◆ Research paper
DOI: 10.5281/zenodo.10791171

Utilization Analysis of Water Demand and Supply in Akwanga Local Government Area of Nasarawa State, Nigeria

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Abstract: Water is one of the most important renewable natural resources, as no one can survive without it; whether plants or animals. Water is one of the basic human needs that is imperative for sustaining the quality of life on earth. However, its unequal spatial distribution and mismanagement make it scarce. This study, therefore, analyzes the utilization demand and supply of domestic water in Akwanga Local Government Area of Nasarawa State, Nigeria. To achieve the above, the coordinates of the water sources were collected from the field, and a point map was created to show the spatial distribution using the Geoinformatics (GIS) technique. A purposive sampling technique was used in selecting study household respondents to administer a questionnaire and interview. The sample questionnaire and conducted interview were used to elicit and examine requisite information on the demand, supply, and socio-economic utilization of water in the study area. In specific terms, the Random sampling technique was used to administer 399 respondents while only three hundred and thirty-two 332 (83.2%) were returned fully completed. The SPSS software was used for questionnaire data analysis. Analytic techniques involve descriptive statistics such as frequency distribution, and simple percentages. Inferential Regression analysis and correlation were used to combine the variables accounting for water demand, supply, and shortage. The study reveals that women and children are mainly in search of water. Variable indicators examined include the physical environment, household size, distance to a water source, amount of water demand, supply infrastructure; socio-economic implication of water. The result of the correlation coefficient shows there exists a very high positive linear relationship between the water demand and water supply. The study recommends that the process of water supply development should be stepwise by the participatory and managerial capacity of communities. This is in addition to the expansion of pipe-borne water network coverage to every household.

Keywords: Akwanga LGA, water, demand and supply, GIS, statistics

1 Introduction

Water is a colorless, transparent, odorless liquid that forms the seas, lakes, rivers, and rain and is the basis of the fluids of living organisms. Water (H_2O) is a natural resource of fundamental importance that supports all forms of life (Water Forum March, 2013). Water is an important resource to man (Bello, Adzandeh, and Rilwani, 2014). He can survive longer without food than without water (Olorunfemi, Salahudeen, and Adsesiya, 2011). Humans require clean water resources for industrial, agricultural, and residential purposes (Liguo, Huang, and Li Yin, 2017). Water is essential to life and its supply, consumption, and spatial distribution are closely associated with economic growth and the development of society. Apart from air, water is indispensable to life. It is a foundation for human prosperity because adequate and high-quality water supplies provide a basis for the growth and development of the social, economic, and culture of a people (Ward, 2011; Young, 2012). The importance of water to man cannot be overemphasized; it holds the most important benefit to man's sustenance besides shelter, food, and clothing (Ajadi, 2011). According to Ifabiyi and Ahmed (2011), it is recognized all over the world that water is a vital resource to human existence and also a major factor in commanding the progress of civilization. The earth's surface comprises over 70% water, 97% of this water is ocean water which is highly salty as a result of the much-dissolved minerals it contains and as such, cannot be directly consumed without prior desalination (Bello, Adzandeh, and Rilwani, 2014). Of the 3% fresh water remaining, 79% is locked up in glaciers and ice caps at the poles, 20% is groundwater and the remaining 1% is found in rivers, lakes, soil moisture, atmospheric water, etc. (Mimi and Smith, 2000). It is important to point out that excess water (inundation) in the environment is dangerous to plants and animals (Nkeki, Bello, and Agbaje, 2023; Bello and Ogedgbe, 2015; Bello, Adzandeh, and Rilwani, 2014).

Nevertheless, access to secure, safe, and sufficient sources of potable water is a fundamental requirement for the survival, well-being, and socio-economic development of humanity (Cannella, 2014). A large percentage of the population in developing countries continues to live with inadequate access to safe and convenient water supply, and in most cases, water supply is unreliable (Cochran and Cotton, 1985). Nigeria is regarded as one of the countries designated as having "water stress" (WHO/UNICEF, 2000). More than 60% of rural Nigerians are denied access to portable water (Huang and Yin, 2014). This unfortunate situation has been described as "paradoxical" given the enormous hydrological resources of the nation. United Nations Organization (2006) believed that the water situation in Nigeria can be attributed to the lack of political will by the government at all levels to develop high capacities for optional exploitation of her abundant water endowment. Obeta (2016) attributed water failure in Nigeria to a cosmetic and unscientific approach to water provision which characterizes most water supplies in the country. About 90% of rural areas and 60% of urban areas face water-related problems in Nigeria (Anad, 2007).

The daily per capita consumption of water in Nigeria varies between 10-27 liters as reviewed by many studies, with an average of 46 liters, being far, far below the internationally recommended minimum requirement of 115 liters per person, per day. This shortfall in water requirement is due to differences in availability and supply (UNICEF, 2009). While portable water is scarce, damages resulting from excess water (flood) has continued to be on the rise in Nigeria due to climate change and rapid urbanization (Bello, Onothoja and Asikhia, 2013; Bello and Rilwani, 2016; Taofik, Bello, Ndabula, Jidauna, and Ademola, 2017; Bello and Ortese, 2023).

The people of Akwanga Local Government Area (LGA) in Nasarawa State, Nigeria, though with the presence of Made water works with a production capacity of over $8m^3$/day volume of water to supply Akwanga, Gudi, Gagaku, Sabon Gida, and Keffi, as well as other communities along the federal road, are yet, confronted with the problem of water demand and corresponding supply. In Akwanga LGA, the study area, the quantity of water supply is drastically reducing as a result of an increase in population, non-steady water supply, coupled with the weather conditions such as the dry season where streams and rivers dry up and the water table retreat to its permanent level far down the aquifer. Thus, the objectives of the study are to identify and map the sources of water for domestic use, examine the factors affecting water demand and supply, and also determine the quantity of domestic water demand and supply in Akwanga LGA. Considering the vital roles played by water in all spheres of human endeavors, and in Akwanga LGA in particular, the need to investigate the challenges posed by inadequate water supply to forge a way out to mitigate the perceived paucity becomes inevitable, hence; this study.

1.1 Statement of the Hypothesis

The null hypotheses empirically tested in this study, which invariably formed the basis of investigation are:

H_{01}: There is no relationship between household size and water demand and water supply

H_{02}: There is no significant relationship between the amount of water demand and water supply

H_{03}: There is no significant relationship between distance covered to water sources and water supply

2 Materials and Method

2.1 Study Area

Akwanga Local Government Area (LGA) is located in Nasarawa State, North-Central Nigeria. It lies approximately between latitudes 8^0 51' 25" N and 8^0 40' 20" N, and longitudes 7^0 45' 00" E and 7^0 31" 05" E. Akwanga LGA and its environs are built on predominantly basement complex; characterized by near-surface outcrops of underlying basement rocks and shallow overburden (Ahmed and Smith, 1987). Migmatite – Gneisses associated with the older granite. There are a few seasonal springs at different locations in or close to the flood plain. The fluctuating groundwater table seems to influence the lifespan of roads and shallow foundations (Alao, 1982). Over the course of the year, the temperature typically varies hovers around 97f (36.1 ^{0}C), and can also get to as high as 102f (39 ^{0}C). Soils in Akwanga are mostly derived from the parent rocks of the basement complex and granite crystalline rocks with well-developed profiles with high nutrient, well-structured, and high biological activities which enhance farming activities in the study area (Jimoh, 2014). There are two broad vegetation types: Forest and Savanna. There are three variants of each, running as near parallel bands east to west across Nigeria. The savanna, especially Guinea and Sudan, are the major grains, grasses, tubers, vegetable, and cotton growing regions characterized by scattered tall trees and short grasses due to grazing activities.

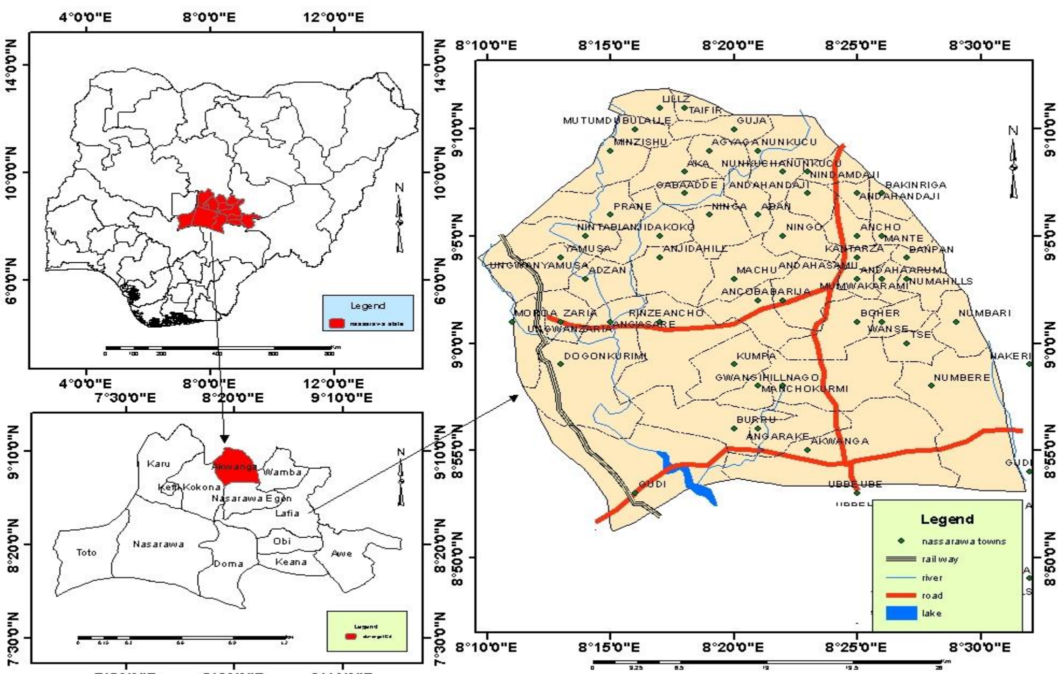

Figure 1 Location of Akwanga LGA, Nasarawa State, Nigeria

2.2 Methodology

The data used in this study were collected from both primary and secondary sources. The study adopted a survey and measurement research design. Using measurement research design, the coordinates (x, y) of the sources of domestic water use in each of the sampled communities were collected using a handheld Garmin 72+ GPS receiver device. Also, demographic data such as sex, age, marital status, occupation, level of education, household size, level of income, and housing type, in addition to the amount of water used in each household for domestic activities, distance to water source, who is responsible for the collection of water in a household, payment for the water, time taken to get to water sources, the method used in storing water, water management strategies, water wastage by the households and topography challenges were collected from the sampled respondents using a well-structured questionnaire that was carefully prepared and specially numbered.

The population for this study consisted of the entire population of Akwanga LGA which is 151,100 based on the 2006 Nigeria census record (NPC, 2006). Sampling was done using different techniques based on the characteristics of the population. The study area consists of eleven council wards, these are Agyaga, Anchobaba, Moroa, Ancho Nighaan, Andaha, Gudi, Akwanga East, Akwanga West, Gwanje, Ningo/Bohar, and Nunku. A purposive sampling technique was also used. This was due to time factors, financial constraints, and the broadness of the Study Area. As such, the study selected six (6) council wards mostly prone to water demand and supply cases in the area (Table 1). In addition, the study used a random sampling technique as every member of the population from which the samples were selected has an equal chance of being selected. Using Taro Yamen (1967) formula;

$$\boldsymbol{n} = \frac{\boldsymbol{N}}{\mathbf{1} + \boldsymbol{N}(\boldsymbol{e})^{\mathbf{2}}}$$

Where n is the required sample size; e is the level of significance which indicates the confidence the researcher has on the sample that the sample elements drawn from a normal population have all the characteristics of the population and are therefore, a reflection of that population. N is the Population size

Therefore, $n = 151100/(1 + 151100(0.05)^2) = 398.9$. Therefore, the adopted sample size for the study was approximately 399.

Data analytical techniques used were such as simple percentages, frequency distribution, and chats. Also, regression was used to correlate between water demand and supply.

3 Results and Discussion

3.1 Water Sources for Domestic Use in Akwanga LGA

Figures 2 and 3 respectively show the spatial distribution of water sources and types of sources of water in Akwanga LGA where households sourced water for domestic use. The study revealed that most of the water sources for domestic use in the area are mostly from hand-dug wells, streams, boreholes, and pipe-borne water supplies. Also, as illustrated in Figures 2 and 4 the study shows that the distribution of water sources in Awanga is such that households travel long distances of kilometers from community to community in search of water, especially during the dry season. This is considered a very big challenge. This is the case because, in the dry season, if not all, most of the water sources in the area dry off (the streams and hang-dug wells) leaving them with no choice but to go about in search of other alternative sources of water.

Table 1 Sample Locations of Water Sources in the Study Area

Agyaga	Agyaga Ninja Ashe Takpir Angwan pah	Borehole Hand-dug well Stream	$8^0$31’12’’E $8^0$41’20’’E $8^0$18’28’’E	$9^0$22’04’’N $9^0$03’43’’N $9^0$33’21’’N
Anchobaba	Rija sarki Gbuhwen Ancho sarki Tidde Ungwan Zaria	Borehole Hand dug well Stream	$8^0$33’09’’E $8^0$19’55’’E $8^0$51’11’’E $8^0$17’24’’E	$9^0$00’57’’N $9^0$03’24’’N $9^0$23’31’’N $9^0$09’33’’N
Moroa	Moroa Bakin kogi Ungwan Yara Anjida sarki Akwandar	Borehole Hand dug well Stream	$8^0$15’14’’E $8^0$15’52’’E $8^0$15’12’’E	$9^0$03’24’’N $9^0$03’43’’N $9^0$03’46’’N
Andaha	Andaha North Andaha south Andaha Hakimi Katanza Andaha daji	Borehole Hand dug well Stream	$8^0$11’46’’E $8^0$33’02’’E $8^0$22’32’’E	$9^0$30’54’’N $9^0$22’10’’N $9^0$29’41’’N
Gudi	Motor Park C.M.S Gudi Ungwan dariya Motor Park	Borehole Hand-dug well Stream Tap	$8^0$11’21’’E $8^0$32’07’’E $8^0$22’11’’E $8^0$31’05’’E	$9^0$06’44’’N $9^0$09’33’’N $9^0$40’11’’N $9^0$08’21’’N
kwanga	Student Village Police station Akwanga North Kofan Hakimi Akwanga south	Borehole Hand dug well Stream Tap	$8^0$15’14’’E $8^0$15’14’’E $8^0$15’14’’E $8^0$15’14’’E	$9^0$05’23’’N $9^0$10’24’’N $9^0$15’44’’N $9^0$14’09’’N

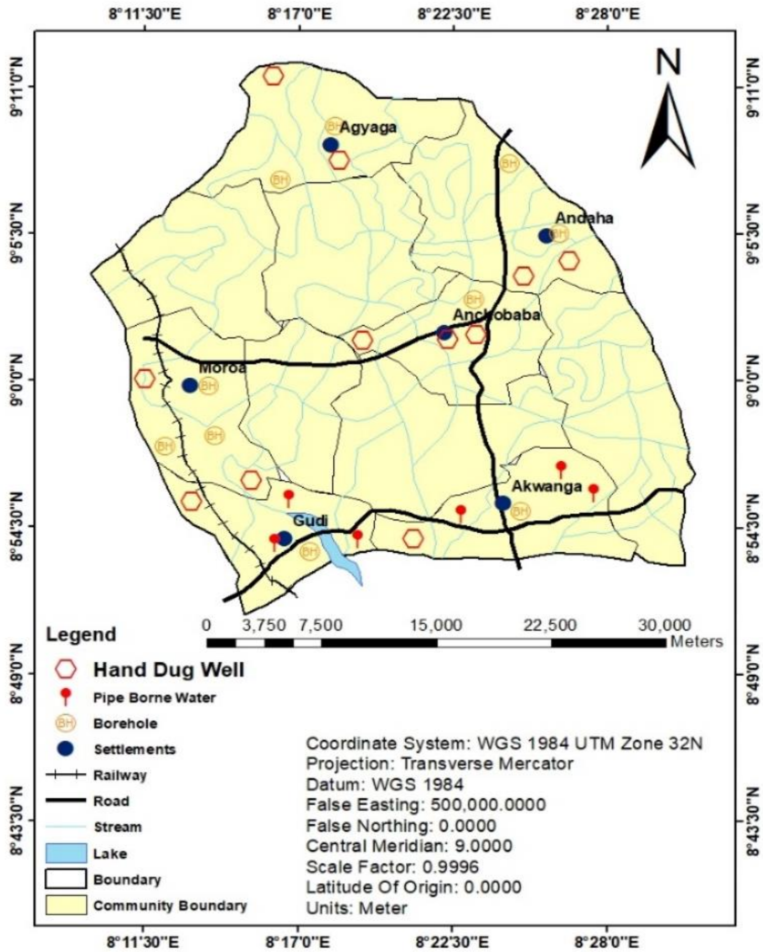

Figure 2 Location of Water Sources in Akwanga LGA

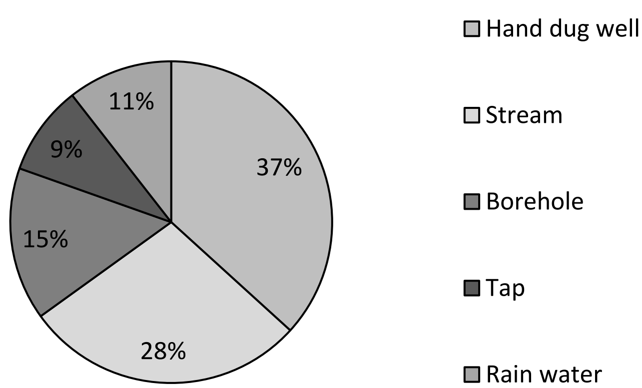

Figure 3 Sources of Water in the Area

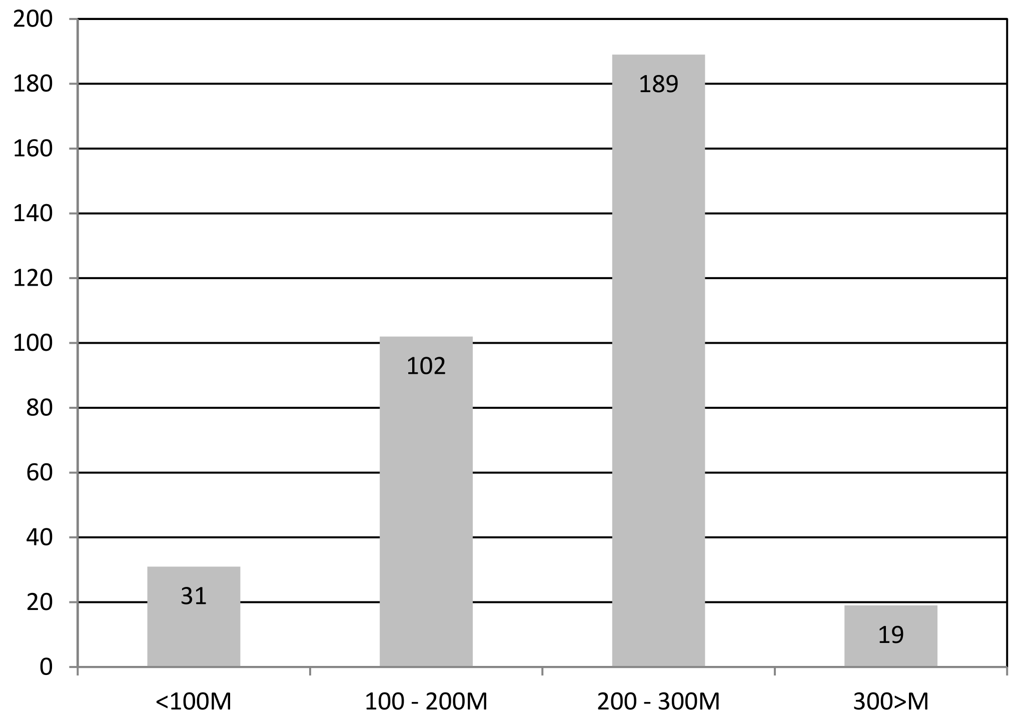

Figure 4 Distance to Water Sources

3.2 Factors Affecting Water Demand and Supply

From the administered 399 copies of questionnaires to adult household respondents in Akwanga, 332 copies (83.2%) were duly completed and returned. Table 2 shows the factors affecting the demand and supply of water in Akwanga LGA. Table 3 shows water demand according to household usage. From both results, the study revealed that the majority of the respondents (59.7%) used about 12,284 liters of water for domestic cleaning, while 22.6% of households used about 652 liters for cooking. Implicitly, the study indicates that the total water demanded for domestic use by the 332 households (respondents) per day is about 20,588 liters. Thus, there is a need to have a reliable and sustainable source of water for the people, otherwise, any shortage; whether seasonal or otherwise, will be a big challenge in terms of access and disease spread.

Table 2 Factors Affecting Water Demand and Supply

S/No.	Factors	Frequency	Percentage
1.	Rapid Population Growth	67	20.2
2.	Seasonality of Water Sources	86	25.9
3.	Absence of Water Infrastructure	70	21.1
4.	Distance to Stream/Spring Water Sources	51	15.4
5.	Inadequate Community Participation	9	2.7
6.	Topographic Constraints	30	9.0
7.	Poor Maintenance of Water Supply Facilities	3	0.9
8.	Absence or Inadequate Water Storage Facilities	16	4.8
TOTAL		**332**	**100**

Table 3 Basic uses of Water among Households per day

Households Water Usage/Demand	No of Households	Quantity in Litres	Percentage (%)
Drinking	332	4,652	22.6
Cooking	332	3,652	17.7
Cleaning	332	12,284	59.7
Total		**20,588**	**100**

From the results presented so far, it is pertinent to note that the study also revealed that 37% of the respondents source water from hand dug well, 28% of the respondent source water from streams, 15% of the respondent source water from boreholes, 9% of the respondent's source water from tap, and only 11% of the respondent's source water from rain. It shows that the highest number of people in the study area depend on well water, followed by boreholes as illustrated in Figure 3. As shown in Figure 4, the study further revealed that 55% of the household members trek a distance of between 200 and 300m, about 30% of the households trek a distance of between 100 and 200m, 9% of the household members also trek a distance of less than 100m, while 6% of the household member trek more than 300m to get water. This result indicates that the people in the study area trekked long distances before they could get water because it was far from their residence. This situation is typical of a rural and semi-urban (fringe) settlement as seen in Akwanga LGA.

In terms of water sources, the study revealed that about 59% of the total households agreed that they source their water from boreholes, 17% from hand dug wells, 9% from streams, while the remainder (15%) get their water from other sources besides those identified above. With limited water available to the people, and in an attempt to manage what is available, the possibility of using polluted water becomes inevitable. Polluted water leads to widespread diseases. This should be looked into vigorously, hence; the need to make portable water readily available in quality and quantity to the people in Akwanga LGA of Nasarawa. The patronage of borehole water by more than half of the studied population is attributed to the perceived safety of the water for drinking (Figure 6). Most wives are more involved in water collections (Figure 6) with about three-quarters (275 out of the total 332 households) and the water is mostly free of charge (Figure 7). Similarly, the study further shows that about 56% (Figure 8) have to trek for about an hour to get water while 90% (Figure 9) of the households affirmed that they have storage for the water they collected. The storage includes large plastic containers and clay pots. The study also revealed that 90% of the respondents indicated that the water type they use for drinking and cooking is perceived to be safer while 21 (6%) chose the particular water source because of easy accessibility while the remaining 14 (4%) chose the particular water because it is cheaper to afford (see figure 5).

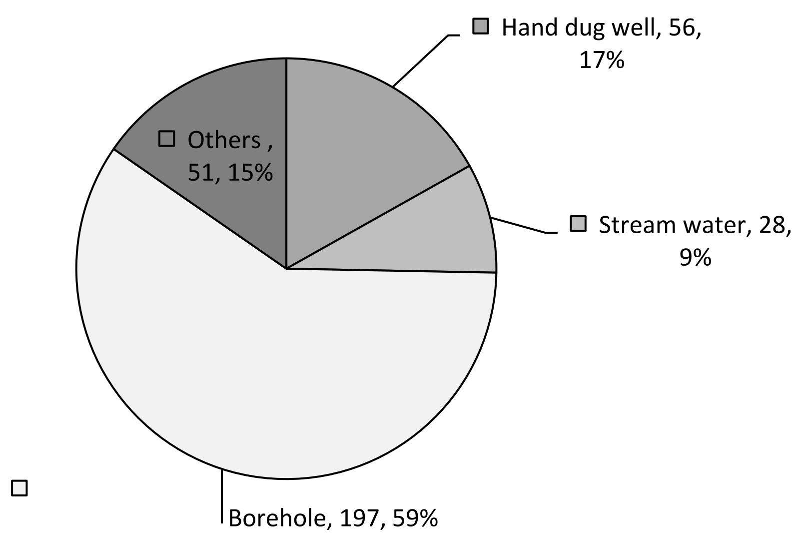

Figure 5 Sources of Water for Drinking and Cooking

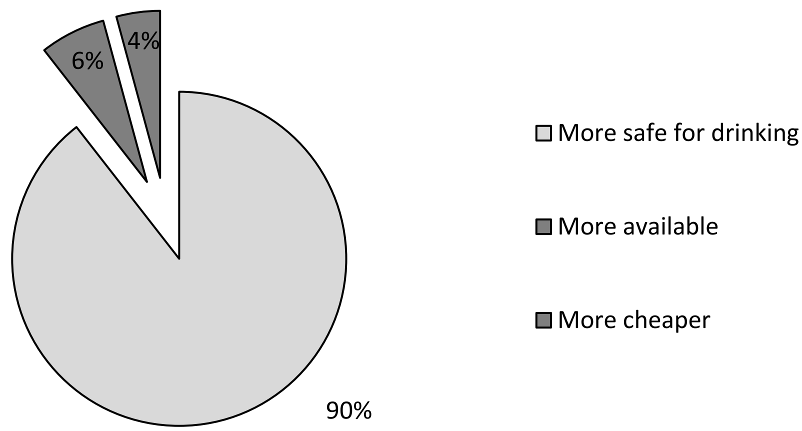

Figure 6 Reasons for Water Source Selection

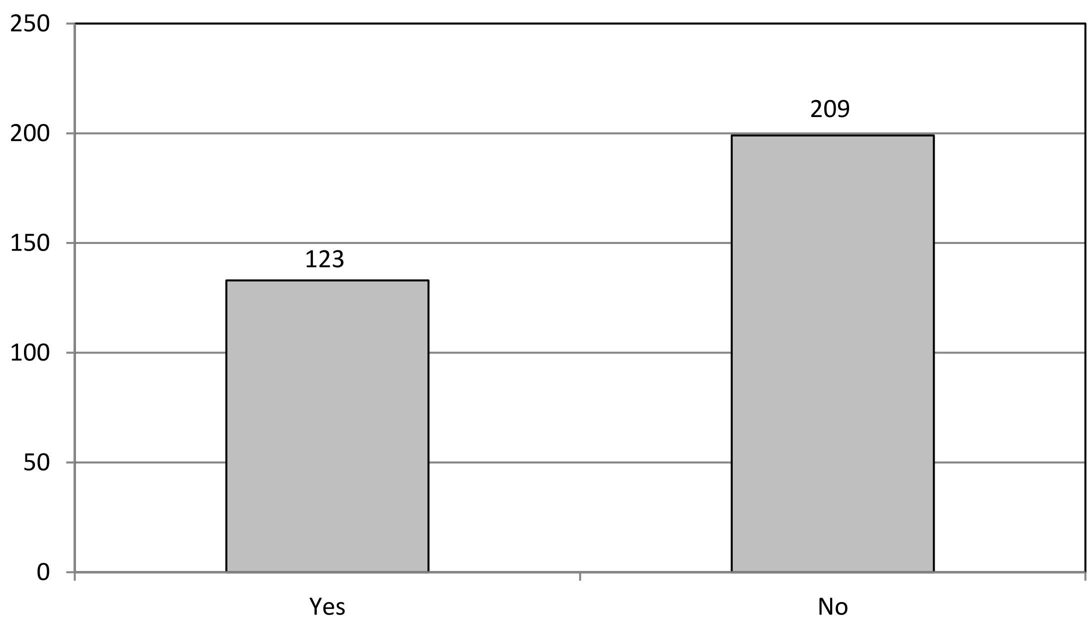

Figure 7 Buying of Water

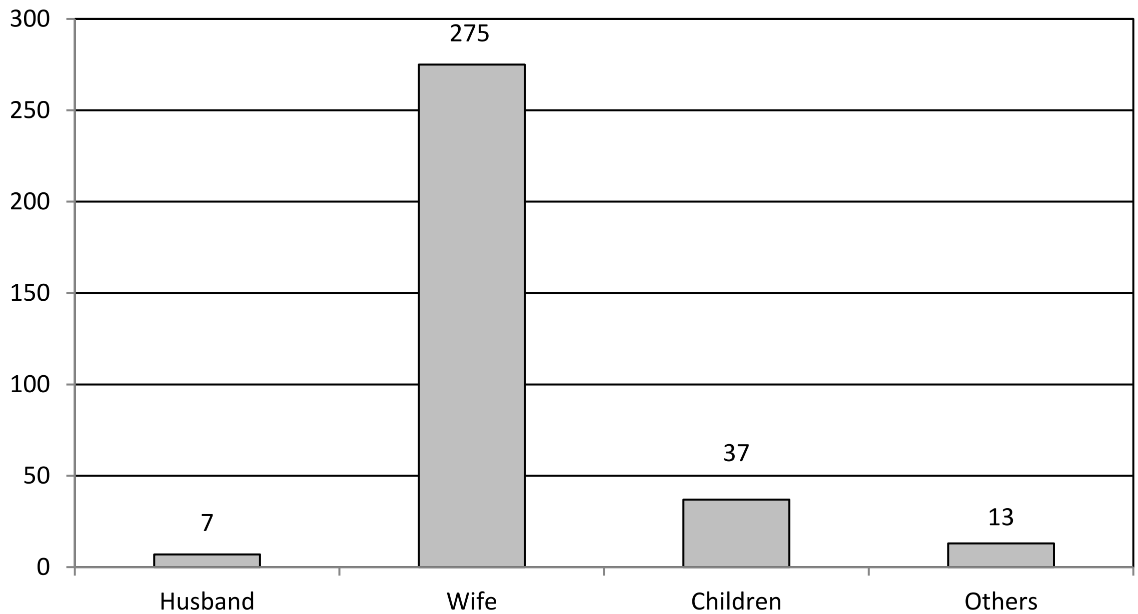

Figure 8 Water Collection Responsibility

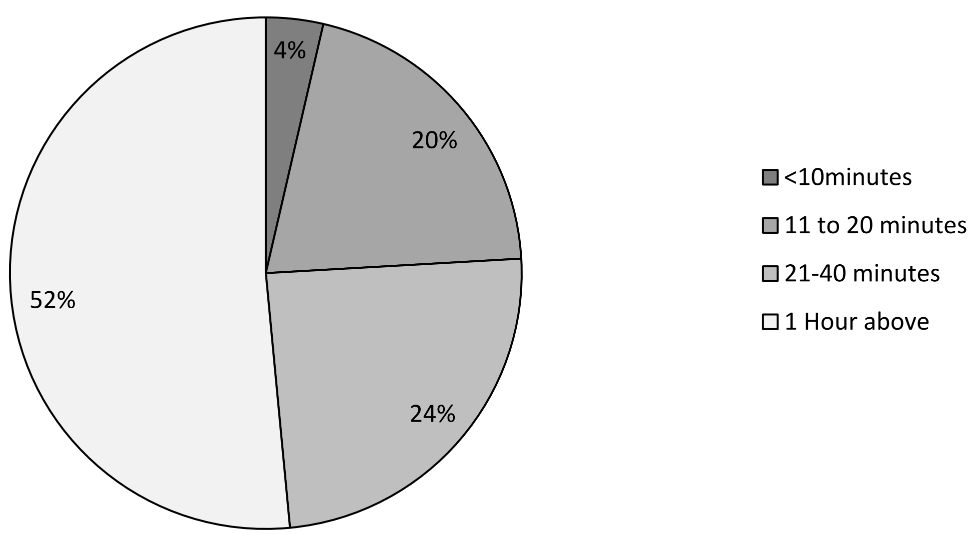

Figure 9 Time Taken for Water Delivery to Households

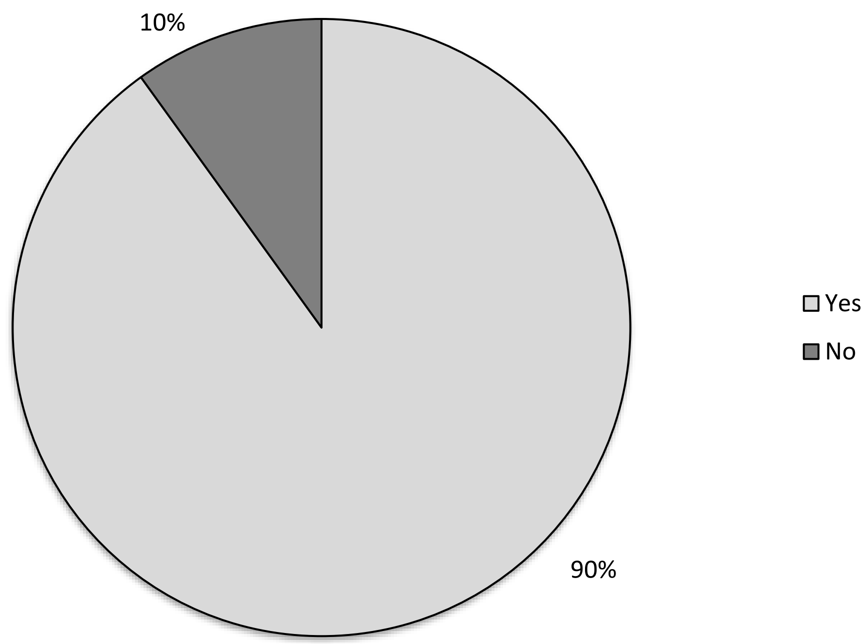

Figure 10 Water Storage Practices

Furthermore, Figure 8 reveals that besides the 52% of the respondents that spend 1 hour and above to get water, 24% of the respondents spent between 21 and 40 minutes to get water, 20% of the respondents spend between 11 to 20 minutes to get water, while 4% of the respondents spent less than 10 minutes to get water. This is due to the proximity to water sources as not everyone is closer to these sources due to the spatial spread of residence. In an area where 52% of respondents spend 1 hour and above to get water, the study shows that they do experience long queues coupled with a mammoth crowd of people struggling to fetch borehole water. Figure 9 further shows that only about 10% of the households do not store water. The reasons for the storage of water by the other 90% of households include reducing their trekking every day in search of water, for sustainability of the households when there are cases of water crisis, to save them from buying from water vendors, and making water available whenever they want to use it. This became necessary due to inconsistency in water supply sources.

In addition, the study also revealed as shown in Figure 10 that about 50.3% of the respondents make use of storage facilities like Jerry cans, 33.1% use buckets 12.7% use overhead tanks, and 3.9% store in pots. The methods of water storage are found to be adopted by the various holds to make water easily available when in need.

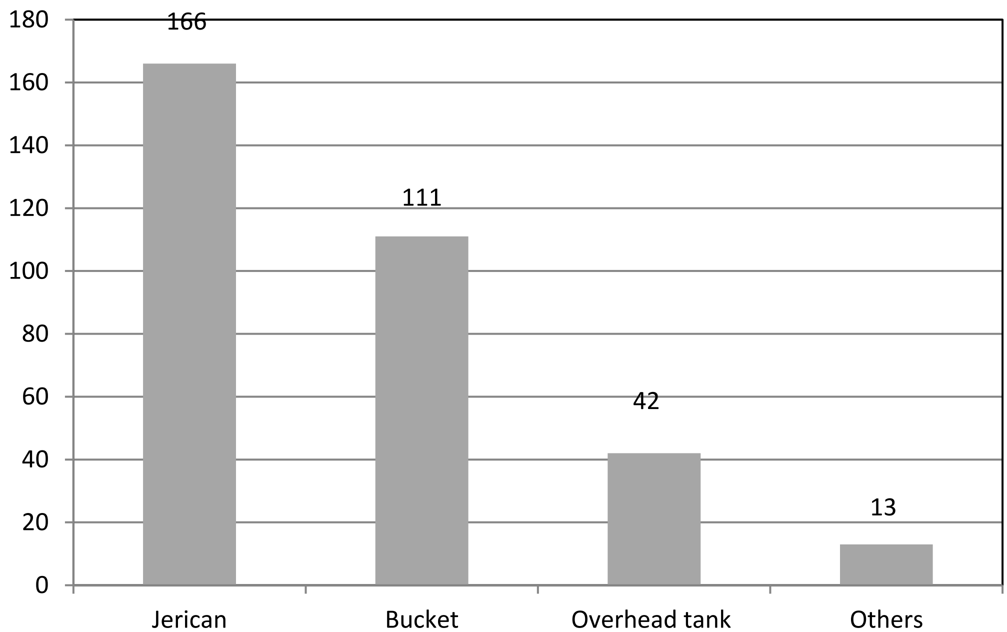

Figure 10 Water Storage Methods

3.3 Determining the Quantity of Domestic Water Demand and Supply

The study investigated the relationship between water supply and demand in the study area using regression analysis techniques. The result is discussed below.

3.3.1Model Validity check

In an attempt to ensure that the results of this study are robust and valid for interpretation, results of diagnostic tests such as the Durbin Watson test, variance inflation factor (VIF), and tolerance statistics performed are presented in Tables 5 and 6 respectively.

Table 4 Correlations Matrix

		Water supply to households	House hold Size	Water demand by households	Distance covered to water sources
Pearson Correlation	Water supply to households	1.000	.786	.679	.773
	Household Size	.786	1.000	.674	.782
	Water demand by households	.679	.674	1.000	.765
	Distance covered to water sources	.773	.782	.765	1.000
Sig. (1-tailed)	Water supply to households	.	.000	.000	.000
	Household Size	.000	.	.000	.000
	Water demand by households	.000	.000	.	.000
	Distance covered to water sources	.000	.000	.000	.
N	Water supply to households	332	332	332	332
	Household Size	332	332	332	332
	Water demand by households	332	332	332	332
	Distance covered to water sources	332	332	332	332

3.3.2 Test for Autocorrelation

The Durbin Watson statistics used to test for the presence of autocorrelation among the variables in this study is estimated at 0.170. This figure is less than 2 (see table 5). This indicates that the assumption of independent error is not tenable for this study since Durbin Watson's statistics are below 2. This result further confirms that the model used in this study does not suffer from the incidence of autocorrelation and as such, there is no possibility of spurious regression (Durbin and Watson, 1951).

Table 5 Model Summary

Model	R	R Square	AdjustedR Square	Std.Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig.F Change	
1	0.852[a]	0.727	0.724	0.322	0.727	290.689	3	328	0.000	0.170

a. Predictors: (Constant), Distance covered to water sources, Water demand by households, Household Size
b. Dependent Variable: Water supply to households

3.3.3 Test for multi-collinearity

The variance inflation factor (VIF) statistics, tolerance statistics, and correlation matrix are used to test for the presence of multi-collinearity among the variables in the model. Concerning the multi-collinearity test using VIF, Table 6 shows the variance inflation factor (VIF). Although there is no formal VIF value for determining the presence of multi-collinearity, values of VIF that exceeds 10 are often regarded as indicating multi-collinearity, but in weaker models, values above 2.5 may be a cause for concern (Kouisoyiannis, 1977;

Gujarati and Sangeetha, 2007).

Bearing the above criteria in mind, the variance inflation factor (VIF) statistics for all the independent variables of this study consistently fall below 5 (see Table 5) this shows the absence of multi-collinearity among the variables. This implies that the model exhibits a low risk of potential multi-collinearity problems as all the independent variables have a variance of inflation factor (VIF) below 4.7. Also, the tolerance values continuously lie between 2.429 and 4.570 (see table 6). Again, this is more than 0.1; this further substantiates the absence of multi-collinearity problems among the independent variables. It is been suggested that tolerance values less than 0.1 almost or certainly indicate a serious collinearity problem (Menard, 1995).

Finally, Table 6 shows the correlation matrix which indicates the absence of multi-collinearity among the explanatory variables. High correlation causes problems with the relative contribution of each predictor variable to the success of the model (Gujarati and Sangeetha, 2007). Thus, the study reveals that all correlation values concerning the study variables are less than 0.78. Therefore, correlation values above 0.78 are considered harmful for analysis (Gujarati and Sangeetha, 2007).

Table 6 Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	0.020	0.074		0.267	0.789					
	Household Size	0.659	0.057	0.620	11.530	0.000	0.836	0.537	0.333	0.288	3.469
	Amount of water demand	0.135	0.036	0.168	3.740	0.000	0.679	0.202	0.108	0.412	2.429
	Distance to water sources	0.106	0.054	0.122	1.975	0.049	0.773	0.108	0.057	0.219	4.570

a. Dependent Variable: Water supply to households

Table 6 presents the model coefficients for all variables used in the study. The regression line as shown in the result above reveals an intercept of .074. This simply implies that when all the other variables are not considered, the Tobin Q ratio (relationship) of the listed variable considered in the study is significantly estimated at 7.4% occasioned by factors not incorporated in this study. However, the result of the estimated model shows that

Household Size and Distance covered by water sources negatively impact on water supply in the study area with beta coefficients of .122 and.620 respectively. This implies that a unit change in Household Size, Distance covered to water sources, and water demand will lead to a significant decrease in water supply at .122 and .620 respectively thus indicating a significant negative impact.

The model also reveals a beta coefficient of.168 units in respect to. This indicates that a unit change in water supply will bring about a significant positive change in the ratio of the above-listed variables in the study area by 168 units respectively.

Test of Hypotheses (T-Test statistics)

A T-test was used to test the significance of the relationship between variables. It was done at a 5% level of significance with an n-l degree of freedom. This was done in line with the decision rule. The results of the three hypotheses stated are analyzed below.

Test of Hypotheses one

$H0_1$: *There is no relationship between household size and water demand and water supply*

In testing this hypothesis, the results in Table 6 reveal that Household size had a t-calculated value of 11.530 and a correspondent significant probability statistic of 0.000 which lies within the 5% level of significance. This leads to the rejection of the null hypothesis and accepting the alternative hypothesis. The study therefore concludes that there is a significant relationship between household size and water demand and supply in the study area.

Test of Hypothesis Two

$H0_2$: T*here is no significant relationship between the amount of water demand and water supply*

The results in Table 6 reveal that the amount of water demand had a t-calculated value of 3.740 and a correspondent significant probability statistic of 0.000 which lies within the 5% level of significance. This leads to the rejection of the null hypothesis. The study, therefore, concludes that the amount of water demand is significant with the amount of water supply in the area.

Test of Hypothesis Three

$H0_3$: *There is no significant relationship between distance covered to water sources and water supply*

In testing the third hypothesis, the results in Table 6 reveal that the distance covered by water sources had a t-calculated value of 1.975 and a correspondent significant probability statistic of 0.049 which also lies outside the 5% level of significance. This leads to the rejection of the null hypothesis. The study therefore concludes that the distance covered by water sources has a significant effect on water demand and supply in the area.

In conclusion, it is noteworthy to state that from the results obtained in this study as shown in Table 6, all the tested variables have significant effects on water demand and supply in the study area.

5. Conclusion

Using GIS techniques, the study identified the locations of water sources in the study area. The study further identified factors responsible for a water supply shortage in the study area including geology, climate and relief, Rapid Population Growth, Seasonality of Water Sources, Absence of Water Infrastructure, Distance to Stream/Spring Water Sources, Non-protection of Stream/Spring Water Sources, Politicizing Water Project, Aging Water Infrastructure, Topographic Constraints, and Inadequate Community Participation. Furthermore, the study revealed that wives (females) are the main gender involved in water collection as compared to their male counterparts. The study also revealed that the sources of water for domestic use are mostly outside and far away from the household's immediate vicinity. The main sources of water include deep boreholes, shallow hand-dug wells and streams, and pipe-borne (public tap) substations. Further, the study reveals that the socioeconomic characteristics of the respondent significantly impact their water demand and supply. Furthermore, the study found that there exists a very high positive linear relationship between the household water demand and water supply, and the water supply by the Nasarawa State Water Board (Made Water Works) which is located in the area is inadequate to meet the demand of households. The study, therefore, recommends, among others, that frantic efforts should be made by both State and Federal governments to expand pipe-borne network coverage to every household in the study area as well as ensure a steady supply of water. However, in the case of the inability of the authorities to achieve 100% household connection to the water network, efforts should be made to strategically and randomly construct public water stations to serve remote areas. Thus, consumers should be encouraged to endeavor to pay their water bills regularly to improve the water supply. However, there is a need to develop more alternative sources of water such as boreholes to provide an alternative when there is a breakdown in the government-operated piped-water network. The people should also devise a way to harvest rain, clean, and store them for different uses as the need may arise, especially during the rainy season.

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This paper DOI: 10.5281/zenodo.10791171
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