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*Full Length Research Paper*

# Determinants of domestic water consumption in a growing urban centre in Osun State, Nigeria

**Ogunbode, Timothy O.[1]* and Ifabiyi, Paul I.[2]**

[1]Faculty of Law, Bowen University, Iwo, Osun State, Nigeria.
[2]Department of Geography and Environmental Management, University of Ilorin, Kwara State, Nigeria.

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**Household access to potable water is required for sanitation and general well-being. This challenge is under the influence of variables that play both temporal and spatial roles. This research examines the determinants of domestic water use in Iwo, Osun State, Nigeria. Ten households each were randomly selected from ten of the fifteen political wards in the town for the administration of 100 copies of questionnaire. Female respondents in the investigation were 84.30%. Factor analysis extracted nine out of the thirty one water use components in the analysis. These variables explain 76.0% of the total variance in domestic water use. Multiple regression analysis shows $r^2$ value of 80.60%. The all-inclusive standardized model generated by stepwise regression analysis showed that five variables are strong predictors of domestic water use in the study area. Water planners need to consider these variables in water supply planning. It is suggested that further investigations be conducted on the quality of water from these sources due to its closeness to the respondents to ensure its fitness for human consumption.**

**Key words:** Domestic water demand, water demand modelling, water accessibility, growing town.

## INTRODUCTION

A timely and spatially accessibility to potable water is salient to human well being. It is considered an essential resource for the possibility of life, regardless of amount or proportion (USEPA, 2000) Even so, urban access to potable water in Nigeria is about 42% in 2008 (WHO and UNICEF, 2010). Thus, several published works have been geared towards the development of predictive models which can be applied to estimate the prospective water use at a given period of time and space, for instance, Xinming et al. (1990), Arbues et al. (2003), Okeola and Sule (2010), Al-Amin et al. (2011), Aper (2011), Ayanshola et al. (2010), Ifabiyi and Ahmed, (2011) and Adeoye et al. (2013) among others. The relevance of water use forecasting according to Cook et al. (2001) and Ifabiyi et al. (2012) are as follows: Firstly, it ensures better water management, secondly, it ensures fair sharing and distribution of this resource thereby preventing crisis often associated with water accessibility,

*Corresponding author. E-mail: taogunbode@gmail.com.

thirdly, water use forecasting assists in overcoming the challenges of urban and suburban growth; fourthly, it assists system optimization which leads to least cost; fifthly, it allows an understanding of the underlining factors that will affect water demand; and lastly, forecasts provide information about the past and future water use. Boumann et al. (1998) listed four main methodologies in forecasting water demand namely per capita and per unit approaches, end-use models, extrapolation methods and structural or causal models. Galan et al. (2009), however noted that the choice of any of these approaches is based mainly on the intended use and time frame of the prediction and the available data.

Thomas (1998) had noted that domestic water use varies according to the living standards of the consumers in urban and rural areas. In addition to this, Al-Amin et al. (2011) also observed that the quantity of water is variable depending on the cultural habit, settlement pattern, typed of supply, water source among others. However, it is observed that the space is not equally endowed with adequate water resources. Some areas are sufficiently endowed with both surface and subsurface water resources as in the tropical areas making the accessibility easier with all other factors held constant. On the other hand, some areas have to invest a lot in other to have water required to keep life going such as in the arid areas (Arab Water Council, undated; Foster et al., 2011).

The challenge of ensuring timely and spatially accessibility to potable water has become an important issue. The reason is that the quality and quantity required for human health and leisure depends on several factors, especially when we try to determine the quantity of water that may be demanded at any point in time at household level (for instance Onda et al., (2012). According to Ayanshola et al. (2010), accurate estimation of water demand should put into consideration variables such as income, population and sex, while Al-Amin et al. (2011) listed cultural habit, settlement pattern, type of supply and water source as water use determinants in homes. Ifabiyi et al. (2012) found in Sokoto, Nigeria that levels of education, income levels and marital status correlated positively with total household water use while time cost and the distance to water points correlated negatively.

Unfortunately, lack of data has been considered as the principal factor hampering proper and adequate water demand estimation especially in the developing nations (Ayanshola et al., 2010). Metering of water use which could have helped in efficient water use is not in use in Nigeria, thus bases for proper definition of the actual water use, according to Bilthas (2008) is lacked. Zhou et al. (2002) and Ruijs et al. (2008) noted that sufficient data is a required tool for planning water demand management and studies. This work is aimed at evaluating the variables that determine domestic water use in a growing urban centre and their strength in forecasting domestic water use. This will invariably assist in result-oriented water demand planning and designing.

## MATERIALS AND METHODS

This study was carried out in Iwo Township (Figure 1). Iwo is one of the 30 Local Government Areas in Osun State, Nigeria. The town has an area of 245 $km^2$ with a population of 191,348 according to (National Population census, 2006). It is located between the coordinate axis of 7°38'N and 4°11'E. Iwo is subdivided into five quarters which are subdivided into 15 political wards (Table 1). The town consists of Muslims, Christians and traditionalist but the former were observed to form the dominant ones. The central part of the town which consists of the palace and other ancient buildings and compounds now incorporates modern buildings (Enclopedia, Britanica). It has witnessed a tremendous increase in the number of people and spatial coverage as a result of the location of Bowen University, a private University owned by the Nigerian Baptist Convention established in 2002 and also, the location of Reality Radiovision Station owned by the Osun State Government among other developmental projects. The most popular periodical market in the town, Odo-Ori Market attracts people from nooks and crannies of Osun State and other neighbouring States. These establishments have led to the influx of people of diverse professions and areas of life into the town. Some of whom have either settled in their own private buildings while others stay in rented apartments or guest houses located within the town. The major source of potable water in Iwo is Aiba Water Reservoir located within Government Forest Reservation Area in the town. The inadequate supply of water from the Water Works has led to the exploitation of underground and surface sources in the town (Olutona et al., 2012).

Multistage sampling technique was used in arriving at the sample size. Ten wards out of which ten households were randomly selected formed the area of coverage for the purpose of this survey. The quarters and the wards selected are shown in Table 1.

Data was collected through the administration of a pre-tested 100 questionnaire among the randomly selected households (see Appendix 1). This work intentionally focused on age groups from 18 to 65 years because they form active category of the age group and so will be able to give relevant information on domestic water use. The data was subjected to factor analysis for normalisation and to determine the factors that explain water use for domestic purposes in the study area. Multiple regression model was applied to generate predictive model of water use in the town. All statistical analyses were performed using SPSS software, Version 16.0, 2007.

## RESULTS AND DISCUSSION

Table 2 shows that about 58.60% are of primary level, 27.30% post primary level, 12.10% are of tertiary level while the remaining 2.00% are other levels, one of which could be Islamic education. Generally, literacy level in Iwo is not different from what is obtainable in Nigeria as a whole, of about 56.9% (UNESCO, 2012). The literacy level is equally high and this has been found to have influence on domestic water use (Ifabiyi, 2011).

Table 3 shows that female gender was 85.9% while the male gender was 14.1%. The investigation focused on heads of households especially women by virtue of their traditional role in water provision for home use. However, the proportion of males in the study was only accommodated where female is not available or indisposed in the course of the investigation. Table 4 shows that respondents that were within the age range of 46 to 65 years were 75.8, 22.2% were from 18 to 45

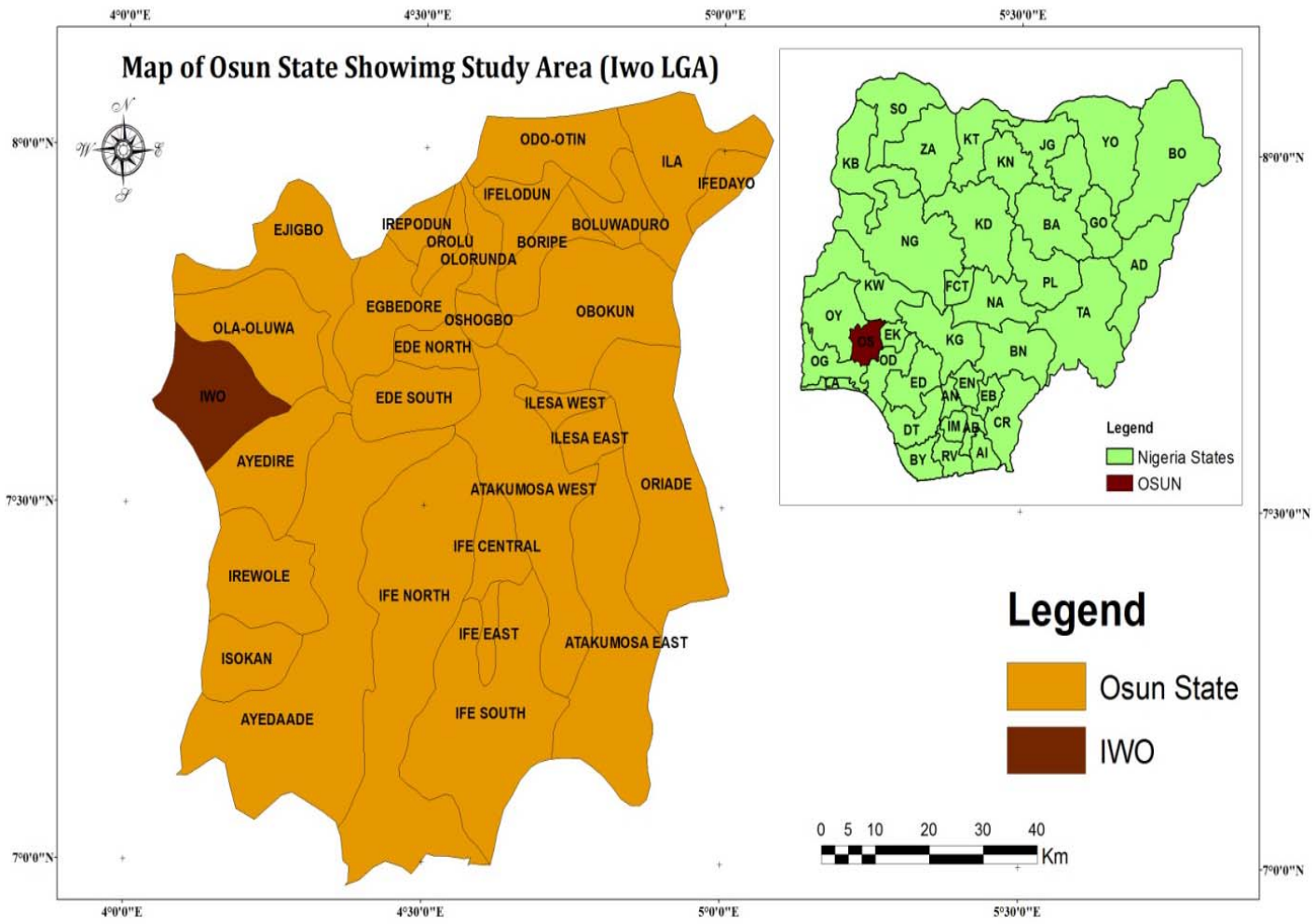


**Figure 1.** Map of Iwo, Osun State, Nigeria.

**Table 1.** Iwo LGA quarters and their respective wards with their selection status.

| S/N | Name of Quarters | Name of Wards | Status |
|---|---|---|---|
| 1. | Gidigbo | Ward One | Selected |
| | | Ward Two | Selected |
| | | Ward Three | Not selected |
| 2. | Isale-Oba | Ward One | Selected |
| | | Ward Two | Selected |
| | | Ward Three | Not selected |
| | | Ward Four | Selected |
| 3. | Molete | Ward One | Not selected |
| | | Ward Two | Selected |
| | | Ward Three | Selected |
| 4. | Oke-Adan | Ward One | Selected |
| | | Ward Two | Not selected |
| | | Ward Three | Selected |
| 5. | Oke-Oba | Ward One | Not selected |
| | | Ward Two | Selected |

Source: Author's field compilation (2013).

**Table 2.** Respondents' distribution by level of education.

| S/N | Level of education | Frequency | Percentage |
|---|---|---|---|
| 1. | Primary | 59 | 58.6 |
| 2. | Post primary | 27 | 27.3 |
| 3. | Tertiary | 12 | 12.1 |
| 4. | Others | 2 | 2.0 |
| | Total | 100 | 100% |

Source: Author's fieldwork (2013).

**Table 3.** Respondents' gender distribution.

| S/N | Gender | Frequency | % |
|---|---|---|---|
| 1. | Male | 14 | 14.1 |
| 2. | Female | 86 | 85.9 |
| | | 100 | 100.0 |

Source: Author's fieldwork (2013).

**Table 4.** Respondents' age distribution.

| S/N | Age distribution | Frequency | % |
|---|---|---|---|
| 1 | <18 | 0 | 0.0 |
| 1. | 18-45 | 22 | 22.2 |
| 2. | 46-65 | 76 | 75.8 |
| 3. | >65 | 2 | 2.0 |
| | Total | 100 | 100.0 |

Source: Author's fieldwork (2013).

**Table 5.** Respondents' religious group distribution.

| S/N | Religious group | Frequency | % |
|---|---|---|---|
| 1. | Christians | 51 | 50.5 |
| 2. | Muslims | 49 | 49.5 |
| | Total | 100 | 100.0% |

Source: Author's fieldwork (2013).

**Table 6.** Respondents' distance to water sources.

| S/N | Distance to water source (minutes) | Frequency | % |
|---|---|---|---|
| 1. | 0-10 | 70 | 69.7 |
| 2. | 11-20 | 28 | 28.3 |
| 3. | 21-30 | 1 | 1.0 |
| 4. | >30 | 1 | 1.0 |
| | Total | 100 | 100.0 |

Source: Author's fieldwork (2013)

years while 2% were 65 years and above. Table 5 shows that Christians form 50.5% of the respondents while Muslims were 49.5%. The proportion of the Christians involved slightly exceeded that of Muslim. Table 6 shows that 69.7% of the respondents were within 10 min trek from water source, 28.3% has maximum of 20 min to water source while the remaining 1.0% have maximum of 30 min to the source. Also, 1.0% have greater than 30 min to water source in the study area. It was observed during the investigation that most homes have their own hand-dug wells or borehole. This reduces the stress of trekking a long distance in search of water. More so, this study was carried out during the rainy season when acquifer yields are appreciable.

**Table 7.** Respondents' sources of water.

| S/N | Source of water | Frequency | % |
|---|---|---|---|
| 1. | Hand-dug well | 92 | 92.0 |
| 2. | Borehole | 8 | 8.0 |
| 3. | Rivers/streams | 0 | 0.0 |
| 4. | Rainfall | 0 | 0 |
| 5. | Pipe-borne | 0 | 0 |
| | Total | 100 | 100.0 |

Source: Author's fieldwork (2013).

Table 7 shows the various sources of water for domestic purposes in the study area. The finding shows that 92% of the respondents claimed to rely on hand-dug wells as their source of water while the remaining 8% get their water from boreholes. None of the respondents claimed relying on surface streams, rainfall and pipe-borne water for domestic water uses probably because it is far from them or the unreliable quality of water from such sources.

## Determinants of domestic water use

The results of factorability show that Kaisser-Meyer-Olkin (KMO) measure of sampling adequacy is 0.69. Bartlet's test of sphericity is significant at 99.00% level of significance. This implies that the data is factorable. Table 8 shows the variables that influence domestic water use as extracted by factor analysis. Analysis revealed that the first two axes explained 31.22% of data variability. The 9 components extracted from the 31 components analysed (Appendix 2) explain 76.00% of the variation in domestic water use in the study area. The components are household size, water supplied by the suppliers, household preference for water source, age range of the suppliers, water supply for dish washing and

**Table 8.** Extracted water use components and their respective factor 350 characteristics.

| S/N | Water use components[1] | Loading[1] | Eigenvalue[2] | Variance (%)[2] | Cumulative (%)[2] |
|---|---|---|---|---|---|
| 1. | Household Size | 0.964 | 5.20 | 16.77 | 16.77 |
| 2. | Quantity Supplied by fetchers | 0.795 | 4.48 | 14.46 | 31.22 |
| 3. | Preference for a source | 0.832 | 2.46 | 7.94 | 39.17 |
| 4. | Age Range of suppliers | 0.801 | 2.26 | 7.30 | 46.47 |
| 5. | Religious Use of water | 0.964 | 2.05 | 6.62 | 53.08 |
| 6. | Water supplied for Dish washing | 0.757 | 2.00 | 6.45 | 59.54 |
| 7. | Water supplied for bathing | 0.708 | 1.80 | 5.89 | 65.35 |
| 8. | Age of Respondents | 0.720 | 1.70 | 5.49 | 70.84 |
| 9. | Gender Composition | 0.642 | 1.60 | 5.16 | 76.00 |

Source: [1] Extracted from SPSS-generated Table 7; [2]Extracted from SPSS-generated total of variance.

Table **9.** Model summary.

| Model | R | R Square | Adjusted R square | Std. error of the estimate |
|---|---|---|---|---|
| 1 | 0.897 | 0.805 | 0.786 | 72.94145 |

Source: SPSS-generated table.

bathing, age of the respondents, religion and gender composition.

The relevance of household size in domestic water use cannot be overlooked. This study revealed that this variable has the highest explanation of 16.77% of variance out of the 9 components. It implies that the larger the household is, the likely the higher the domestic water use. This finding is similar to those of Keshavarzi et al. (2006) and Ayanshola et al. (2010) where household size was observed to be one of the determinants of domestic water demand. Also, the quantity of water supplied by the supplier explains 14.46% of the total variance in domestic water use in the study area. This implies that the more the water supplied by the suppliers or fetchers, the likely the higher the household water use and vice versa, assuming all other factors are held constant. This is similar to the observation of Olajuyigbe (2010) in the south western Nigeria.

In the same vein, household preference for a water source also influences domestic water use in the study area with 7.94% of variance. The observation is the central focus of Vásquez (2011). This factor is relevant where family prefers a particular source for a given home use. This may arise in a situation where a given source is preferred for drinking or washing. Hard water may not be preferred for washing because of it does not foam easily.

Another component extracted is the age range of the suppliers that explains 7.30% of the total variance. Households dominated by young adults are more likely to have more supply of water than those homes dominated by aged or children of less than school age. Religious use of water explains 6.62% of the variance in Iwo. This component, also observed by Ruma and Sheikh (2010), becomes important because of the presence of Muslims in Iwo that use water for ablution purposes.

The supply of water for dish washing and bathing purposes with 6.45 and 5.89% of the total variance, respectively, becomes important in Iwo because the closer the water source the more likely is the higher water supplied for these purposes. Similar observation was made by Environment Agency (2008). Water rationing for these domestic activities may not be relevant as largest proportion of the respondents have maximum of 10 min to water sources. The age component has 5.49% of the total variance. This component may be important especially where the respondent is within the age of working class. Such group of people are likely to use more water for various domestic purposes (e.g. toilet cleaning, lawn watering) which may not be relevant in homes with aged and teenager. The last and the least percentage of variance of 5.16 which is for gender composition. The more the females in a given household, the higher the domestic water use it is likely to be. Females have been found to use more water than their male counterparts. This observation of female gender contribution to domestic water use is similar to that of Xinming et al. (1990).

## Domestic water use modelling

The results of multiple regression analysis as revealed in Table 9, show a high coefficient of determination ($r^2$ = 80.60% ± 72.94 SE) at 95% significance level. This shows that the variables extracted are valid for explanation of variation in domestic water use in the study area.

**Table 10.** Coefficients of the predictors of domestic water use in the study area.

| Model | Unstandardized coefficients | | Standardized coefficients | T | Significance |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | | |
| (Constant) | 476.020 | 7.371 | | 64.584 | 0.000 |
| Water supplied for bathing | 71.976 | 7.408 | 0.457 | 9.716 | 0.000 |
| Age range of suppliers | 65.428 | 7.408 | 0.415 | 8.832 | 0.000 |
| Quantity of water supplied | 61.848 | 7.408 | 0.392 | 8.349 | 0.000 |
| Household size | -59.188 | 7.408 | -0.376 | -7.990 | 0.000 |
| Water supplied for dish washing | 54.299 | 7.408 | 0.345 | 7.330 | 0.000 |

Source: SPSS-generated table.

The data was further subjected to stepwise regression analysis. The model which was generated show that five components were strong predictors of domestic water use in the study area. These are water supply for bathing, age range of fetchers, quantity of water supplied, household size and water supply for dish washing. Equation 1 shown is valid at 95% level of significance ($R^2$= 79.5% and S.E=73.34): The coefficients of the variables are presented in Table 10. The standardised model generated is presented in equation below:

$$Y = 476.02 + 0.457_{BAT} + 0.415_{AGR} + 0.392_{QTS} - 0.376_{HSZ} + 0.345_{DSW}$$

Where: Y is the predicted daily total household water use, BAT is water supplied for bathing, AGR is age range of water suppliers/fetchers, QTS is quantity of water supplied, HSZ is the Household size, and DSW is water supplied for dish washing.

## Conclusion

An investigation into the determinants of domestic water use in Iwo, a growing city in Osun State, Nigeria has been examined. The results of descriptive statistics showed that females form the larger proportion of the respondents and 98.00% have maximum of 20 min to their various water sources. Also, the dominant sources of water of 100% of the respondents are hand-dug wells and boreholes. Factor analysis extracted nine water use components out of the 31 components involved in the analysis. The nine components explain 76.00% of the variations in domestic water use in the study area. Multiple regression analysis shows a high $r^2$ value of 80.60%. The all-inclusive model generated from stepwise regression analysis show that five water use components are strong predictors of domestic water use. Daily household water use model derived is valid at 95% level of significance ($r^2$= 79.50% ± 73.34SE). The components are water supply for bathing, age range of water suppliers/fetchers, quantity of water supplied, household size and water supplied for dish washing.

In conclusion, it is evident from this study that domestic water use on daily basis in Iwo is not static but rather under the influence of certain variables. The implication of the results here is that policy makers in urban water supply planning should incorporate such variables as discovered here in water supply planning for its sustainability. However, since water sources were observed to be within the reach of the respondents, it is suggested that investigation be conducted on the reliability of water sources in terms of its quality to ensure its conformity with the standard recommended to safeguard human health.

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**Appendix 1.** Questionnaire on the determinants of domestic water demand in a growing city in Osun State, Nigeria.

**Section A**

1. Name of Ward_____
2. Level of Education: A No education___. B. Primary___C. Secondary____D. Tertiary___E. Others___
3. Sex: Male_____Female____
4. Age:A. <18_____B.19-45_____C. 46-65____ D>65___
5. Household size A. <5____B. 6-10____C. 11-15____D. 16-20____E. >20_____
6. Type of the House: Traditional Compund___ B. Modern Self-Contained____
7. Number of Rooms in your house A. 2__ B. 3___. C. 4___ D. 5____ E.>5___
8. No of Females in the family_____ No of Males in the family_____
9. No of Children of school age in the family A. <3___ B. 4-6____ C. 7-9___ D. >9____
10. Occupation A. Farming___ B. Trading___ C. Civil Service___ D. Others ___
11. What is your monthly gross income? A.<N10,000____B. N10,000- N25,000____
C. N26,000 – N40,000_____D.N41,000-N55,000_____E. >N55000_____
12. What is the distance of the nearest water source to your house?___

**Section B: Kindly complete the table below appropriately.**

| | Micro-component uses | Quantity of household water use per day (in litres) | Sources of water (Please tick appropriately) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | River | Pipe-borne | Hand-Dug Well | Powered bore hole | Rain water | Vendor | Bottled/ sachet water |
| 13. | Drinking | | | | | | | | |
| 14. | Cooking | | | | | | | | |
| 15. | Bathing | | | | | | | | |
| 16. | Cloth Washing | | | | | | | | |
| 17. | Dish washing | | | | | | | | |
| 18. | Toilet flushing | | | | | | | | |
| 19. | Car washing | | | | | | | | |
| 20. | Others | | | | | | | | |

21. Is your house connected to a running pipe borne water ? Yes_____ No_____
22. Which of these sources is located within your house? Hand-dug well___Borehole___Tap water.___
23. Do you conserve water? A. No____ B. Yes____
24. If yes to question 19, how do you conserve water?
A. Drums_____B. Overhead tanks_____C.underground tank____D.others_____
25. If No, to question 19, why? A. water runs 24hrs/day___B.No container____ C.Distance of the water source_____
26. How often do you fetch water? A. Daily___B. every 2days___C. Every 3days___D. weekly___
27. How long does it take you to collect water for home use?
A. <10minutes ____B. 11-20minutes____C. 21-30minutes____D. >30minutes._____
28. Do you pay for water? Yes_____ No_____
29. If yes to 25, how much do you pay monthly?A.<#250__B. #250-#500__
C. #500-#750___ D. >#750____
30. How often does your tap run? A. Daily____ B. Once a week___ C. Twice a week D. weekly
31. Which of the sources will you prefer? A. Hand-dug well____B. Borehole___C. Stream/river____D.Pipe Borne____
32. State the reason for your choice in No 27 _____
_____
33. Is your water source reliable'? A. Yes_____ B. No_____
34. If your answer in 31 is No, can you please give the reason? _____
_____
35. Who is responsible for fetching water in your family? A. Females___ B. children____ C. Men_____
D. Vendors____ E. All of the above_____
36. What is the age range of those family members that are responsible for fetching water in your family?
A. 5-12yrs____B. 13-18yrs____C.18-25yrs___D. >25yrs____
37. How many litres of water would they fetch in a day?
A. <50litres ____ B. 51-100litres____C. 100-150litres____D. >150-200litres_____E. >200litres
38. What time of the day do you use more water? A. Morning time___ B. Afternoon time___ C. Evening time_____
39. Give your general view of the water supply situation in your village A. Adequate__B. Inadequate__ C. Poor____

**Appendix 2.** Water use components analysed.

| |
|---|
| 1. Level of education |
| 2. Sex |
| 3. Age of the Head |
| 4. Household size |
| 5. Religion |
| 6. No of females |
| 7. No of males |
| 8. No of children |
| 9. Monthly Income |
| 10. Distance from source |
| 11. Reliability of the source |
| 12. Water supply for drinking |
| 13. Water supply for cooking |
| 14. Water supply for bathing |
| 15. Water supply for cloth washing |
| 16. Water supply for dish washing |
| 17. Water supply for sanitation |
| 18. Water supply for car washing |
| 19. Other uses |
| 20. Time spent |
| 21. Price of water |
| 22. Tap availability |
| 23. Source preference |
| 24. Regular supply of water |
| 25. Reason for the regularity |
| 26. Reliability during dry period |
| 27. Reason for reliability (dry) |
| 28. Alternative source |
| 29. Age range of fetchers |
| 30. Quantity fetched by the fetchers |
| 31. Respondents' view on water accessibility. |