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Analyses Of Domestic Water Supply And Demand Using Geography Information System (GIS) In Boji-Boji Agbor, Delta State Nigeria

Ejemeyovwi, Danny Ochuko.[1] and Ideh Mattew Nkem.[2]

[1](Ph.D) Associate Professor Dept. of Geog, and Regional Planning, Faculty of the Social Sciences, Delta State University Abraka, Delta State, Nigeri.

[2]Dept. of Geog, and Regional Planning, Faculty of the Social Sciences, Delta State University Abraka, Delta State, Nigeri.

Abstract – The research study was conducted in Boji-Boji Agbor, Ika South LGA of Delta State, Nigeria to determine the nature and problems of water resources in the area, sources of water supply, domestic uses of water as well as water supply and demand requirements. The study identified the various sources of water supply and demand, problems associated with water supply, the average quantity of water demand in liters by households and use Geographic Information System (GIS) tool in analyzing supply and demand to suggest ways of solving problems involved in water supply and demand in the area. The study applied the use of questionnaire, interview, observation and GIS data as primary sources of data to the research The names of the bore-hole owners, their address and other sources of water supply were collected to serve as an attribute data which were tied to each location collected with the GPS. Furthermore, the secondary data sources include archival data, existing and published academic works that include journals, internet and online data, etc. The data obtained from 250 questionnaires administered is based on simple random sampling techniques, were validated and tested using two hypotheses vz. i. There is no significant difference in the use of water got from the various water supply sources – River, government bore-hole, private bore-holes, wells and satchet/package water. ii. Supply of water in Boji - Boji Agbor, is not depended on the following factors – water pollution misuse of available facilities, distance, high cost of water, increased demand, inadequate facilities, lack of government water scheme, leakages of pipes, diseases. The result of the study showed that private pump is the major source of water in Boji-Boji-Agbor with most significant usage for domestic use (cooking, bathing, washing, etc). The result of the first hypothesis tested showed that the standardized B Coefficient value for government borehole (0.715), river (0.683), private borehole (0.659), wells (0.639) and sachet /packaged water (0.502) indicates that the model is significant at 0.05 level of significance and that there is a positive correlation between the use of water from the various water sources and water supply in Boji-Boji Agbor. The result of the second hypothesis showed that, water supply to Boji-Boji Agbor is significantly dependent on water pollution, misuse of available facilities, distance, high cost of water, increased demand, inadequate facilities, lack of government water scheme, leakages of pipes and diseases since the R model value of 0.892 is significant at 0.05 level of significance indicating that there is a strong positive relationship between the dependent and independent variables. The study concluded that the level of influence of water demand factors in the area is very high as the variables (water pollution, misuse of available facilities, distance, high cost of water, increased demand, inadequate facilities, lack of government water scheme, leakages of pipes, and diseases) indicates a positive correlation existing between water supply and factors in the area. GIS map for demand and supply of water was also presented. The study recommends that citizens need to be educated on the use of water such that issues of wastage or misuse of government water facilities would be avoided.

Keywords – water resources, sources, domestic uses, water supply and demand, GIS map.

I. INTRODUCTION

According to Sharma (2009) water is an indispensable natural resource of the earth on which all life depend. He proceeded to say that the water will use keeps us cycling endlessly through the environment. Anoop (2017) posited that water is a transparent fluid which form the world's streams, lakes, oceans and rain and is the major constituent of the fluid of living things.In the distant past in Boji - Boji Agbor, it was observed that the inhabitants go as far as Orogodo River to fetch water for their domestic use. There was always traffic of people throughout the day and the river was the only source of water in the area. The situation improved and government established and built water schemes in some positions. More so, few individual invested in boreholes scattered along the streets. The present situation in Boji - Boji Agbor is different and has improved. More wealthy individuals had resorted to bore –hole project in virtually all the streets and so have exploited the situation to make money from the inhabitants who are willing to pay the exhorbitant prices for Water supplies. Only fee inhabitants get connected to government water supplies which are found in few strategic positions.

The researchers applied the tools of Geographic Information System (GIS) in the analysis of the problems encountered in water supply for the domestic and other uses by the people of Boji - Boji Agbor. According to Goodchild (2010), Geographic Information System (GIS) is a system designed to capture, store, manipulate, analyze, manage and present all types of geographical data. GIS has been widely applied in solving water distribution, supply, quality quantity and other related problems. In most developing countries as observed in the study area, the majority of the population does not have access to clean water due to inadequate supply system. As noted by Adeniram and Oyelowo (2013) it is necessary to plan and construct suitable water supply schemes in order to ensure the availability of sufficient water to the various sections of the community in accordance with their demand and requirements.

How far have the various sources of water gone in solving the problems of water supplies in the area? What has the government done in arresting the problem of water supply and utilization in the area? Are private bore-hole owners making any effort at reducing their exhorbitant high prices? Thus, the researchers worked out a panacea to address these questions for desired effects.

1.2 Statement Of The Problem:

The simulation capabilities of GIS and its tools have been utilized by both professionals and researchers in the design operation and improvement to various water network supply systems. The application of GIS tools in the solving and/or optimizing water supply network problems have been reported by Adeniram and Oyelowo (2013), Aderere and Olufemi (2015), and Topos, Ram and Mohammad, (2017).

Water supply is one of the problems that have confronted man since, the establishment of settlements including urban habitation. It has been observed that the inhabitants of Boji - Boji Agbor move (2,3,4) kilometers to get water from Orogodo River and government water sites. They also pay high prices simply to get water from nearby private pumps (bore- holes) for their daily use. Considering the gravity and volume at which the inhabitants fetch water throughout the day, one wonders the various uses to which water is put into in the area. Whether water supply from one source in far used beyond that from other sources is another a yarning hollow. Thus, the struggles and quarrels within and between the inhabitants of Boji-Boji Agbor, so as to get water quicker at the appropriate time, remains a question of worry to the researcher.

Hence, based on these observations and problems, the researcher hopes to investigate into:

The nature of water as resource , sources of water supply, uses of water supplied from the various sources, problems of water supply and app[ication capabilities of ARC GIS Software and other GIS tools in analyzinggata on water supply and demand in Boji - Boji Agbor.

1.3 Aim and objectives of the Study

The aim of this research work is to examine the capability of using Geographic Information System (GIS) in analyzing water supply and demand of Boji-Boji Agbor, Delta The objective of the study include:

i. To identify the sources of water supply and demand in Boji-Boji Agbor.

ii. To identify the problems of water supply in Boji-Boji Agbor.

iii. To identify the average quantity of water in liters demanded by the various households.

iv. To apply GIS to analyze water supply and demined of the area. ang

v. To suggest ways and proffer solutions to the problems of water supply and demand in Boji-Boji Agbor.

1.4 Research Hypotheses:

This research is geared towards investigating into the water supply and demand of Boji - Boji Agbor using the following hypotheses:

i. There is no significant difference in the use of water got from the various water supply sources – River, government bore-hole, private bore-holes, wells and sachet/package water.

ii. Supply of water to Boji - Boji Agbor is not depended on the following factors – water pollution, misuse of available facilities, distance, high cost of water, increased demand, inadequate facilities, lack of government water scheme, leakages of pipes, diseases.

1.5 Significance of the Study:

The research is tailored towards the analysis of water supply and demand of Boji - Boji Agbor. Hence, it would help in the following ways:

The study will unfold the capability of applying GIS in analyzing water supply bearing in mind the source, uses, problems of water supply and management of water as resource. It would help inhabitants of Boji-Boji Agbor as they would be better equipped on how to manage the problem of water supply in their area.

The study would be beneficial to the inhabitants as they would be enlightened on the solutions to problems of getting water from their sources. It would help Ika South Local government council in the planning and execution of water projects in her area of jurisdiction. It will guide the ministry of water resources in the establishment of water schemes in urban centers and finally, It would help future researchers in finding solutions to water supply problems based on GIS format.

1.6 Study Area

1.6.1. Location and size:

Boji - Boji Agbor, is the major urban center in Ika South LGA of Delta State. Boji - Boji Agbor has a “twin sister” – Boji - Boji Owa with the ancient local name “Orogodo”. It is located between latitude 6^{O} $00^{\dagger}$N and 6^{O} $24^{\dagger}$N, longitude 6^{O} $00^{\dagger}$ E and 6^{O} $17^{\dagger}$E of Greenwich meridian as shown in figure 1.1. The area is bounded on the North and West by Edo State, on the South by Ndokwa West Local Government Area and on the East by Aniocha North and Aniocha South LGA. In terms of size, Ika South LGA occupies a land area of about 436 km^2 with population density of 527.8/Km^2 (2016).

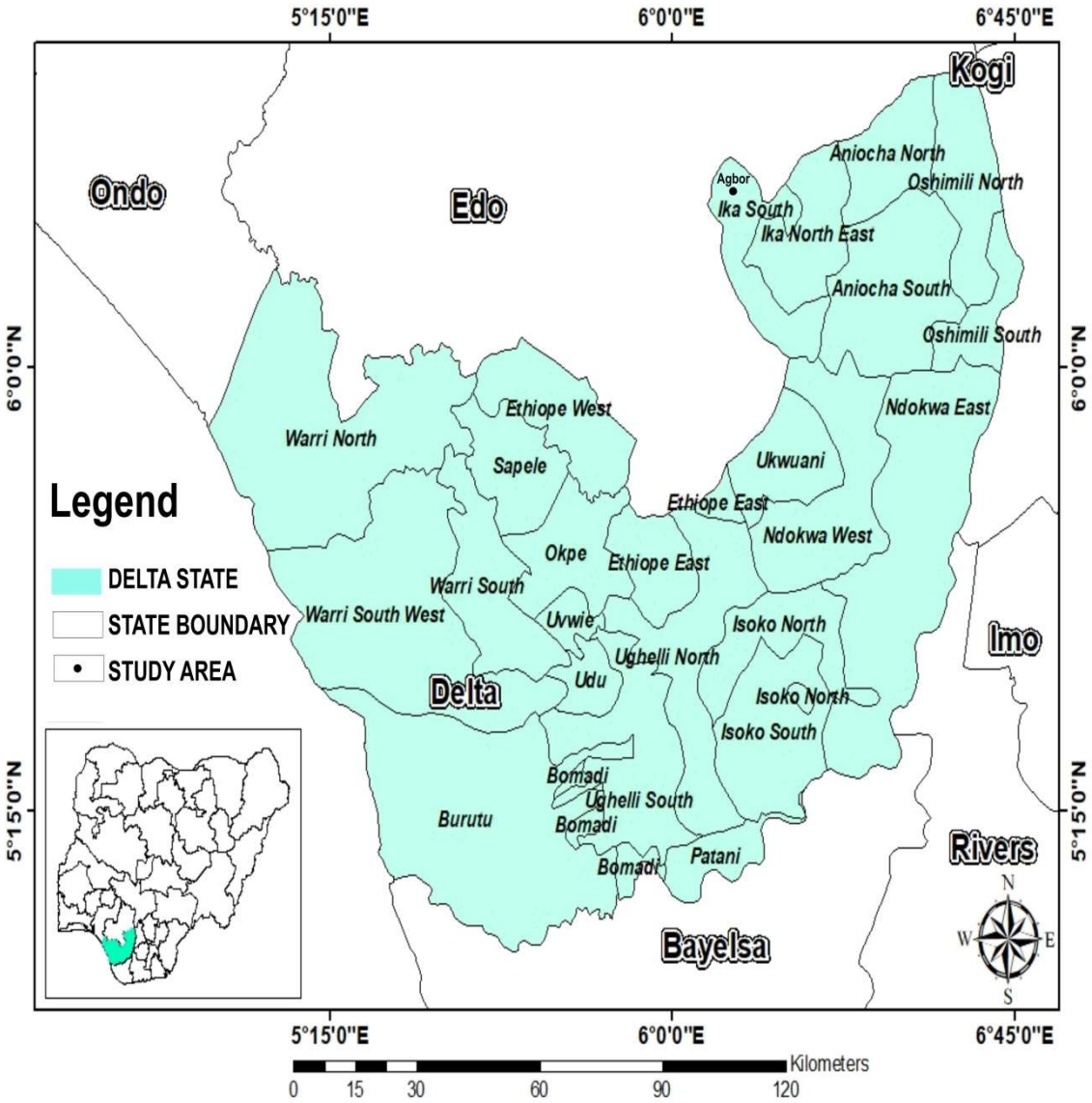

Fig 1.1 Map of Delta State Showing the Study Area

Source: Ministry of Lands, Survey & Urban Development, Asaba, 2005.

1.6.2. Population:

According to the National Population Commission, Asaba, Delta State, IKA South has 167,060 people in 2006 and a projection of 230,100 in 2016. Boji – Boji Agbor has 45,820 people in 1991 ,52,231 in 2006 and a projection of 58,642 in 2016 National Population Commission of Nigeria (Web), National Bureau of Statistics (Web).

1.6.3. Climate:

Boji-Boji Agbor, is in the equatorial climatic belt of Nigeria. It has high temperature of about 27^0C and annual range of 2 – 3^0C as well as high humidity of about 90% with expanded period of wet season between 6 to 8 months (March – September) and 3 to 4 months of dry season (October – January).

1.6.4. Vegetation:

The vegetation of Boji-Boji Agbor consists of secondary vegetation which consists of trees of various species. The trees have ever green leaves though out the year and include mango trees, obeche, orange trees, walnut trees and etc.

1.6.5. Soil Characteristics:

The soil of the area is made of Ferra-soil which are deeply weathered red and yellow wish brown soils with abundant free iron oxides but generally without lateritic iron pan layer. The soil is loamy in nature and rich for agriculture. The soil supports the growth of luxuriant vegetation, arable food crops and intensive market gardening.

1.6.6. Relief and Drainage:

Generally, the terrain of Boji-Boji Agbor is characterized by undulating lowland which descends towards the river. This causes erosion which flows into the river during the raining season. The drainage is made up of Orogodo river which flows southwards in the area and has great potential for vegetable gardening.

1.6.7 Socio Economic Activities:

The study area I of "IKA" speaking tribe of Delta State. They engage in farming, trading, driving, some private office works and government civil service job. The area has daily and periodic market where farm products such as Cassava, yam, plantain, etc. which constitute the items sold in the market.

1.6.8 Water Supply and Demand:

This research submitted to the Department of Geography and Regional Planning, Delta State University, Abraka, Nigeria is designed towards the analysis of domestic water supply and demand using Geographic information System (GIS) in Boji – Boji Agbor, Delta State.

The ARC GIS software and other tools would be applied and use to ex-ray the sources of water supply in the area and the various uses to which water is put to.

The sources of water investigated in the area of study include – Orogodo River, bore-holes. Government and private water outfits, tankers, and packaged water. In the study area, there is still the practice of harvesting rain water for use. The uses of water in the area include domestic- bathing, washing, drinking etc, for recreation, a lot of swimming pools, for irrigation especially along, Orogodo river and for individual purposes in companies and building houses for the mixture of cement.

1.7 Scope Of The Study:

This dissertation was designed to cover Boji-Boji Agbor, Ika South Local Government Area of Delta State. It was designed to apply Geographic Information System (GIS) in the analysis of domestic water supply and demand in the area which includes Orogodo river, government water scheme - water board, private bore-holes, wells, rain water and package water [commonly called pure water].

The researcher investigated the problems of the people getting water for their daily usage. Information was x-ray the problem stems from the inhabitant utilization of water gotent from the various supplies in the area and the studies also address why most of the inhabitants move long distances, as far as Orogodo river to fetch water and others prefer paying exorbitant prices for nearby water supplies from private bore-holes.

1.8 limitation of the study:

This research was faced with a number of constraints which include the following:

The work is limited by the fact that information regarding the water supply network under investigation was not easily gotten from the inhabitants of the area. This is due to the fact that sampling method used only covered a given representative of the population. There are limitations due to the fact that the researchers did not cover all the streets of Boji-Boji Agbor, and therefore the surrounding environments. Such areas as Alihame, Ime-obi were not visited due to their inaccessibility. Thus we could not actually ascertain why the remote people from these area does not go far into Orogodo to get water. Should it be that their water supplies are now surficient. The researchers were unable to ascertain the extent of damage done to Orogodo river, the common and major source of water supplies in the area. This is based on the fact that the river is always flooded and filled with debris during rainy season of the year. Limitation due to the fact that the high cost of government water schemes in the area as well as those of private bore-holes information could not be reviewed on such issues and therefore, were not known. Finally, GIS is a new paradigm shift to the people in the study area and so the relationships and of concerns water supply with GIS is a yarning hollow.

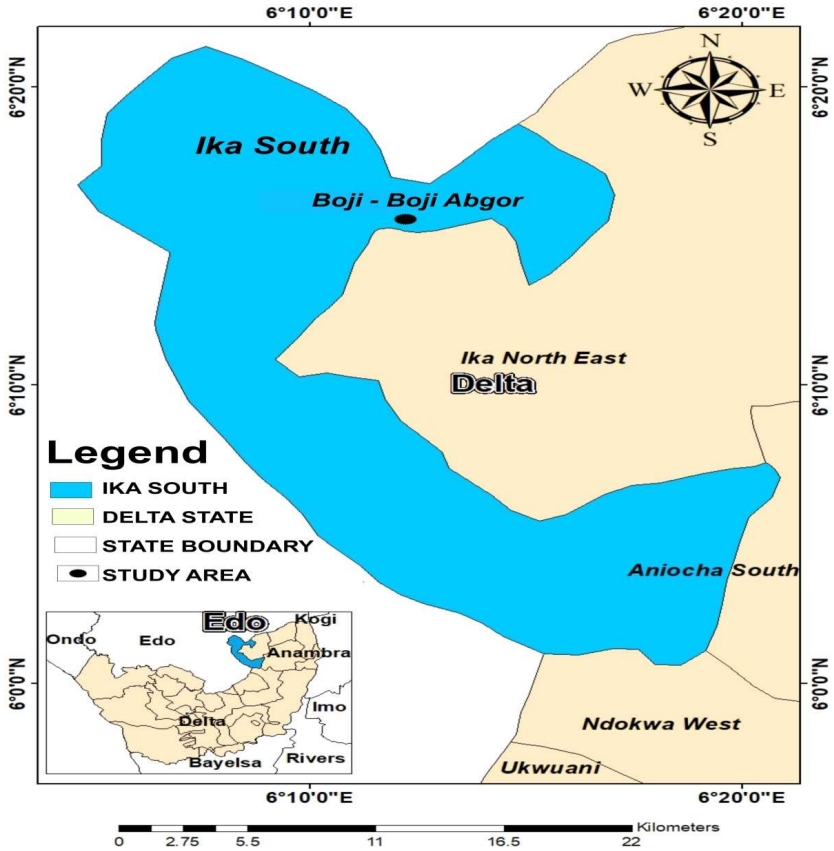

Fig 1.1: Map of Ika South Showing the Study Area.

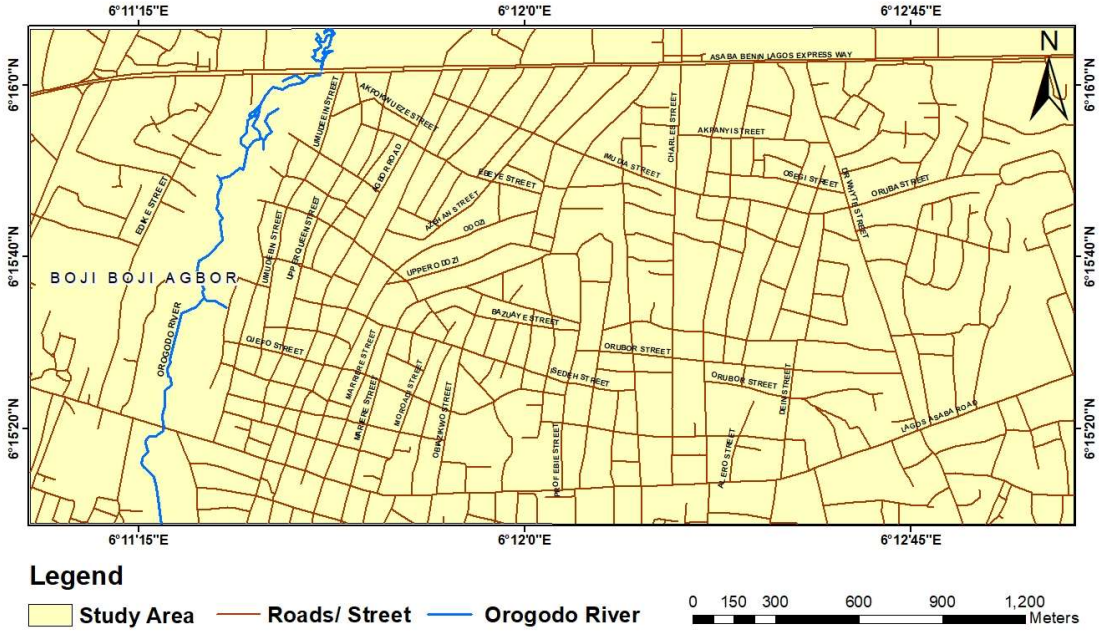

Fig .2: Road Network Map of Boji – Boji Agbor

Source: Researcher (2020).

II. Conceptual Framework And Literature Review

This chapter is devoted to presents adopted concepts in this research work and review of related literature on using GIS in analysis of Domestic Water Supply and Demand in Boji – Boji Agbor, Ika South Local Government area of Delta State.

2.1. Conceptual Framework

The research work essentially border on using Geographic Information System (GIS) for analysis of Domestic Water Supply and Demand in Boji –Boji Agbor. Hence, the work is based on the following concepts and parameters as presented in the form:

i. Hydrological Cycle (Water Cycle)

ii. Water Supply and Demand

iii. Geographic Information System (GIS) Analysis of Water Supply and Demand and Spatial Data Models in GIS.

2.1.1 Hydrological Cycle (Water Cycle)

The hydrological or water cycle is defined as the ceaseless movement of water by evaporation into the atmosphere: by mass transportation as a vapour component of the atmosphere, by precipitation on land and sea, by movement into the grand to become soil moisture and grand water; by runoff in rive from land and sea; by discharge of grand water to rivers and lakes and directly to the seas from glaciers and ice caps (Oyebande, 1998). See the diagram below:

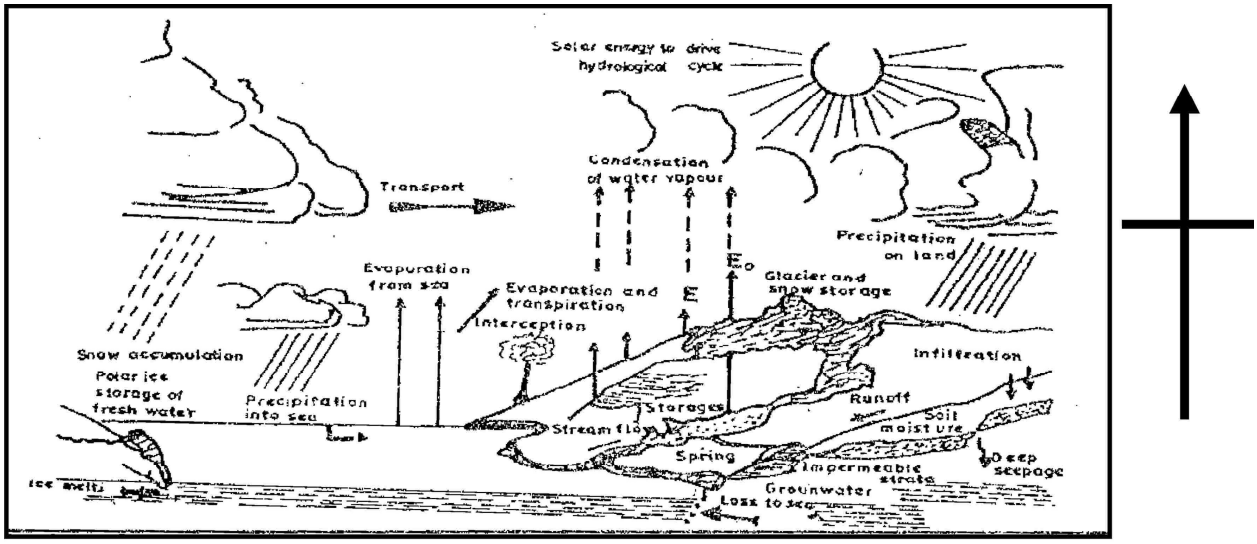

Fig 2.1. The hydrologic cycle.
source: Oyebande, (1998).

Fig. 2.1: The Hydrological Cycle or Water Cycle

In the study area is within the tropical equatorial rain forest belt with prevailiing processes of Evaporation, movements, condemnation, and precipitation, surface and underground run – off and percolation involved. Water is in constant flow between hydrosphere and lithosphere and this is known as hydrological cycle or water cycle. In their contibutions, Raul, Roshan, George and Amando (1990) explained the hydrological cycle as water in nature is constantly on the move as shown in figure 2.1. This is based on the formast that involve the envitronmental processes of precipitation, evaporation, sublimation, transportation and groundwater flow..

2.1.2 Water Supply and Demand

According to Raul (1990), it is necessary to plan and construct suitable water supply schemes in order to ensure the availability of sufficient quantity to the various section of the community in accordance with their demand requirements**.** The sources of water as

presented by Tripathy and Panda (2001) include: Rain water,, River and stream water ,Spring water, Well and Pond water, Lake water, Sea water and Sub – surface or groundwater,Thus, detailed perspectives were presented by Walmsly and Pearce (2011) and Mund (2014) that exrayed the following sources of water;

a. Surface Water – This is water which is not closed to atmosphere and outcomes from overland terrain flow. Examples of surface water according to them ar streams or rivers, sea or ocean water and natural lakes

b. Groundwater – This is water found below the earth's crust in water bury rocks (Aquifer) and are not more than 2500 feet below the earth's crust. Springs and wells emanated from this source of water supply.

Other sources of water according to these modern writers are the hydrological cycle and rain water. The hydrological cycle has been described earlier under the conceptual framework.The descriptions of the sources of water as put forward by these writers are as follows;

i. **Streams or Rivers:**

Streams are the arteries of natural drainage on the earth surface – the major channels of surface water flows toward lower levels of land (Walsly and Pearce, 2010). As these authors posit it, streams vary greatly in size and length, from small tributaries to broad, full flowing rivers. They further analyzed that where landmasses and drainage basins are large and precipitation is abundant, streams of all sizes are numerous and permanent; where drainage basins are small and especially where precipitation is meager, streams are often small and intermittent.

On their part, Mund (2014) agreed with Grafton and Hussey (2011) that rivers are fed by the rain water falling down on the earth's surface. The rain water while passing over the surface towards rivers get a number of soluble and insoluble impurities or pollutants.

i. **Sea or Ocean Water:**

Mund (2014) asserted that sea and ocean water is the largest source of natural water available on the surface of the earth. It is saline to taste.

ii. **Ground waters of the lands:**

Grafton and Hussey (2011) as greed with Tripathy and Panda (2001) of the widespread surface waters of the earth's land area, large amounts are continually sinking into the upper parts of the earth's crust to form ground water. They went further to say that although, not usually visible, these underground waters are as important as surface waters, both in the physical processes of the environment and in serviceability to man.

As Grafton and Hussey (2011) explained, there is a section of the upper part of the earth's crust illustrating the zone of saturation, the water table, the relationship of the water table to the land – surface and some possible developments of lakes, swamps, springs and wells. As water moves downward from the surface it fills the spaces between the soil particles and the crevices and cracks of bedrock as far down as they penetrate into the earth's crust. The zone in which all such spaces and cracks are filled is called the zone of saturation and its top level is known as the water table.

iii. **Springs and Ponds**

In their book titled "Fundamentals of Environmental Studies" Tripathy and Panda (2001) explained that out of the total rainfall, a huge quantity of water moves down into the under surface of earth till it reaches the impervous rock structure which prevents it from proceeding still downward. Due to some changes in the internal structure of the earth, sometimes the water oozes out from the soil strata in the form of springs.

The spring water is clear and transparent because it is devoid of any suspended impurities. However, it may contain many soluble impurities like salts of sodium, Calcium etc. (Grafton and Hussey, 2011).

On ponds, Mund, (2014) have this to say "Wells are simply holes that extend below the water table so that ground water may be brought to the surface through them". Most ponds today according to them are either driven or drilled.

vi. Rain Water: According to Sharma (2009) rain water is obtained in the purest form in the absence of air pollutants. He posited that the rain water is obtained by the process like evaporation, condensation and precipitation. In the presence of solar

radiation, water present on the surfaces of the earth undergoes evaporation. The water vapour rose up to the higher attitude where these condensed forming clouds. These clouds, which further cooled, precipitate on the earth as rain (Sharma, 2009).

On Water Demand, it is basically for Domestic and Industrial uses. However Sharma (2009) stated that water is needed daily by organisms, for irrigation, navigation, industrial use, electricity production and domestic use. Anoop (2017) posited that water demand is for the following uses; Drinking, Washing, Chemical use – (Used in chemical reactions as a solvent or reactant and less commonly as a solute or catalyst).,Heat Exchange – (Its high heat capacity both for cooling and heating),.Fire Extinction – (A good fire extinguishing fluid), Recreation, Water industry – (Drinking packaged water and waste water services e.g sewage treatments).,Industrial Applications and Food processing

On the other hand, Asthana and Asthana (2012) agreed with Egboh (2010) on the following uses of water:Domestic uses,Irrigation, Power generations, Floatability (Timber log transportation), Navigation,Political use, Social use

They went further to exray six different categories of uses or needs as follows, Public water supply, Fresh water fisheries, Marine fisheries and wide – life,Industrial water supply, Agricultural water supply, Recreation and aesthetic enjoyment.

More so, George et al (2016) summarized the uses of water in the following ways:

(a) Domestic Purposes:include Cooking, Drinking, Bathing and Washing

(b) Agricultural Purposes are Irrigation, Farming, gardening and Fisheries

c. Industrial Purposes include Manufacturing , Recreation, Swimming, Rafting and Boating

d. Hydro – Power Generation (For the generation of electricity projects)

Tripathy and Panda (2001) said that water is used for body cleaning and washing of clothes and household utensils. It is absolutely necessary for agriculture without which production of food will not be possible.

2.1.3 Geographic Information System (GIS) Analysis of Water Supply and Demand

Geographic Information system (GIS) is a tool for solving water problems and is used as array of computer hardware and software for manipulation, storing, analyzing, modulating, modeling and displaying of geographically referenced data for solving complex human related problems (Seyi Fabiyi, 2001). This suggests that GIS is neither the software nor the hardware, neither is it the procedure to solve problems nor the expertise, but a good integration of the different components of GIS.

Ejemeyovwi (2015) quoting Kermering (1994) stated that GIS involve the use of array of computer hardware and software, for the purpose of data collection, storage, structuring, manipulating, analyzing and visualizing spatial data referenced by geographic coordinates. According to him, these tools can be adopted by water resource managers to effectively plan and predict future availability of sources of water supply and demand.. Goodchild (2010) defined GIS as a system designed to capture, store, manipulate, analyze, manage and present all types of geographical data. He further explained that the key word to this technology is geography – this means that some portion of the data is spatial. In other words, data that is in some way referenced to locations on the earth. Spatial or Thematic data are usually presented in tabular form, known as attribute data. Attribute data can be generally defined as additional information about each of the spatial features. It is the partnership of these two data types that enable GIS to be such an effective problem solving tool through spatial analysis. GIS is just more than software. People and methods are combined with geospatial software and tools to enable spatial analysis, manage large data sets and display same in geographical form (Goodchild, 2010).

Furthermore, Ayoade (2015) stated it to be Geographical Information System “GIS” and is basically a computer – assisted system for the capture, storage, retriever, analysis and display of geo – referenced or spatial data. He went further to analyze that GIS can be regarded as part of a larger discipline of GEO – INFORMATICS or GEOMATICS, broadly considered in the science and technology dealing with the structure and character of all aspects of spatial information or geo information, their acquisition, storage, processing, analysis, production, presentation and dissemination (Ayoade, 2015).

2.1.4 Spatial Data Models in GIS

Conversion of real world geographical variation into discrete objects is done through data models. It represents the linkage between the real world domain of geographic data and computer representation of these features. Information in a GIS are the vector

data model and the raster data model. These data models are used for encoding, storing, analyzing and displaying spatial data (Fabiyi, 2001).

i. **Vector Mode:**

A typical vector model represents the features the way they are in reality. The vector data records spatial information as X, Y coordinates in a rectangular (planar) coordinates system. Vector data is well suited reading the locations of discrete geographical features with precise location like street, parcel boundaries, streams and telephone poles. A typical data is made up of series of arc nodes and vertexes. Features that can be captured as points are represented by nodes that have no direction with specific coordinates X, Y and Z. line features are captured as series of modes connected by arcs. Area features are captured as series of nodes connected by arcs and the starting node or the first node shares the same location with the first or the ending nodes. In other words, the line that closes represents an area feature (Fabiyi, 2001).

ii. **Raster Model**

Raster data model record spatial information in a regular grid or matrix organized as a set of rows and columns (Fabiyi 2001). Each cell within this grid contains a number representing a particular geographical feature such as soil type, elevation, land use and slope. Raster data represents information in image form in which each cell or picture element (pixel) stores value recorded by an optical or electronic device.

III. Literature Review

This study presents the review of related literature on using GIS in the analysis of Domestic Water Supply and Demand in Boji –Boji Agbor. This is carried out under the following sub – headings: The form and nature of water resources, problems of water supply sand Application of GIS in water Resource Management.3

3.1 The Form and Nature of Water Resources

Water is an indispensable natural resource of this earth on which all life depend (Sharma, 2009). Furthermore, he stated that water used keeps cycling endlessly through the environment. In this manner, it is a resource basic for the sustenance of life within the physical environment. Anoop (2007) posited that water is a transparent fluid which forms the world's streams, lakes, oceans and rain, and is the major constituent of the fluid living things. Also it is a chemical compound. Water molecule is made of one oxygen and two hydrogen atoms that are connected by covalent bonds. Moreso, Efe (2003) has this to say "Water is fundamental in the existence of any living community. This is because the numerous human based activities all requires water input". Considering this statement, the fundamental nature of water cannot be over emphasized; it is vital for the existence of both plants and animals in their communities. Water is transparent, tasteless, odourless and nearly colourless chemical substance, which is the main constituent of earth's streams, lakes and oceans and the fluids of most living organisms (Barom, Cenci, Tettamani and Beram, 2007). They further explained that water is made up of billions of molecules. That each molecule is made of one oxygen and two hydrogen atoms held together by strong covalent bonds. Water is found in three different states on earth; namely gas, solid and liquid. In their contributions, Reece Jane (2013) agreed that water is a polar inorganic compound that is at room temperature a tasteless and odourless liquid which is nearly colourless apart from an inherent hint of blue and argued that, water is by far the most studied chemical compound and is described as the "Universal Solvent" and the "Solvent of life" (Reece Jane, 2013). It is the most abundant substance on earth and the only common substance to exist as solid, liquid and gas on earth's surface.

Again, water is a natural resource of fundamental importance. Without water, life is not possible says Asthana and Asthana (2012). On the same platform, Charles and Verma (2010) posited that water can exist in three phases; liquid, solid and gaseous stating that hydrogen and oxygen atoms form water molecule (H_2O). Furthering that being a universal solvent is enriched with a wide spectrum of various substances and varies greatly in its chemical composition.

Water is therefore one of the most important substances in nature for the maintenance of life. It is called "a primary source of all that exist". It is one of the most astonishing compounds on earth and even now has not yet been fully deciphered. It is characterized by a complex of anomalous properties that make it very different from other substances (Gleick and Palamappan, 2010).

3.2. Application of GIS in Water Resource Management

GIS has great potential in water management and applied in many places experiencing water distribution and supply problems. Some of them are discussed below viz;

Adeniran and Oyelowo (2013) carried out a research on EPANET analysis of water distribution network of the University of Lagos, Nigeria". They observed a gap between the current water supply and the water demand in the University. They applied EPANET GIS software for water supply network. The analysis of the existing water distribution showed a rather inefficient network which is the reason for lack of water supply to most parts of the University (Ademiran and Oyelowo, 2013). Arjun, Kankesh, Neha, Esheta, Mhum, Virck, Sharma and Neeruj (2015) did a research on Kathgarh village titled a design of water distribution system using EPANET program that perform extended period simulation of hydraulic and water quality behaviour within pressurized pipe networks. A network consists of pipes, nodes (pipe junctions), pumps, valves and storage tanks or reservoirs. EPANET was used to track the flow of water in each pipe, the pressure at each node, the height of water in each tank and the concentration of a chemical species throughout the network during a simulation period comprised of multiple time. The researchers adopted sampling program design, hydraulic model calibration, chlorine residual analysis and consumer exposure assessment. The software was used to assess alternative management strategies for improving water quality in the system. The results were presented in a variety of formats-colour coded network map, data tables, time series graphs and contour plots.

Moreso, Okwere, Hart, and Jackson (2015) carried out a research on mapping the spatial distribution of water borehole facilities in Bori and part of Port –Harcourt in Rivers using Geographical Information Systems (GIS) Techniques. The Spatial Information of the water borehole facilities where determined using hand-held GPS equipment in addition to their attribute data. The data generated was analyzed using Geographical Information System Application Arc GIS10.1 Software. In the same vain, Tapos, Rain, and Mohammad (2017) carried out a research on the analysis of water quality in urban water supply system of Bangladesh. Some concern chemical, biological and physical parameters were tested for an initial assessment of the water quality of the source water samples collected from nine production well of the area (Pourashava) water supply system indicated a high concentration of the arsenic , iron and in the production of well water. In the whole, urban water supply system in Bangladesh is not satisfactory because it posses human risk. It was therefore suggested as management tool that, government should take necessary steps to reduce the risk of supply of contaminated water (Tapos et al (2017). Adelere and Olufemi (2015) in their research on water supply scheme of University of Ibadan, developed a model captioned Strategic Planning for Municipal Water Supply Scheme Using System Dynamics. The model is a useful tool to assist water management and policy makers in making decisions and evolving strategic planning for water supply. In SPMWS model, DYNAMO, FORTRAN, CLIPPER 5 and EPIGLUE environment. The model was validated using existing data for the period of (10) year water supply scheme. The model is found useful to managers and planners for water supply scheme.

3.3 Justification for use of Arc GIS Software

Arc GIS is a geographic information system (**GIS**) software for working with maps and geographic information maintained by the Environmental Systems Research Institute (ESRI). It is used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering geographic information, using maps and geographic information in a range of applications, and managing geographic information in a database.

Arc GIS, part of the ESRI Geospatial Cloud, is the world's most powerful mapping and spatial analytics software. It is used by 90 of the Fortune 100 and half of the Fortune 500 brands for advanced analytics. ESRI invests heavily in research and development to provide innovative solutions that integrate cutting-edge data science methods.

It has also been used by several researchers for analysis involving water demand and supply in Nigeria such as; Anwuri O. Okwere and Lawrence Hart et al (2015), Mapping the Spatial Distribution of Water Borehole Facilities in Rivers State Using GIS

Arc GIS provides contextual tools for mapping and spatial reasoning so you can explore data & share location-based insights. The software offers unique capabilities and flexible licensing for applying location-based analytics to your work. It also enables teamwork projects by giving users ability to create, use, and share maps on any device.

The Arc GIS software provides the toolset you need to expose patterns, relationships, anomalies, and incidents in massive amounts of spatial data, regardless of format and source. It can be used stand-alone or in combination to support field workflows such as GPS devices thereby enabling office and field personnel to work in unison, using the same authoritative data.

Because of its versatility, ease of operation and analytical capabilities ArcGIS is used across border by researchers and professionals in all fields of study including that cutting across various water analysis. The maps produced help users spot spatial patterns in their data so they can make better decisions and take action.

Adeniran and Oyewolo (2013) like other researchers – Ajur et al (2015), Tapos (2017) and Adelere and Olufemi (2015) reviewed, on water distribution/supply network analysis. These researchers based their study on a single GIS tool Environmental Protection Agency Network (EPANET) – A GIS simulation software. Their studies were based on a particular source of water; water pipe distribution of bore - hole with overhead tanks. The other sources of water such as river, rain – water, well, tankers, packaged water, etc. were not mentioned or considered in the discussion. In the same way, on the uses of water, the researchers based their findings on population demand, fire demand and unaccounted for water. The specific uses of the population's demand for water were not mentioned. These may include domestic use for bathing, drinking, washing etc, for agriculture, industrial, among others.

IV. Research Methods

This section presents step by step procedures used in conducting this study. This facilitates the researcher's evaluation of the findings and conclusions of the study. The details are discussed in the following sub-headings:

i. Research Design
ii. Types and Sources of Data
iii. Sampling Framework
iv. Validity and Reliability of Research Instrument
v. Method of Data Collection
vi. Method of Data Analysis

4.1 Research Design

In this study, the survey design technique was used. Therefore questionnaires were administered to collect relevant information needed for the research and reconnaissance visit were made to the study area for proper evaluation of the selected zones of the area.

The descriptive research method will also be adopted in this study. This will enable the researcher in collecting meaningful information in describing the multiple sources of water supply, water demand, and the problems associated with water supply in the area. This will enable the researcher proffer solution to the problem of water supply in the area.

4.2 Types and Sources of Data

The sources of data for the study are the primary and secondary data.

4.2.1 Primary Sources:

Primary data were collected via questionnaire and field survey. The primary data were obtained through the use of questionnaire and administered to the inhabitants of Boji-Boji Agbor. were also carried out to obtain the coordinate positions of the proposed sources of water supply under investigation, from which spatial and attribute data were deduced. Spatial data shows the precise geometric location of features in space, which are the Easting (X) and northing (Y) coordinate of water sources. The geometric data acquisition was carried out using the hand held Global Positioning System (G.P.S). A handheld GPS is a navigational system involving satellites and computers that can determine the latitude and longitude of a receiver on Earth by computing the time difference for signals from different satellites to reach the receiver, The system is based on a constellation of twenty – four (24) satellites which are orbiting the earth at an altitude of 20,000 km. The satellites act as reference points which positions in space relative to the earth's surface are precisely captured. The names of the bore-hole owners, their address and other sources of water supply were collected to serve as an attribute data which were tied to each location collected with the GPS.

The Questionnaire Survey: The questions in the questionnaire are the close-ended type in which the respondents are required to give their responses based on alternatives. The inhabitants of Boji- Boji Agbor gave their response on the sources of water found in

the area, water demand in the area, the problems associated with water supply, the nature of water supply, the size of family house-holds, quantity of water used and the measure taken to make water more available to the said community.

Field Observation from Global Positioning System (GPS): The German handheld GPS (Astro 320 Model) was used to geo-reference the sources of water supply in the area. This was used for analysis with the ARC GIS software.

4.2.2 Secondary Sources:

Secondary data were collected via textbooks, newspapers, journals, magazines, internet, seminar papers and documented maps from ministry of lands, survey and urban development and water board. Secondary data were collected from the Delta State University Main Library-Abraka as well as the internet to compliment the information obtained from both the questionnaire and the field observation methods. Information derived includes water board records of the number of government bore-holes and the number of private bore-hole owners registered with it. The political map of the Delta State was collected from the ministry of lands, surveys and urban development, Asaba as well as map of Ika South L.G.A showing the study area. The population data of the Local Government Area was also collected via the internet based on the information relayed from the National Population Commission (NPC) Asaba.

4.3 Sampling Framework

The population of the research is conveniently put in two phases- phase 1, comprises all the inhabitants of Boji - Boji Agbor while phase 2, comprises of all the sources of water available in the area which includes, Orogodo River, Government water scheme, private bore – holes, local wells, rain water and packaged water.

The area of study was stratified into four zones based on sources of water and water used/demand of the area. A simple random selection of twenty five (25) inhabitants from each zone was chosen and these were interviewed based on the questionnaire (see the table below:

Table 3.1: Sample Size showing water Supplies and Demand in Boji-Boji Agbor Zone

Zone	Location/site	Sources of water supply	Water demand	No of questionnaires administered
A	Uromi road through police station, Edike Street to Okoh Street.	Orogodo river, private bore holes, package water	Domestic Agriculture, industrial	63
B	From Okoh street through Baleke, Odozi to Mariere street	Private bore holes, government bore hole, local wells, water tanks and package water	Domestic Industrial Easthetic	63
C	From Mariere street through Prof. Ebie street through Odeh, Abude to Okumidgbe street to Dr. white street	Government pump, private bore holes, wells, water tankers, package water.	Domestic Industrial Easthetic	62
D	From Dr. white street through DDPA via Elimcasy Hotel area to G.R.A	Private bore holes, wells water tanks and package water.	Domestic Industrial Agriculture, Easthetic	62
	Total			**250**

Source: Researcher's Fieldwork, (2020)

A total of 250 questionnaires were administered in the study area which was based on the selection of 63 and 62 persons from each zone respectively. The questionnaire was administered to every first head or Landlord of every 15th house-hold. The respondents were chosen using the systematic sampling technique and the Taro Yamane (1964) sampling formular.

4.4 Methods of Data Collection

Data collection methods used by the researcher in this study include the following means:

4.4.1 Interview: The inhabitants of the area sampled from the entire population were interviewed on the sources of water and water demand in the area. They gave their response through vivid discussions of the sources of water supply and water demand as well as the underlined problems.

4.4.2 Observation: The researcher has seen it a life reality through constant visit to the area during the period of study. This was based on sight investigation of the water facilities available in Boji-Boji Agbor. Appropriate data was collected and analysis made on the respective problems under investigation.

4.4.3 Questionnaire Administration: Information on water supply and water demand and the associated problems were got from the inhabitants of Boji-Boji Agbor based on the prepared questionnaire. The data x-rayed from the questionnaire include the sources of water, water demand, the nature of water supply in the area, the problems of the water supply in the area, size of family house-holds, quantity of water used and measures taken to solve the problem of water supply in the area.

Boji-Boji, Agbor was divided into four (4) zones – A, B,C and D as shown under the sampling technique. A total of 250 questions were administered and this was based on a systematic random selection of 63 and 62 persons from each zone respectively. An average of 15 persons was selected from each street from which questionnaire was administered to them. The respondents were approached in a friendly manner and after explaining the purpose of the study to them they willingly accepted to complete the survey.

4.5 Validity and Reliability of Research Instrument

A protest on the questionnaire, administration of the questionnaire and post – test on the questionnaire showed comprehensive and reliable result of the problem under investigation. It yielded the same result and information. The information got from the questionnaire, interview, observation and GPS are relevant to the study. The inhabitants provided information regarding water supply and demand in the area and the associated problems.

The study instrument- interview, observation, GPS and questionnaire administration cover the entire area of Boji-Boji Agbor in a systematic random selection of 25 inhabitants from each zone who were not part of the sampled population. All the sources of water in the area-Orogodo River, government boreholes, private bore holes, local wells, water tanks and packaged water were visited for sight observation without any bias.

The instrument were subjected to further analysis using the PPMCC correlation analysis to test the relationship existing between the variables and the result of the reliability test placed at 0.83 shows that a strong positive relationship exists indicating that the instrument measured is valid and reliable.

4.6 Method of Data Analysis

The following method of data analysis were adopted in this study.

i. Compilation of result from questionnaire
ii. Plotting of Geospatial Data
iii. Delineation of water supply map using plotted data
iv. Creation of water demand map using Analytical Hierarchy Process and Multi Criteria Analysis.

4.6.1 Compilation of result from questionnaire:

The result from the questionnaire would be collated and used to determine the major sources of water to the people in the various zones and their various domestic uses. The problems of water supply as well as their gravity would also be deduced from the answers given in the questionnaire. Based on the questions from daily water consumption, the questionnaire would also be used to estimate water demand in the various zones as well as the quantity of water supplied based on the **GEEPEE** water tank. The questionnaire also takes into account the factors that would be considered in determining the amount of water demanded in the area

as well as its level of importance. The answers resolved from the questionnaire would be very useful in proffering solutions to problems regarding water supply and demand in Boji-Boji Agbor.

4.6.2 Plotting of geospatial data:

The data obtained using the **GPS** device from the field observation indicating the longitude and latitude was inputed into **Arc GIS** and environment and plotted on a map. The data provides the **geospatial** location of the major sources of water supply in the various zones in the location sites and zones to give access to the density of water supply in the zones and is represented as point data on a map.

4.6.3 Delineation of water supply map using plotted data:

The plotted data was used to create a water supply map. The map showed clearly the areas with higher volume of water supply sources as well as lower volume sources. This was done using the **Interpolation and classification** on **Arc GIS** to show the nature of water supply from various sources. The output map from this process showed the water supply analysis for Boji-Boji Agbor.

4.6.4 Creation of water demand map using analytical hierarchy process (AHP) and multi criteria analysis:

AHP is one of the main mathematical models currently available to support the decision theory (Thomas, 1970). The **analytic hierarchy process** (**AHP**) is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It was developed by Thomas L. Saaty in the 1970s partnered with Ernest Forman to develop Expert Choice in 1983, and has been studied extensively and refined since then. It represents an accurate approach for quantifying the weights of decision criteria. Individual experiences are utilized to estimate the relative magnitudes of factors through pair-wise comparisons. Each of the respondents compared the relative importance between the two items under special design. In addition, the AHP incorporates a useful technique for checking the consistency of the decision maker's evaluations, thus reducing the bias in the decision making process.

Multi-Criteria Decision Analysis or **MCDA** as developed and maintained by Environmental System Research Institute, is a valuable tool that we can apply to many complex decisions (Saaty, 1970). It is most applicable to solving problems that are characterized as a choice among alternatives. It has all the characteristics of a useful decision support tool: It helped us to focus on what is important, is logical and consistent, and is easy to use. At its core MCDA is useful for:

- Dividing the decision into smaller, more understandable parts,
- Analyzing each part, and
- Integrating the parts to produce a meaningful solution

In essence, three factors were considered in the questionnaire, which are; population, Land Use and Distance from source of water supply. The questionnaire provided the hierarchy to determine the weight or importance of each factor. Based on the result, maps was be plotted for each factor with consideration and calculation of the **consistency ratio** on **Microsoft Excel**. These maps would be classified into five classes each and put into the **Arc GIS**. The result from this process determines the water demand based on those criteria used in water Demand Analysis map

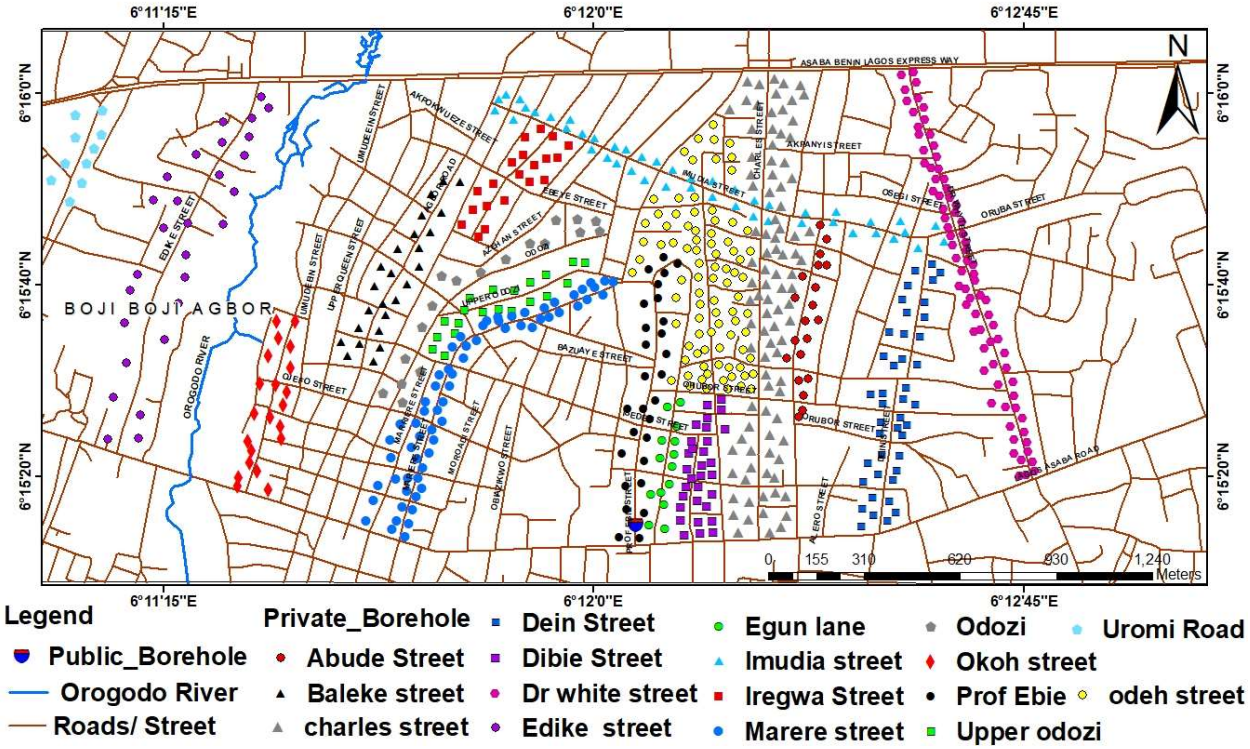

Fig 3.1 Sketch map of Boji – Boji Agbor showing the borehole Locations

Source: Researcher's Fieldwork (2020).

4.7 Test Of Hypotheses

The first hypothesis was tested using T-Test statistical technique while the second hypothesis was tested using regression analysis. These techniques have been applied by Sharma (2009), Oyelowo (2013) and Anoop (2017) in analyzing the impact of water supply and demand on residents areas in Nigerian Cities.

V. Data Presentation And Analysis

5.1 Data Presentation and Analysis

Data required for this research study was obtained and analyzed below. Statistical graphs were plotted to represent the relevant data of the questionnaire. Hypotheses formulated were tested using appropriate statistical tool with the aid of Statistical Package for the Social Sciences (SPSS, version 21). The Analytical Hierarchy Process was also calculated on MS Excel to determine the level of importance or weight of the factors required to create the water demand map and GIS techniques was also employed to produce spatial analysis map showing the spatial distribution points and sources of domestic water supply in the study area. Other data collected include the ground truth data presented as evidence to substantiate the research work.

5.2 Questionnaire Administration

The information obtained from the administration of questionnaire in the area are presented in tables, percentages and graphs below.

Table 4.1: Questionnaire administration in the area

Zone	Sampled Location	No of questionnaires administered	No of questionnaires retrieved
A	Uromi road through police station, Edike Street to Okoh Street.	63	50
B	From Okoh street through Baleke, Odozi to Mariere street	63	58
C	From Mariere street through Prof. Ebie street through Odeh, Abude to Okumidgbe street to Dr. white street	62	49
D	From Dr. white street through DDPA via Elimcasy Hotel area to G.R.A	62	43
	Total	**250**	**200**

Source: Fieldwork, 2020

Table 4.1 shows the distribution of questionnaire in Boji-Boji Agbor. Out of the 250 questionnaires administered in the area (Zones A-63, B-63, C-62, and D-62), only 200 copies of the administered questionnaires were returned after two weeks of their administration. The 200 questionnaires retrieved from the 250 questionnaires administered to the respondents in Zone A (Uromi road through police station, Edike Street to Okoh Street), Zone B (from Okoh street through Baleke, Odozi to Mariere street), Zone C (From Mariere street through Prof. Ebie street through Odeh, Abude to Okumidgbe street to Dr. white street), and Zone D (from Dr. white street through DDPA via Elimcasy Hotel area to G.R.A) are depicted in Fig 4.1 below;

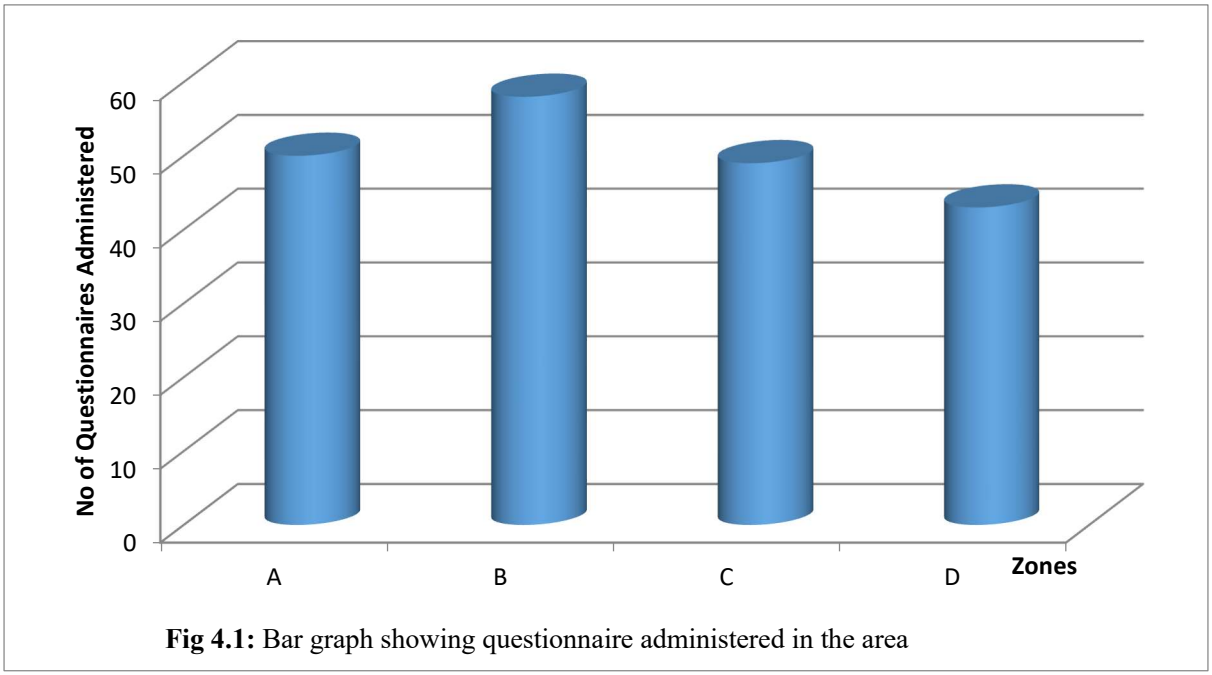

Fig 4.1: Bar graph showing questionnaire administered in the area

Table 4.2: Household size

Household size		**Frequency**	**Percentages (%)**
Under 3		48	24
4-6		86	43
7-10		42	21
Above 10		24	12
Total		**200**	**100**

Source: Fieldwork, 2020

Table 4.2 showed that 24% of the respondents have household size of under 3, 43% have 4-6 household size, 21% have 7-10 household size and 12% have household size of above 10 persons per dwelling unit. This implies that majority of the respondents have large household size.

5.3 Sources of Water Supply in Boji-Boji Agbor

Table 4.3: Sources of Domestic Water Supply and Water Demand

		DOMESTIC USES OF WATER					
S/N	**Sources**	**Washing**	**%**	**Bathing**	**%**	**Cooking**	**%**
I	River	46	23	42	21	112	56
Ii	Government pump	56	28	72	36	72	36
Iii	Private pump	114	57	58	29	28	14
Iv	Rain water	88	44	42	21	70	35
V	Local well	56	28	38	19	94	47
Vi	Packaged water	0	0	22	11	178	89

Source: Fieldwork, 2020

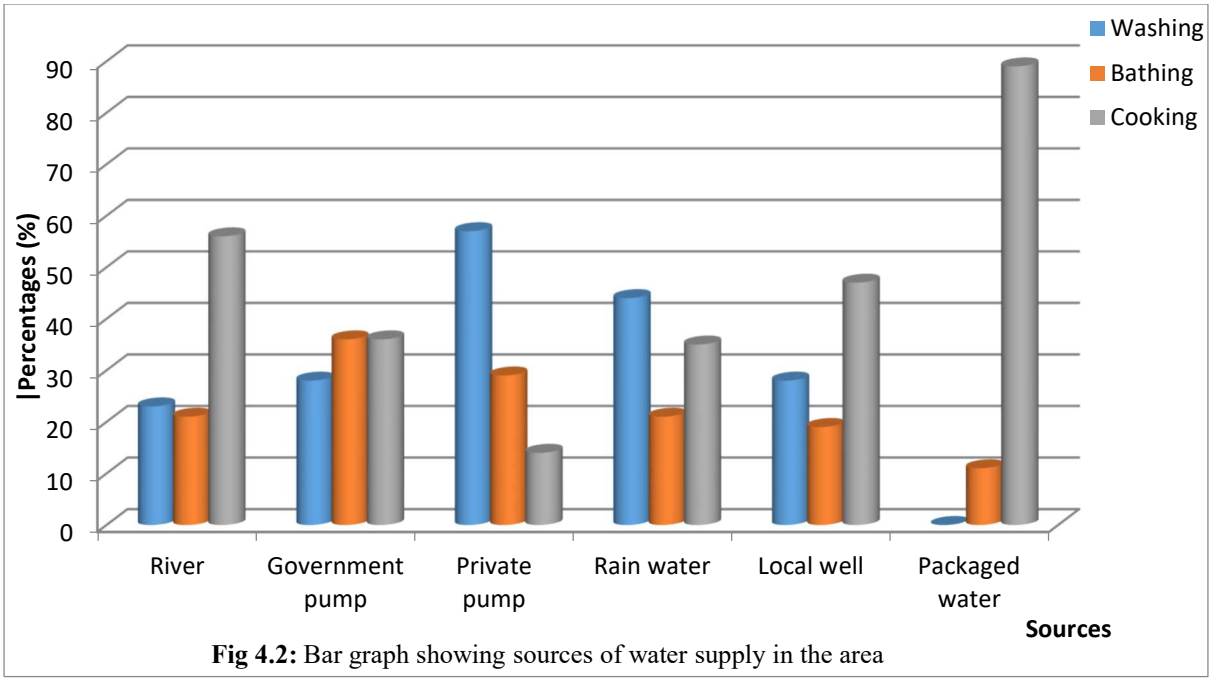

Fig 4.2: Bar graph showing sources of water supply in the area

Table 4.3 and fig 4.2 revealed the various sources of domestic water supply and water demand in Boji-Boji Agbor. It could be deduced that 56% of the respondents indicated that River which is a major source of domestic water is mainly used for cooking purpose, 36% respectively said government pump water serve for bathing and cooking purpose, 57% confirmed that private pump majorly serve for washing purpose since the pump is not good enough to drink, 44% also attested to the fact that rainwater is majorly used for washing purpose while 47% and 89% respectively said local well and packaged water serves as water for cooking. This implies that the various sources of water supply in Boji-Boji Agbor served as washing, bathing and cooking purpose.

Table 4.4: Water sources available in the area

Sources	Frequency	Percentages (%)
River	42	21
Government pump	8	4
Private pump	26	13
Rain water	124	62
Total	**200**	**100**

Source: Fieldwork, 2020

Table 4.4 showed that 21% of the respondents use river sources, 4% use government pump, 13% use private pump and 62% greatly depend on rain water. This implies that quality water supply is not easily accessible in Boji-Boji Agbor since majority of the residents have to rely on rain water for their domestic water usage.

Table 4.5: Capacity of water tank

Capacity	Frequency	Percentages (%)
Big	108	54
Medium	76	38
Small	16	8

Total	**200**	**100**

Source: Fieldwork, 2020

Table 4.5 showed that 54% of the respondents have big water tank ranging from 1500-2000 capacity, 38% have medium water tank size and 8% have small water tank. This means that most residents of Boji-Boji Agbor have water tank storage system used in storing water.

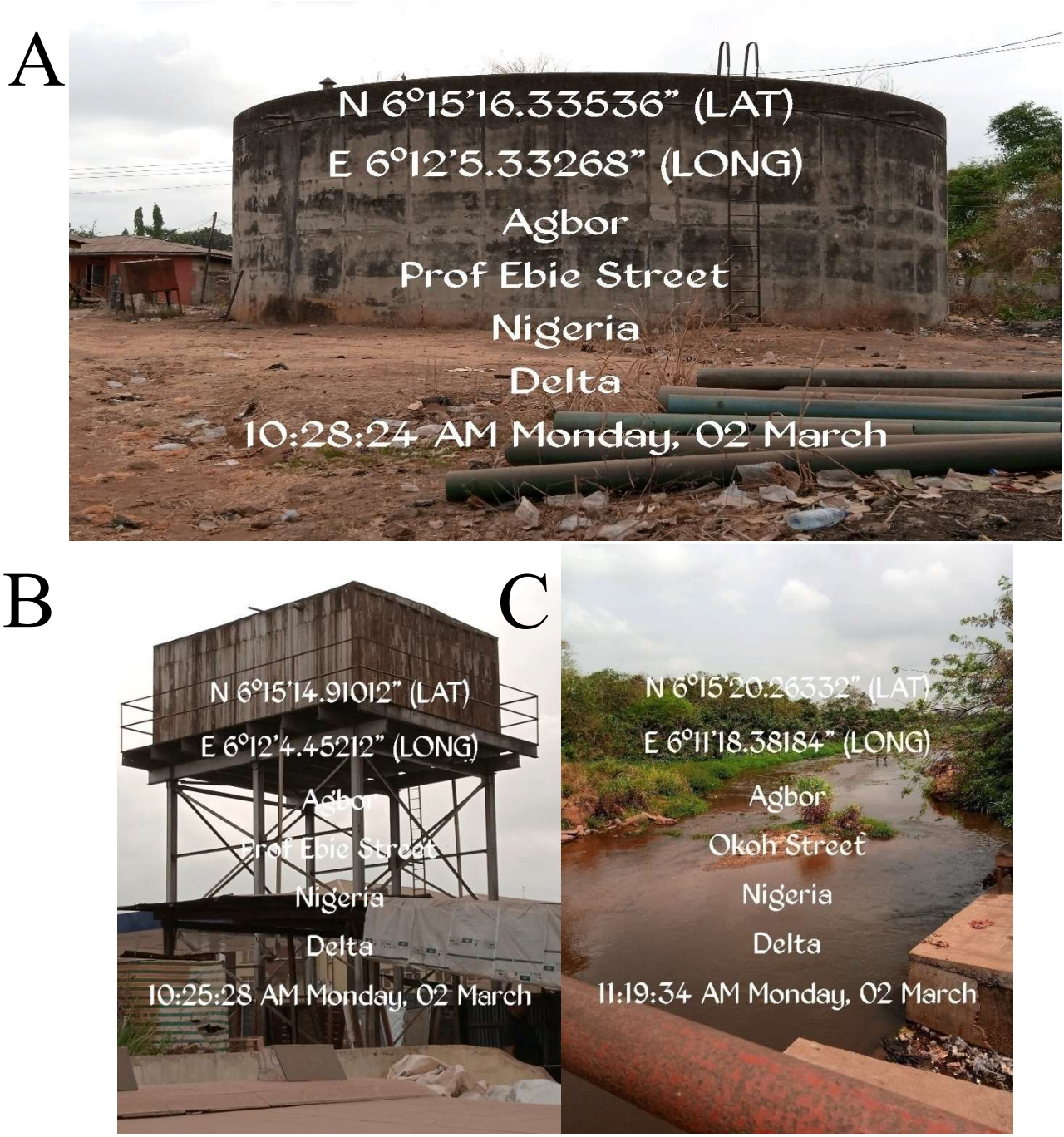

Figure 4.3: A and B shows the location of the public water reserviour tank, C shows the location of Orogodo River.

5.4 Water demand in Boji-Boji Agbor

Table 4.6: Most important factor that determine water demand

	4	3	2	1
Factors	**Very important**	**Important**	**Least Important**	**Not important**
Population density	82 (41%)	68 (34%)	20 (10%)	30 (15%)
Land use	74 (37%)	98 (49%)	20 (10%)	8 (4%)
Distance from water source	24 (12%)	34 (17%)	122 (61%)	20 (10%)

Source: Fieldwork, 2020

Table 4.6 showed that 41% of the respondents indicated that population density is very important in determining water demand, 49% indicated that land use is also important in determining water demand and 61% indicated least importance when considering the distance from water source. It could be deduced that population density, land use, and proximity of water sources are important factors that determine water demand in Boji-Boji Agbor.

5.5 Problems of Water Supply in Boji-Boji Agbor

Table 4.7: Problem of water supply in the area

Problem	**Highest**	**High**	**Moderate**	**Low**	**None**
Pollution	0 (0%)	16 (8%)	42 (21%)	106 (53%)	36 (18%)
Distance	0 (0%)	22 (11%)	18 (9%)	66 (33%)	94 (47%)
High cost	0 (0%)	38 (19%)	14 (7%)	42 (21%)	106 (53%)
Wasteful use	12 (6%)	28 (14%)	68 (34%)	16 (8%)	76 (38%)
Increased demand	66 (33%)	28 (14%)	88 (44%)	14 (7%)	4 (2%)
Lack of government water scheme	144 (72%)	20 (10%)	14 (7%)	22 (11%)	0 (0%)
Leakage of pipes	26 (13%)	86 (43%)	74 (37%)	14 (7%)	0 (0%)
Inadequate facilities	120 (60%)	68 (34%)	12 (6%)	0 (0%)	0 (0%)
Diseases	10 (5%)	62 (31%)	18 (9%)	86 (43	24 (12%)
Power supply	174 (87%)	22 (11%)	4 (2%)	0 (0%)	0 (0%)

Source: Fieldwork, 2020

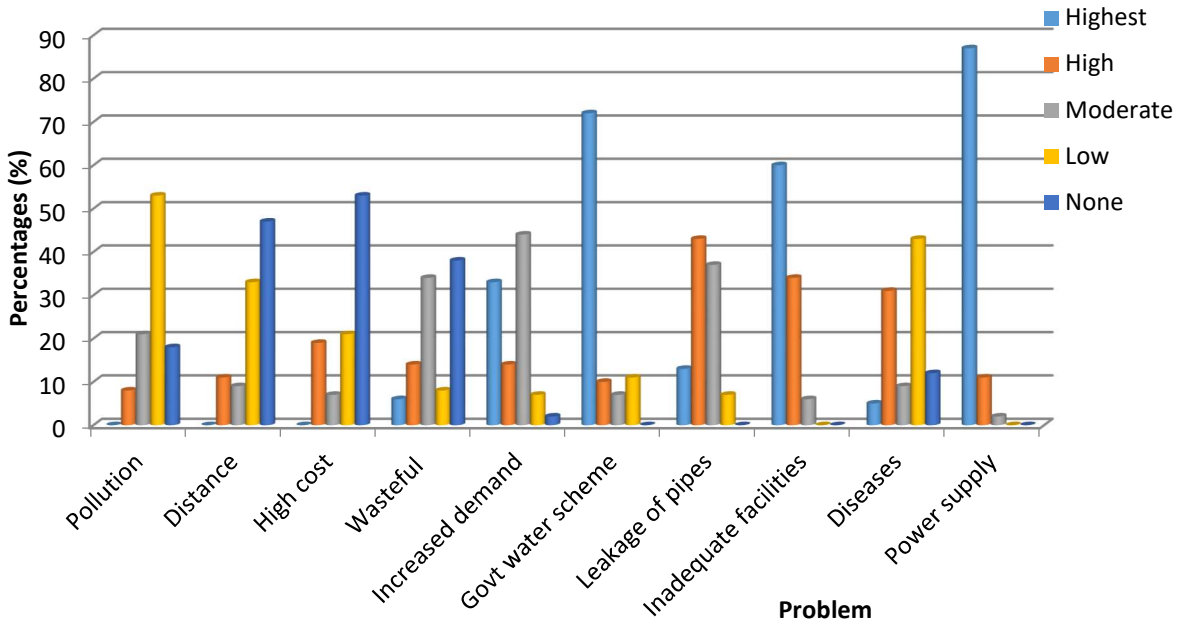

Fig 4.4: Group Bar Graph showing the problem of water supply in the area

Table 4.7 and Fig 4.4 showed the problems of water supply in the area. It could be deduced that pollution contributes 42% to water supply problem in the area since a larger proportion of the total population confirmed this view. Also, 47%, 53%, and 38% of the respondents respectively said that none of the options provided is applicable to distance, high cost, and wasteful use which means that these items mentioned have lesser impact on water supply in the area. Similarly, 33% of the respondents indicated that increased demand have compounded the problems of water supply in the area, 72% said lack of government water scheme also affects water supply, 43% said lack of pipes, 60% said inadequate facilities, 43% said diseases and 87% said power supply is a major problem of water supply in Boji-Boji Agbor. This implies that water supply problems are mostly caused by environmental factors.

5.6 Other possible ways of solving the problems of water supplies in Boji-Boji Agbor

Table 4.8: Digging of private borehole have reduced water problems

Response	Frequency	Percentages (%)
Yes	168	84
No	32	16
Total	**200**	**100**

Source: Fieldwork, 2020

Table 4.8 showed that 84% of the respondents agreed that digging of private boreholes have reduced water shortage problems while 16% did not agree. This implies that digging of private borehole have reduced water problems.

Table 4.8: Digging local well as a measure adopted in solving the problems of water supply in the area

Response	Frequency	Percentages (%)
Yes	184	92
No	16	8
Total	**200**	**100**

Source: Fieldwork, 2020

Table 4.8 showed that 92% of the respondents agreed that one of the measures taken to solve problems of water supply is digging local wells while 8% disagreed. This implies that digging of local well is one of the best measures in solving the problems of water supply in the area.

5.7 Spatial Analysis Map showing Water Supply and Demand in Boji-Boji Agbor. The spatial analysis showing distribution of water supply sources in Agbor is presented below.

;5.7.1 Water Supply in Boji-Boji Agbor

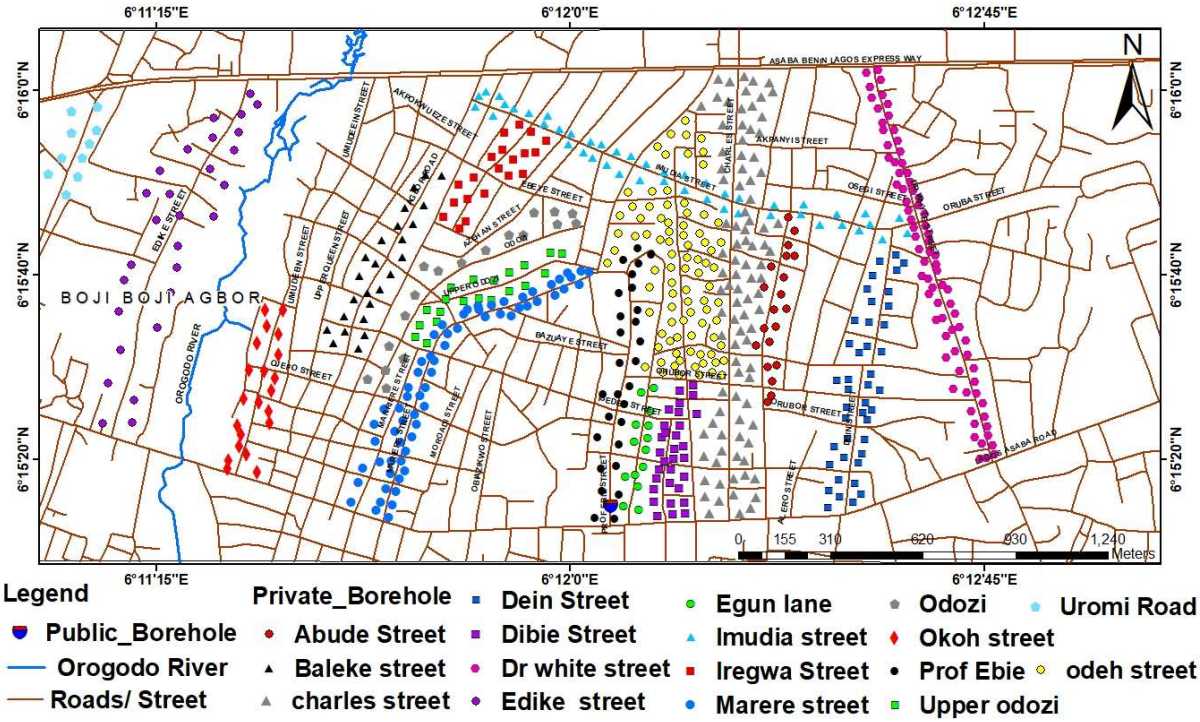

Fig 4.5: Sketch Map of Agbor showing water supply sources

The map above (Fig 4.5) shows the major sources of water in Boji-Boji Agbor. Water is supplied primarily from private pumps and the Orogodo River towards the west side of the map. The map shows the presence of just one public water pump towards the South, however two were located in the same area which were determined to be non-functional from ground truth analysis. The number of water private pumps were counted by street, and a total of 586 private water pumps were counted in the Boji-Boji Agbor Area, with most of the pumps clustered at the centre and few towards the west.

5.7.2 Water Demand in Boji-Boji Agbor

The water demand map is produced using the Analytical Hierarchy Method as discussed. The demand map is gotten by overlaying three factors (Water Proximity, Land Use and Population) after determining their weight using the Pair-Wise Comparison method. This would help is to determine what factor takes the most priority and the consistency of our choices. A consistency ratio less than 10% (0.01) is the acceptable threshold for validity of the data. The consistency ratio of the data below is well below 0.01 which is an acceptable value to continue with the available data. The weight given assigned 65% priority to population density, 23% to Land Use and 12% to water proximity.

GEOGRAPHIC INFORMATION SYSTEM (GIS) MAPPING

The weighted GIS map was carried out using classified Population density map, land Use map and water proximity map as shown in the Figures 4.6 and 4.7 below.

1. This is based on the premise, a higher population density would demand more water than a lower population density;

2. Land use indicate built-up or urban areas would demand the most water followed by vegetation, bare surface and water bodies, Water proximity show people closer to water source would consume more water than those farther from source of water.
3. The water demand map however showed a very similar spatial trend with the population density map, This is most likely because population density has the largest determining weight on water demand supply.
4. The final GIS map (Figures 4.8 and 4.9) displayed the result showed that water demand is highest at the Western part of the area map, moderate at the Central and least at the Eastern part of the map.

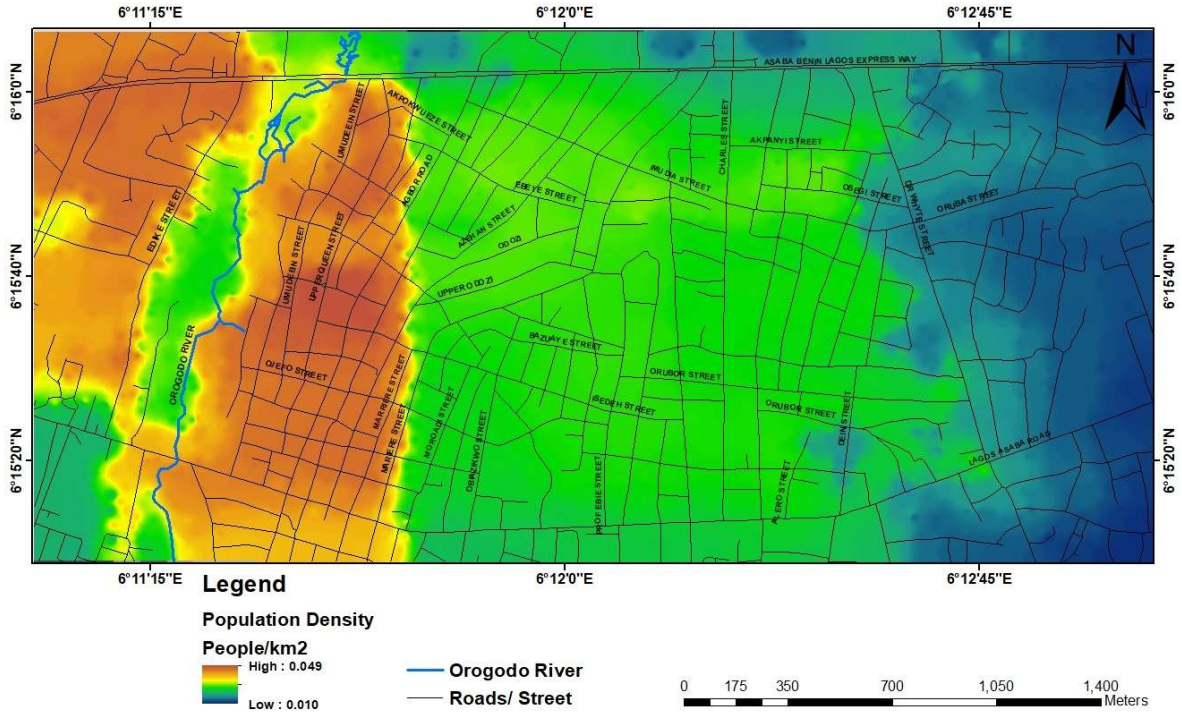

Figure 4.6: Population density map of Boji-Boji Agbor

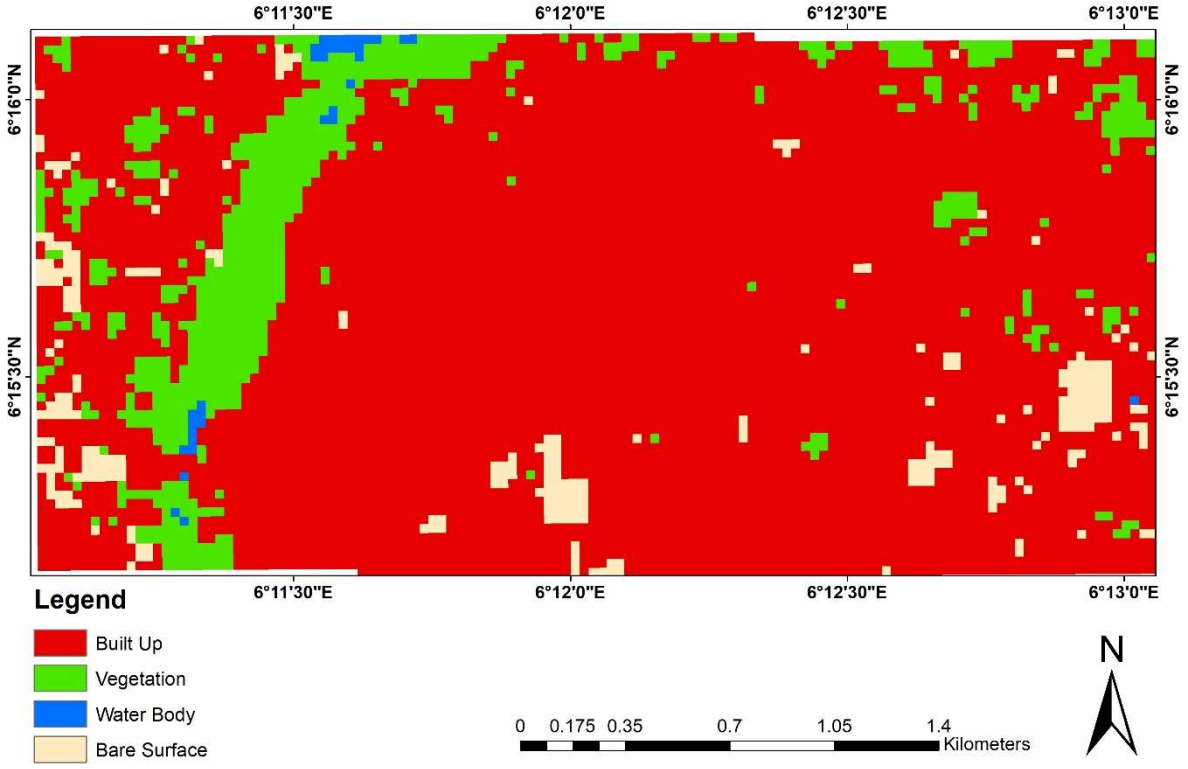

Figure 4.7: Map Showing Land Cover Classes

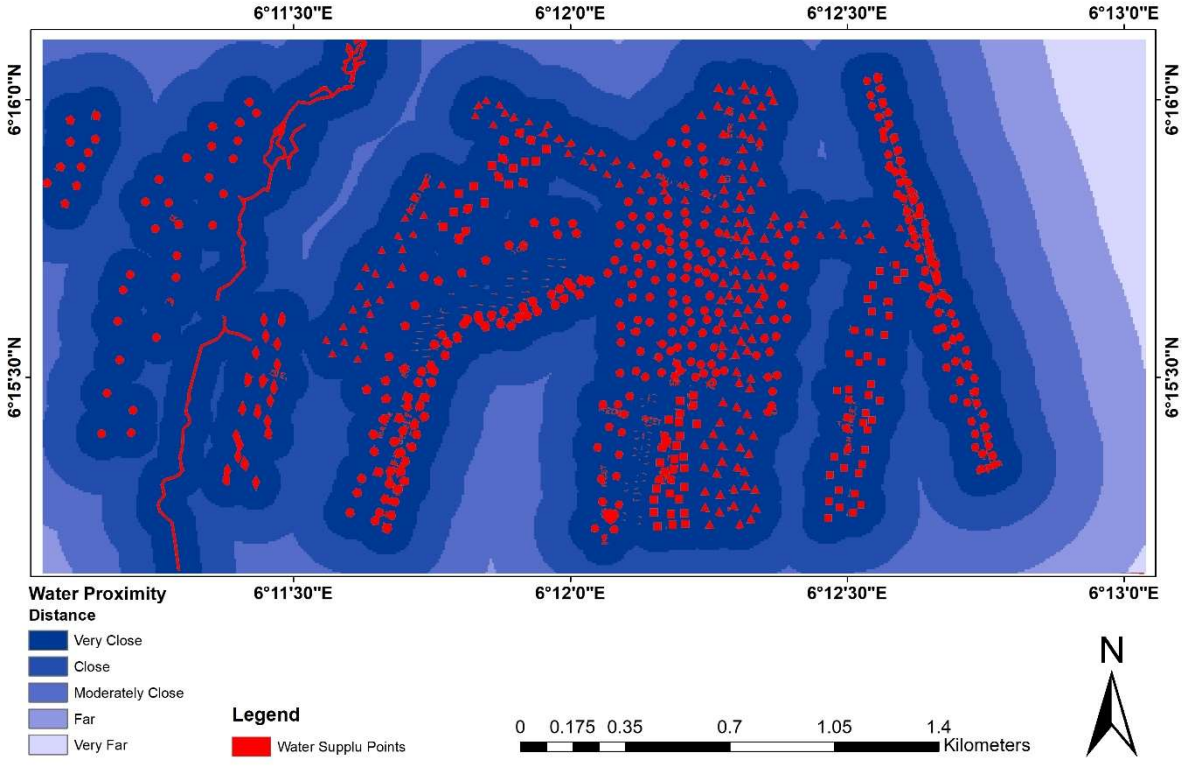

Figure 4.8: Map showing distance from Water Source/Supply (Water Proximity)

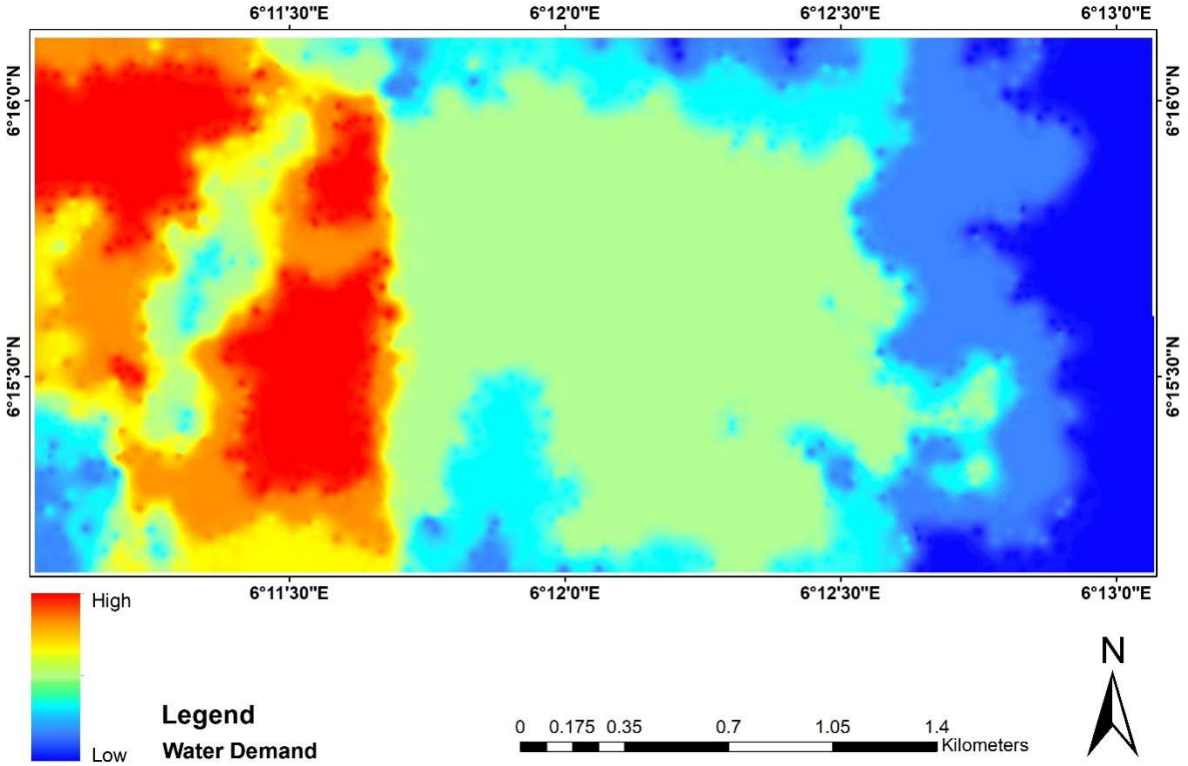

Figure 4.9: Water Demand map of Boji-Boji Agbor

5.8 Hypotheses Testing/Discussion of Findings

Hypothesis 1

$H0_1$: There is no significant difference in the use of water got from the various water supply sources-river, government bore-hole, private bore-holes, wells and package water.

Table 4.9: Standardized B Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	**Std. Error**	**Beta**	**B**	**Std. Error**
1	**(Constant)**	**4.840**	**2.667**		**1.815**	**.107**
	River	**.750**	**.280**	**683**	**.892**	**.398**
	Govt. borehole	**.873**	**.241**	**.715**	**3.626**	**.007**
	Private borehole	**.762**	**.248**	**.659**	**.655**	**.531**
	Wells	**.414**	**.288**	**.639**	**1.43**	**.246**
	Packaged water	**.425**	**.370**	**.502**	**1.43**	**.042**

Source: SPSS Output, 2020

From Table 4.9, the standardized B Coefficient value for government borehole (0.715), river (0.683), private borehole (0.659), wells (0.639) and packaged water (0.502) indicates that the model is significant at 0.05 level of significance and that there is a positive correlation between the use of water gotten from the various water sources and water supply in Boji-Boji Agbor. This implies that water supply is significantly dependent on sources of water in the area. The findings also showed a positive standardized

coefficient and unstandardized coefficient value to support this view. It could be deduced that there is significant difference in the use of water got from the various water supply sources-river, government bore-hole, private bore-holes, wells and package water.

Table 4.10: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.993[a]	.778	-.330	20.89231

Source: SPSS Output, 2020

Table 4.10 showed that the model R value (.993) significant at 0.05 level of significance indicating that there is significant difference in the use of water gotten from the various water supply sources-river, government bore-hole, private bore-holes, wells and package water. It could also be deduced that 78% of the use of water gotten from the various water supply sources can be explained while 22% cannot be explained. Therefore H_0 is rejected and H_1 is accepted which implies that the use of water gotten from the various water supply sources such as river, government bore-hole, private bore-holes, wells and package water differs significantly.

Hypothesis 2

$H0_2$: Supply of water to Boji - Boji Agbor is not depended on the following factors-water pollution, misuse of available facilities, distance, high cost of water, increased demand, inadequate facilities, lack of government water scheme, leakages of pipes, diseases.

Table 4.11: Regression Analysis

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	**.892(a)**	**.796**	**.719**	**4.12746**

Source: SPSS Output, 2020

From Table 4.11, the R model value of .892 is significant at 0.05 level of significance. This means that a significance relationship exist between the variables. A positive correlation also exits between water supply and factors that determine water demand in the area. Using the R square value of 0.796, indicate that water demand factors has 80% contribution to the supply of quality water in the area. Therefore, the supply of water to Boji - Boji Agbor is significantly dependent on water pollution, misuse of available facilities, distance, high cost of water, increased demand, inadequate facilities, lack of government water scheme, leakages of pipes, diseases.

VI. Summary Of Findings, Conclusions And Recommendation

6.1 Summary of Findings

The study was conducted in Boji-Boji Agbor, located in Ika South of delta state to determine the nature of water resource, source of water supply, domestic uses of water,, problems of water supply as well as determine the supply and demand. The study used questionnaire and Geographic Information System (GIS) as primary data to the research. The data obtained from the Questionnaire were validated using the Hypothesis while the weighted overlay in GIS was determined and validated using the Analytical Hierarchy process (AHP).

After conducting the hypothesis test to ascertain the validity of the result obtained from the questionnaire, the null hypotheses were rejected that prompted further study. The result of the study showed that private pump is the major source of water in Boji-Boji-Agbor, with most significant usage for all domestic uses (cooking bathing and washing). This outcome is most likely envisaged as a result of absence of functional government water pumps. The study alos showed that power supply is a major problem to water supply, therefore Other major challenges include inadequate facilities and lack of government water schemes, which together are parts of one problem. The study on the challenges or problems of water supply indicated that power supply is the most significant problem of water supply which is expected as the major source of water is private pumps.

The result of the findings showed that the standardized B Coefficient value for government borehole (0.715), river (0.683), private borehole (0.659), wells (0.639) and packaged water (0.502) indicates that the model is significant at 0.05 level of significance and that there is a positive correlation between the use of water gotten from the various water sources and water supply in Boji-Boji Agbor.

The study revealed that the level of influence of water demand factors in the area is very high as the variables (water pollution, misuse of available facilities, distance, high cost of water, increased demand, inadequate facilities, lack of government water scheme, leakages of pipes, and diseases) indicates a positive correlation existing between water supply and factors in the area. Also, supply of water to Boji-Boji Agbor is significantly dependent on water pollution, misuse of available facilities, distance, high cost of water, increased demand, inadequate facilities, lack of government water scheme, leakages of pipes, diseases since the R model value of .892 is significant at 0.05 level of significance indicating that there is a strong positive relationship between the dependent and independent variables.The data from the questionnaire showed that most of the respondents (43%) had 4-6 people in their household and about 60% of them used big reservoir tanks for water supply.

The water demand map was produced using three primary criteria; population density, Land Cover and Water Proximity at 65%, 23% and 12% priority level respectively. The result showed that the demand is highest towards the west and least at the eastern part of Boji-Boji Agbor. The spatial trend of the water demand is very similar to the population distribution expected as population distribution has the highest priority (65%) in determining the water demand of the area.

6.2 Recommendations

The following recommendations were made;

To carry out a more detailed study of this research data regarding the demand and supply of water in Boji-Boji Agbor or any other location, data regarding the location and capacity of water resources must be available and obtainable from the government water board.

The government needs to step in to see to it that constant or consistent power is generated in the community.The intervention of the government is paramount for proper water distribution to be achieved.

The state and local government have to come up with strategies to endeavour water is supplied to every part of the state including Boji-Boji Agbor, as well as provide the necessary facilities for this task to be implemented.

Citizens also need to be educated on the use of water so that issues of wastage or misuse of government water facilities would be greatly mitigated.

VII. Conclusion

The study concluded that private pumps is the primary source of water, with the Orogodo River as a secondary support to those nearby however government water pumps have however become moribund. The major problems to water supply are power supply, lack of government water schemes and inadequate facilities. Demand for water was found to be greatest at the west and least at the eastern part of the study area. All factors considered, the role of the local and state government is crucial to the mitigation of the problems of water supply in Boji-Boji Agbor.

Contribution to Knowledge

The study contributed to knowledge in the following areas;

i. The water network analysis map of various water supply and demand was defined and presented.

ii. The research work provided GPS map showing water supply and demand in the area.

iii. The study helped the inhabitants of Boji-Boji Agbor as they were better equipped on how to manage the problem of water supply in their area.

References

[1] Adelere, E.A & Olufemi, A.B.(2015). Development of a Strategic Planning Model for a Municipal Water Supply Scheme Using System Dynamics. Journal of Water Resource and Protection, Vol. 18, no 2, pp. 1 – 11.

[2] Adeniran, A.E and Oyelowo M.A.(2013). An EPANET analysis of water supply network of the university of Lagos, Nigeria. Journal of Engineering Research volume 18, No. 2.

[3] Anoop,K.S.(2017). Resource Geography. Random Publications, p.p 91-109

[4] Asthana, D.K, & asthana M.(2012). Environment Problems and Solutions. Printed by S. Chand & company PVT L.T.D. ISBN: 81-219-1654-2.

[5] Ayoade,J.O. (2015). "Techniques of Environmental Planning and Management" in Ayoade J.O. (Eds). Introduction to Environmental Planning and Management.

[6] Charles, C. & Varma, S.(2010). Out of water, from abundance to scarcity and how to solve the world water problems. F.T press(U.S).

[7] Chen, X.Y, Shuang- hulla, Y.L. & Chen, X.L.(2015). A bench making model for household water consumption based on adaptive logic networks. P.P.119-139

[8] Compbell, N.A. & Reece, J.B.(2009). Biology (8th ed). Pearson. ISBN 978-0-8053- 6844-4.

[9] Efe, S.I.(2003). Water quality and it's utilization in the Nigerian rural setting of Abraka. International journal of ecology and environmental dynamics, Vol.1, P.P. 81-89.

[10] Egboh, S.H.O(2010). Water resource development in Egboh S.H.O.(Eds), Man, his Environment and Sustainable Development, Delta State University press, Nigeria P.P. 52-64.

[11] Eggimann, S.M, lena, W.O. mariana, Y, Dorothee, B., & philipand M.M.(2017). The potential of knowing more-a review of data urban water management, environmental science and technology.

[12] Ejemeyovwi, D.O. (2015). Crime Mapping Using Time Series Analysis in Asaba Delta State Nigeria. A remote sensing and GIS Approach. European Journal of Basic and Applied Sciences, vol. 2, no.2 pp. 2 – 10.

[13] Ewhrudjakpor, C., Atubi, A., & Odemerho F. (2013). Statistics for Social Investigations. Grace Publications Int'l Nigeria.

[14] Georg, F. fritz, H. & Gordalla B.C.(2016). Water 1 properties, analysis and Hydrological cycle, widely –VCH verlag GMBH and Co. KGA. ISBN 9783527306732.

[15] Gleick, P.H. & Palamappan, M.M. (2010). Peak water,(PDF), proceedings of the national academy of science . P.P. 107-126 Archived (PDF), from the original on 8 November, 2011.

[16] Good child, M.F.(2010). Twenty years of progress , G.I. Science in 2010, Journal of information science. Vol1.

[17] Grafton, Q.R. & Hussey, K.(2011). Water resource, New York, Cambridge university press.

[18] Mund, J.P.(2014). Capacities for megacities coping with water scarcity.(PDF) UN-water decade program on capacity development.

[19] Okwere, A.O. Hart, L. & Jackson, K.P. (2015). Mappling the spatial Distribution of water Borehole Facilities in part of Rivers State Using Geographical Information System (GIS) Techniques.

[20] Oyebande, L. (1998). The Water Cycle; Carrier of Health and Wealth. How sustainable is it. An Inaugural Lecture Delivered at the University of Lagos on Wednesday, 20th May, 1998.

[21] Raul, A. Roshan , B., George, C. & Armando P. (1990). The Environment and it's Resources. Gordon and Beach, Science Publishers (NEW YORK, LONDON and PARIS).

[22] Reece, J.B, Lisa A. Cain, M.L. Wasserman, S.A. miniorsky , P.P-, & Jackson R.B.(2013). Campbell biology (10th ed) baston, mass. Pearson. ISBN 9780321-775658.

[23] Rhein, M. & Rintoul S.R.(2013) " observation, oceans (PDF). Ipce WGS, ARS(report) P, 257.

[24] Seyi, F. (2001). Geographic information system, techniques and methods. Research support services Ibadan ISBN 978-35606-1-1.

[25] Sharma, S.P.(2009). Environment and ecology. University press(an imprint of laxima publications (PS L.T.D). P.P. 87-113.

[26] Silverstain, T.P. & Heller, S.T,(2017). The real pka of water. Journal of Chemical Education. P.P. 94-108

[27] Topos, K. Ram P. & Mohammad M.K,(2017). Analysis of water quality in urban water supply system of Bangladesh. Journal of environmental and analytical toxicology Vol. 7 No4.

[28] Tripathy, S.N, & Sunakar panda,(2001). Fundamentals of environmental studies VRIN and publication (P) LTD.

[29] Walmsly, N, & Pearce G.(2010). Towards sustainable water resources Management. Bringing the strategic approach up – to – date. Irrigation and drainage systems. ISBN: 24-34-19/203.

[30] Zumdahi, S.S. & Zumdahi ,S.A.(2013). Chemistry (9^{th} ed) cengage learning.ISBN.978-1-13-361/09-7.