. The data generated were analyzed using ArcGIS 10.3 software while 200 m buffering of the boreholes and hand-dug wells were overlaid to know areas that have access to both the boreholes and the hand-dug well in the study area. The result clearly shows that the southern part of the study area having a clustering arrangement possesses more boreholes and hand-dug wells thereby having more access to these water facilities. Moreover, some of the areas within the school were found to be short of these water facilities due to the increased population of both staff and students as well as the malfunction of some of these facilities.

Keywords: Buffer, Global positioning systems, Boreholes

1.0 INTRODUCTION

The absence of a water management database in this study area has created a grave challenge, the student population have being on the increase with a corresponding decrease or stagnation in the water supply system. The absence of a thematic map for water facilities (borehole and hand-dug well) has hampered the effective monitoring and performance level of these facilities. This has also contributed to the arbitrary siting of water facilities in the study area. Therefore, careful management of water supply becomes even more important in the study area to satisfy human needs. Water comes from various sources like rain, wells, springs, mountains as well as ice or snow. It is very critical for man's existence, and without it is life threatened and there would be no life on earth. Hence, water supply is a basic requirement and necessity of life (Akpor and Muchie, 2011; Mara and Evans, 2011; Awodumi and Akeasa, 2017), without it, life and civilization cannot develop or survive for human and economic development (WHO, 2008; Bartram and Cairn, 2010; Mustapha and Adamu, 2017).

Numerous studies have alluded to the looming water scarcity with its inherent conflicts (UNDP, 2006; Behr, 2008), this includes; drought, human activities, and explosive population growth. This has been accompanied by poverty, disease, and hunger (Gleick, 2000). Despite the significance of adequate water quality and quantity for human health and survival, public water supply coverage in the study area appears to be decreasing and deteriorating (Oyinkolade and Oluboyede, 2019), this has resulted in using computers application and software (Remote Sensing and Geographic Information System) for planning and operation of water resources systems. According to Meyer *et al.* (1993) and Jha *et al.* (2007), it has rapidly become an important field of research during the last several decades, GIS is a computer-based application designed to capture, store, manipulate, analyze, manage, and present all types of geographical data this has been integrated with remote sensing to obtain information about objects typically from aircraft or satellites. These have been adopted in water development and management by various workers (Meyer *et al.,* 1993; Jha *et al.*, 2007). Shamsi (2004) in his research, reported that geographic information science is used for mapping, modeling, facilities management, and development, when adopted by a potable water distribution system manager can develop a detailed capital improvement program/operation and maintenance plan. This project is aimed at assessing and generating a database for the spatial distribution of boreholes and hand-dug wells within Federal Polytechnic, Ado-Ekiti using Remote Sensing and Geographic Information Systems (GIS).

2. REGIONAL GEOLOGY SETTINGS OF THE STUDY AREA

The study area falls within the Southwestern basement complexes of Nigeria with coordinates between 7ºN and 10ºN and 3ºE and 6ºE respectively. This area belongs to the rocks of the Precambrian ages which lies between the West African and Congo cratons. The Nigeria Basement complexes extend westward and continuously till it was overlain with sediments from Dahomey – Togo – Ghana region to the east and south Mesozoic recent sediments of Dahomey and Niger coastal basin over the basement complex (Rahaman, 1976). The Crystalline rocks which form the basement complex rocks of Nigeria are exposed in about half the surface area of the country. Due to the crystalline nature of the rock types in this region, the porosity and permeability necessary for the occurrence of large groundwater resources are lacking (Offodile, 1996). However, appreciable porosity and permeability may have developed through fracturing and weathering processes (Dada, 2006)

as bauxite

The study area is located between Latitude 7° 3' and 7° 49' North of the equator and Longitude 5° 27' to 5o 48” East of the Greenwich Meridian (Figure 1). It is bounded in the North by Ido – Osi and Oye Local Governments. The Geology of Ado Ekiti belongs to the basement complex (Igneous rock) rock of the Southwestern basement complexes of Nigeria. The major lithological rock units are crystalline basement rock. These include coarse-grain charnockite, fine-grained granite, medium-grain granite, and porphyritic biotite, biotite-hornblende granite with superficial deposits of clay and quartzite, the association of the fine-grained charnockite and porphyritic biotite – hornblende granite suggest a common age **(**Oyinloye, 2002**).** The charnockite rock is the most abundant in the area. It ranges in color from dark green to greenish-grey rock with milky quartz and greenish feldspar. The outstanding feature of the coarse-grained variety of charnockite rock in Ado Ekiti is that it is similar to those of Oyawoye (1965 and 1972) described around Bauchi Nigeria. Other occurrences are in the form of small dykes of veins in other rocks. The rocks are generally even in texture and homogenous with mineral aggregate mainly of biotite and feldspar phenocrysts. The superficial deposits are clay quartzite rumbles and fine sands (SiO2). The clay is believed to have been formed from the weathering of feldspar minerals present in charnockite rocks due to the alteration of igneous rock by hydrothermal weathering.

The study area falls within the Federal Polytechnic Ado-Ekiti, located on the geographical coordinate of Latitude 07º35′15″N and 07º36′12″N and Longitude 05º17′4″E and 05º18′30″E on the Universal Transverse Mercator (UTM Zone 32) in Ado Ekiti, Ekiti State, South-Western Nigeria. The study area is generally accessible and motorable, the availability of both tarred and untarred roads as well as footpaths provide good accessibility to the study area.

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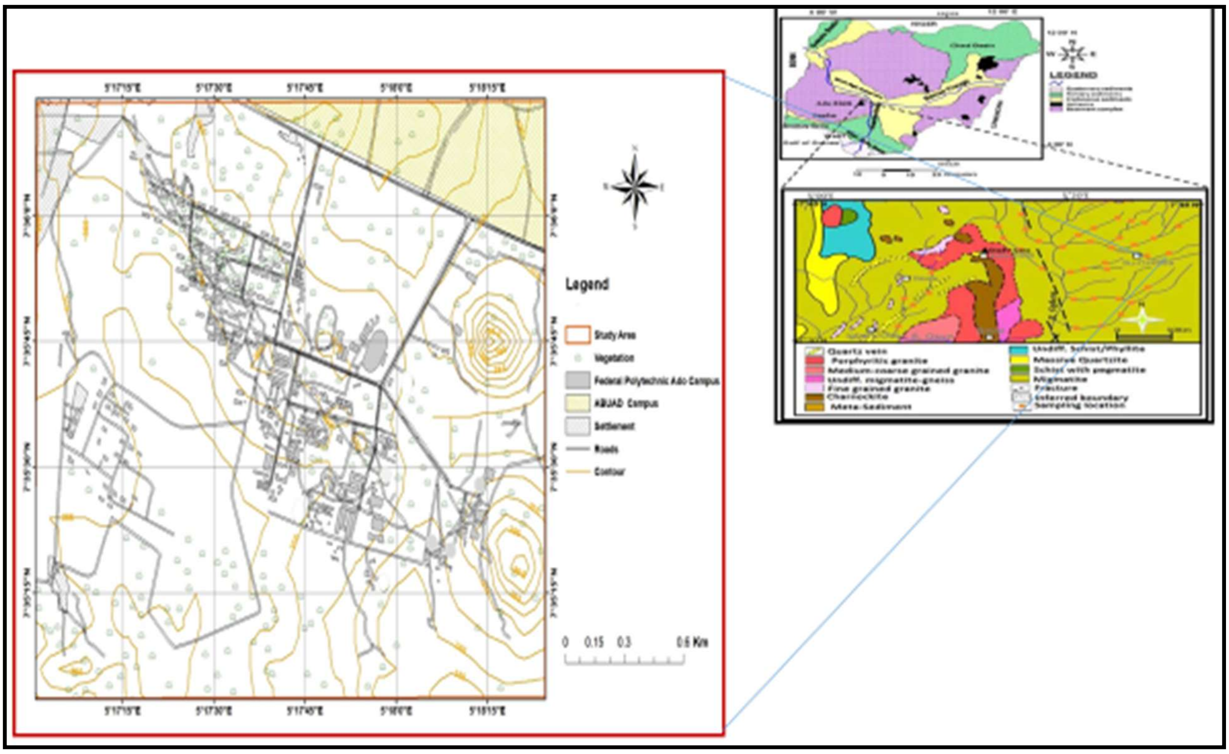

Figure 1: Geological map of Ado-Ekiti and environs showing the location of the study.

3.0 MATERIALS AND METHODS

3.1 METHOD

The research work involves specifically data acquisition and processing using the base map, Handheld Global Positioning System (GPS) receiver, water level indicator, field notebook, pen, and digital camera. These were employed to acquire data that were processed based on GIS applications.

3.2 Data Acquisition and Processing

Data acquisition involves a collection of data using a Garmin (GPS) Map 76CS receiver to locate the existing boreholes and hand-dug wells within the study area. The water level indicator was used to determine the static water level of the boreholes and the hand-dug wells. A digital camera was used to take photographs of some existing water facilities to aid better visual appreciation and spatial analysis of the study area. The coordinates, static water level as well as some attributes of the water facilities within the study area were observed and recorded in the field notebook. In order to fully understand the spatial nature of the acquired data, GIS software was adopted to process and analyze the data which includes georeferencing, digitizing, map visualization, and buffering.

3.2.1 Georeferencing and Digitizing

The base map of the study area (Federal Polytechnic community and its environs) was imported into a GIS environment where the reference system was defined using a projected reference system: WGS 84, Minna/UTM zone 32N respectively. The four corners of the base map (the coordinates) were captured and used as input in the geo-referencing process. The geo-reference tool in ArcGIS 10.1 was clicked on. The four (4) edge coordinates of the map were selected as the control for the georeferencing. The add control tool was used to register the coordinates. The map was further digitized by tracing or freehand drawing the features on the map. The road network was then carefully extracted using a polyline. The buildings were also extracted using a polygon while the water facilities in the study area were represented using the point as displayed in Figure 2a-c.

3.2.2 Visualization of GPS Point and Spatial Analysis

The spatial distributions of the existing water facilities in this study area were displayed in a GIS environment downloaded from the hand-held GPS field record into the computer system using GARMIN Map Source 4.09 software as an interface to provide ease of analysis. These points were later converted to text files and added to Excel. Also, in the arc catalog, the created feature from the x, y z axis was used to display the GPS point in the Arc GIS environment. Spatial and non-spatial data in the GIS database was adopted to answer some generic questions such as querying, buffering, classification, and other GIS analysis about the real world by modeling to confirm whether the model revealed new or previously unidentified relationships within and between datasets, therefore, increasing our understanding of the real world (ESRI 1990)...

3.3.1 Buffering (Proximity analysis)

Buffering is an important tool used to determine the area covered within a specific location in this study to evaluate the number of water facilities (boreholes and or hand-dug wells) points within a specified radius. In this process, the analysis tool in the Arc toolbox in ArcGIS 10.3 was used. The major buildings were put as input features; the radius (200m) was defined and the output feature was saved as a buffer shape file.

4.0 RESULTS AND DISCUSSION

4.1 Data Presentation

Based on the studies conducted within the study area, forty-eight (48) boreholes and thirty-six (36) hand-dug wells were identified... About 75 percent of the boreholes are functioning while the renaming 25 percent in the study area are not functioning. This possibly has occurred due to either poor geophysical survey, improper drilling, or poor maintenance culture. These were characterized as shown in Tables 1 and 2 respectively. The static water level of the boreholes ranges from 1.53 m to 4.21m. The lowest which is 1.53m is located at the CEDVS processing unit while the highest point is 4.21m located at the right hand side of the ICT building. Also, the static water level of the hand-dug wells ranges from 1.53m to 8.3m. The lowest (1.53m) is located at the back of the computer science department while the highest (8.3m) is located at the central mosque area. These are presented below in figures 2a.c respectively.

4.2 **Discussion**

Based on the data acquired and processed, a spatial distribution map of the boreholes and hand-dug wells within the study area was prepared using ArcGIS 10.3 software. Figure 2a-c shows the location and spatial distribution of the boreholes and hand-dug wells (functioning and not functioning) within the study area. These facilities are located in various parts of the institution, some areas are either poorly represented or short of these facilities due to the high density of people in the environment whereas in some areas; the facilities are readily available with very low consumption rates due to these areas being within the offices and lecture halls.

(a)

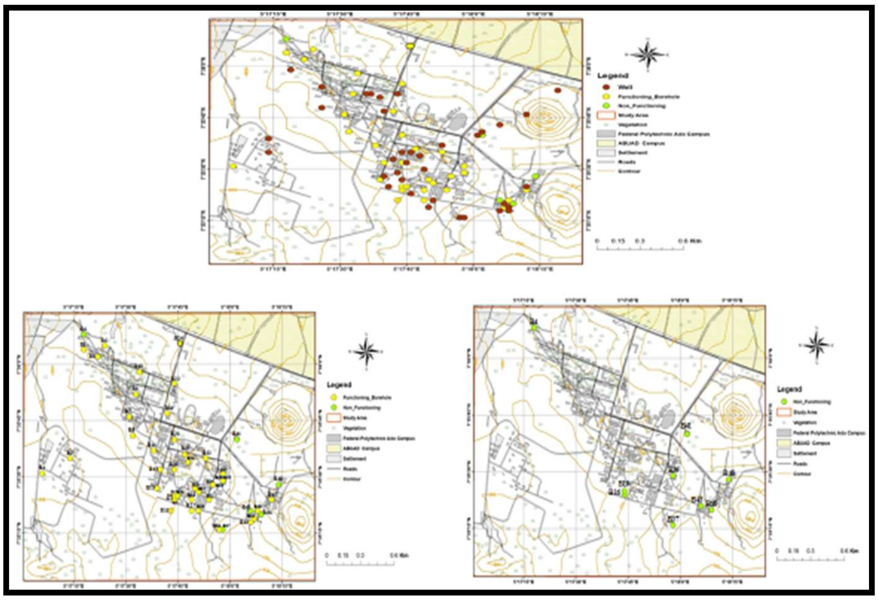

Figure 2a - c: Map showing (a) the spatial distribution of boreholes, (b) the functioning and not functioning boreholes, and (c) the hand-dug wells within the study area.

Nine (9) non-functioning boreholes (25%) in the study area are B4, B16, B19, B37, B39, B41, B43, B46 and B48 respectively. These boreholes are located in Abuja boys' hostel (B43 and B46), CEDVS processing unit (B48), Central mosque (B41), ICT building area (B39), Livestock unit of Agric technology department research farm (B37), back of MPRET department (B16 and B19), and mini-mart of annex gate (B4) respectively.

The result of the Buffering (Proximity analysis) of the borehole is presented in Figure 3a-b. The proximity analysis was conducted within the radius of 200 meters buffer for the boreholes. This is a spatial function in which an area/zone of interest is created around the given features or objects. These analyses were done around the built-up areas that fall within the set criteria of a 200 m radius of each of the boreholes. Towards the western part (Rector's village) boreholes B1 and B2 fall within the set buffer criteria. Comparing the number of buildings with these available boreholes, this was adjudged to be short of water supply. Also, Eight (8) boreholes (B3, B4, B5, B6, B7, B8, B9, and B10) are sited within the annex gate, annex hostel, Lagos female hostel, the old health center, and the school car wash, only seven (7) boreholes of them were observed to be functioning while only B4 was not functioning. This section of the polytechnic house 60% of the students population coupled with staff quarters, an indication the area is thickly populated with less supply of water mostly during the dry season.

Other areas considered for borehole proximity analysis, are around the School of Science and Technology, Admin block, maintenance department, and the old environmental building consisting of seven (7) functioning boreholes. B11, B12, B13, B20, B25, B26, and B32. It was observed that these boreholes are distributed evenly within these areas which are mostly made of offices and classerooms. The water in this area is used for laboratory practical and domestic practice. Boreholes; B14, B21, B22 and B24 located around the Mini mart, Inner school gate, Alumni building, and First Bank are also evenly distributed, although the Mini market may require additional borehole due to high levels of water consumption. Other areas where proximity analysis was conducted within a 200meters radius include the MPRET Building, EED fishery unit, and the new Senior lecturers' office with six functioning boreholes (B15, B16, B17, B18, B19, and B23) while two boreholes B16 and B19 about 10m away from others are not functioning. These areas are mainly laboratories, agriculture, lecture halls, and offices.

Although the water consumption rate still conforms to the activities ongoing in this area, future consideration must be put in mind to constructing more boreholes

2a

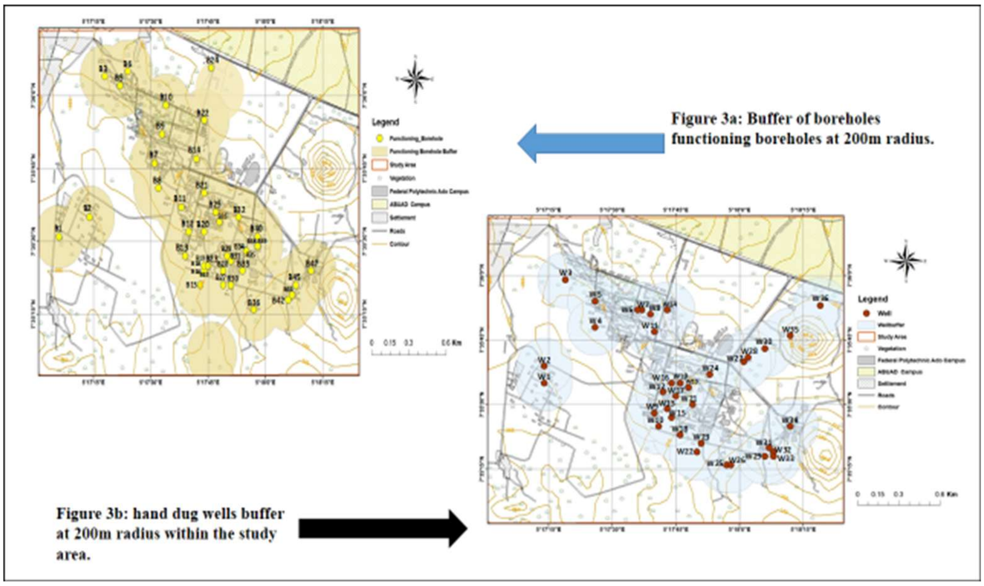

Figure 3a - b: Map showing (a) the buffer of the functioning boreholes and (b) the buffer of the hand-dug wells within the distance of 200.0 meters radius within the study area.

Within the new school of Business studies, new School of Engineering buildings which include the new civil building and Mechanical/Electrical engineering, foundry unit, livestock unit, and research farm of the department of agricultural technology are located ten (10) boreholes: B27, B28, B39, B30, B31, B33, B34, B35, B36, and B37. These boreholes are sited very close to each other and are also located around buildings serving the laboratories, offices and lecture halls agriculture technology demonstration farm. Supply of water to the laboratories and restrooms agric farms epileptic due to inadequate supply of water into some of the facilities, except the boreholes are married together water supply will always be a problem.

Boreholes B38, B39, and B40 are located around the new ICT building and the pure water factory. While boreholes B42, B43, B44, B45, B46, and B47 are located around the Abuja hostel. In this area, only borehole B48 located at the CEDVS processing unit is not functioning. With only B42, B44, and B45 the only functioning boreholes around Abuja hostel, the consumption of water is much due to the high population of students and it is therefore observed that they experience scarcity of water. It can be observed that the sports complex was left out.

Figure 4.4a shows the distribution of hand-dug wells in the study area. A total number of thirty-six (36) wells are in the study area. All the wells in the study are functioning except for some that are not in good shape as a result of leaving the wells without covers. Figure 4.4b shows the map of the 200 m buffer of hand-dug wells. This is a spatial function in which an area/zone of interest is created around the given features or objects. These analyses are done to see the buildings that are falls within the set criteria of 200 m radius of each of the hand dugs wells. This was performed by creating 200 m buffer around the hand-dug wells and then the walking distance to the hand dug wells were determined with respect to the building that falls within the buffer zones. In this study, analysis carried out using a 200 m buffer performed is equivalent to two (2) minutes of trek access to water.

This map shows that the wells are heavily concentrated at the center, the northeastern and southern parts of the study area. This area includes the school of science technology, the main entrance of the school which is made of the worship centers (Chapels and Central mosque), and the Abuja boys' hostel. The center of the study area (School of science and Technology) is generally a bakery, lecture halls, laboratories, and offices, it is observed that wells (W9, W10, W12, W13, W15, W16, W17, W18, W19, W20, and W21) are closely suited to each other and consumption of water may be limited. W3, W4, W5, W6. W7, W8, W11, and W14 are sited northwest of the campus which includes Lagos female hostels and the Annex hostels. Although looking at these areas, it can be seen that the environment is highly populated because students and staffs are residents there and thereby, they consume much water. In the northeast of the study area, area such as the Main entrance, the worship centers (chapels and central mosque) are virtually dependent on hand dug well (W27, W28, W30, W35 and W36 for their water supply. While these hand-dug wells (W25 and W26) are sited within the Agricultural technology department demonstration/research farm and livestock unit, this supplies water to the farm. It was noticed the water is insufficient during the dry season.

Hand-dug wells (W29, W31, W32, and W33) are sited at the Abuja boys' hostel and W34 at the School of environmental studies. Observations showed that this area is highly populated with student hostels, hence an increased consumption of water. Only two wells (W1 and W2) were seen in the western part of the study area (the Rector's village). With the number of buildings in the area, consumption of water is high and scarcity of water during dry season has being a problem in the area.

Figure 4 shows the groundwater flow trend within the study area. Naturally, water moves from the higher head to the lower head because they possess higher energy than the lower head. This shows that groundwater flows downwards from the northwestern part of the study area B4 (elevation 401m and 2.88m static water level) to the southern part B16 (elevation 391 and 2.5m static water level) and from B16 down to B39 (elevation 396m and 4.21m static water level). Also, groundwater flows downward from the southeastern part (B48 with Elevation 394m and 1.53m static water level) to the southern part (B41 to B39). In summary, the direction of groundwater flow (flow trend) in the study area is from northwest – South (NW-S) and from southeast – south (SE-S).

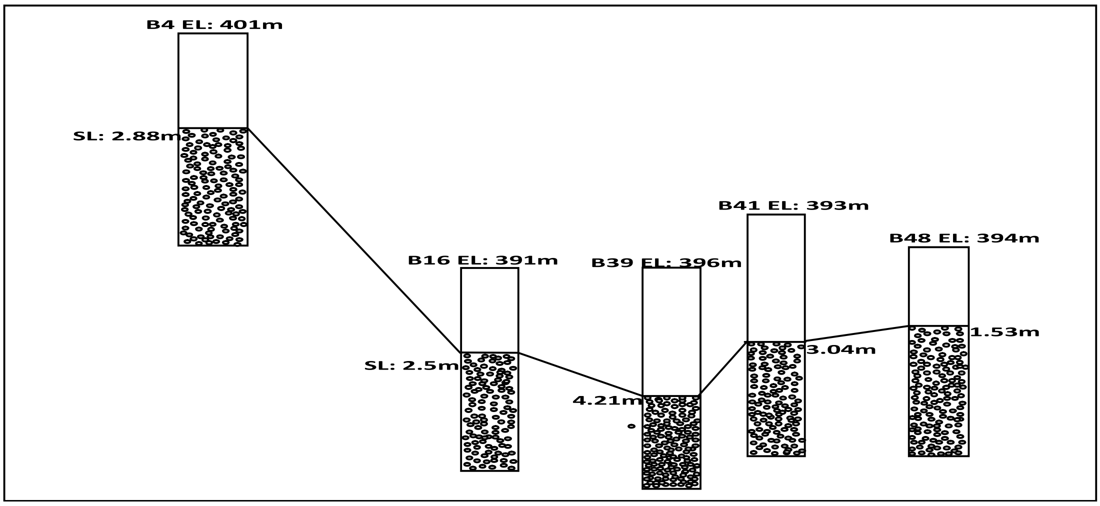

Figure 4: Cross section of groundwater flow trend in the study area.

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This research work identified the spatial distribution of boreholes and hand-dug wells with a majority of the facilities confirmed to be functioning. There is a clear indication that the southern part of the study area has a clustering arrangement of boreholes and hand-dug wells thereby having more access to water facilities. The flow direction (flow trend) of the groundwater in the study area is from Northwest – South (NW-S) and from Southeast – South (SE-S) respectively. Observation shows that some areas are well-favored with adequate water supply while the other areas are deficient in water facilities. However, those areas found with a shortfall in water supplies may either be due to the increased population or lack of adequate water supply, or poor maintenance of the boreholes in these areas. With the development of information and computer technology (ICT) for planning and operation of water resources systems, coupled with knowing the basic concepts of Geographic information system (GIS) in managing spatial data, then applying such system in the management of water facilities network becomes a necessity in this study area.

The GIS concept has assisted that all data (spatial and non-spatial) generated are interconnected within the water supply network and stored in a unique database. This could enable the respective institution involved to plan, manage, and advise the management when and where to drill additional boreholes and as well maintain those that are malfunctioning. Therefore, applying a geographic information system (GIS) will ensure that the management of the water supply network is conducted more efficiently. The designed digital map would help in the sustainable development of water supply to the study area. Therefore, it is expected that for modern societies to be fortified with necessary information regarding the location of the necessary utilities within their immediate environment so as to avoid unnecessary siting of water facilities and to know the possible place to locate one.

5.2 RECOMMENDATION

For the advancement and efficient distribution of potable water within the study area, it is recommended that the authorities saddled with this responsibility should do more in the provision of potable water through siting of boreholes and hand-dug wells with good depth in conformation with the World Health Organization (WHO, 2008), it is recommended that hand dug wells that do not meet the 60 ft depth standard should not be meant for consumption.

For maximum productive boreholes, it is recommended that boreholes should be sited in the areas (points) that have been analyzed and interpreted from the results obtained with at least two or three geophysical survey interpretations, and also, research should be done in the study area to include testing for the quality of the water. Furthermore, the school management should renovate all the existing non-functioning boreholes and taps within the study area while the present water supply should be upgraded regularly because of the rising demand due to the rapid increase in the population of students and staffs most especially in the built-up and clustered areas of the school.

Also, additional boreholes and more tanks (storage) should be made available by the school management at strategic places (sports complexes and mini markets) for better living for the general public. It is also recommended that proper maintenance practice should be carried out periodically so as to prolong the span of the borehole submersible pumps while opened hand dug well that is left open should be covered. It is recommended that the school management should set up a committee to ensure that the sources of water supply are regularly checked to avoid vandalism and that the general public is sensitized on the importance of a healthy water supply. Finally, more research should be carried out on this project using remote sensing and geographic information system (GIS) to update the map of water facilities distribution in the study area.

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