

*Full Length Research Paper*

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

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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, type 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 order 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<sup>2</sup> 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

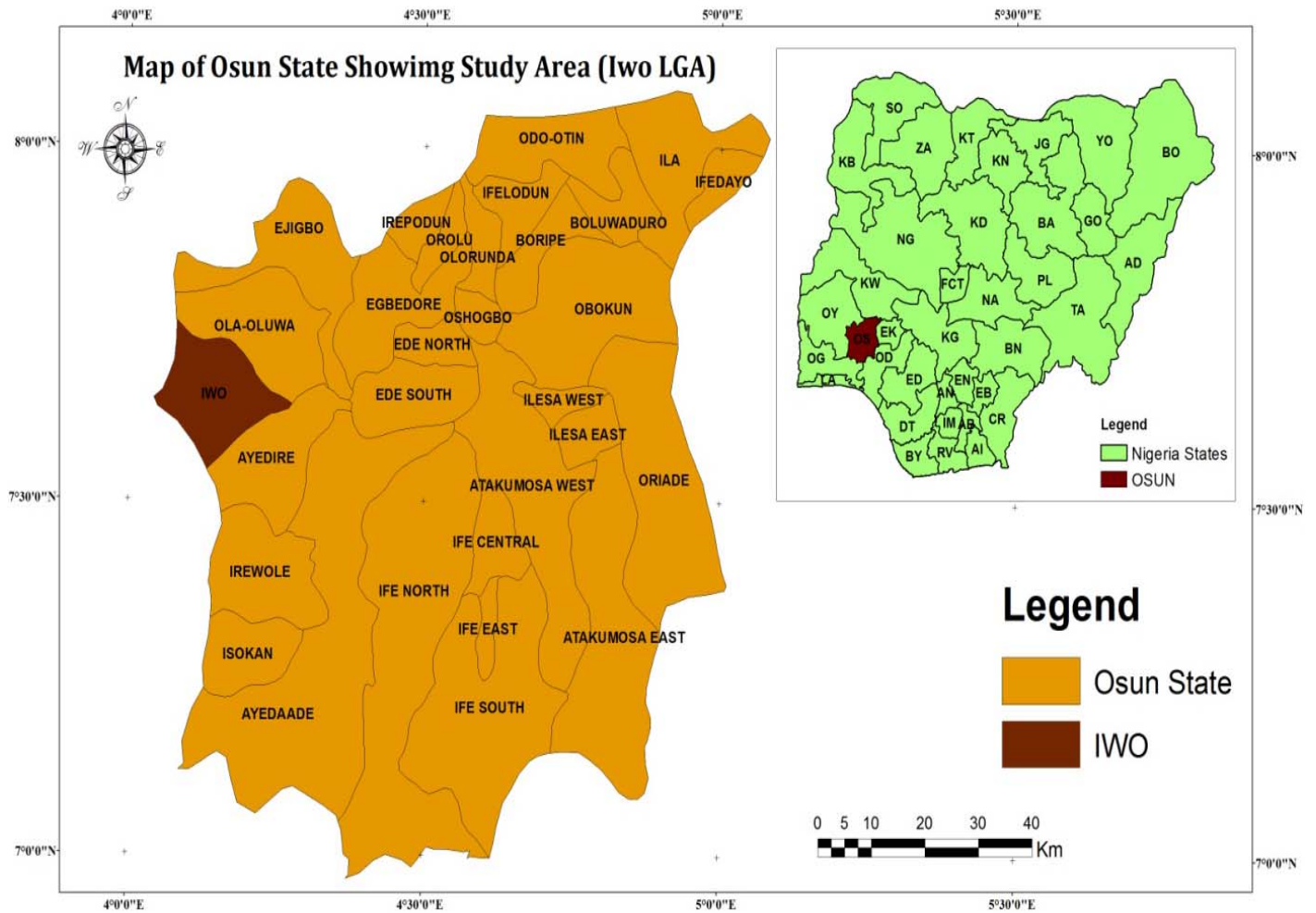


Figure 1. Map of Iwo, Osun State, Nigeria.

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
	Total	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

**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).

trekking a long distance in search of water. More so, this study was carried out during the rainy season when aquifer yields are appreciable.

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 Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is 0.69. Bartlett'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 <sup>1</sup>	Loading <sup>1</sup>	Eigenvalue <sup>2</sup>	Variance (%) <sup>2</sup>	Cumulative (%) <sup>2</sup>
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: <sup>1</sup> Extracted from SPSS-generated Table 7; <sup>2</sup> 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 ( $r^2 = 80.60\% \pm 72.94$  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 ( $r^2= 79.50\% \pm 73.34SE$ ). 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.