MODELLING FORMAL AND INFORMAL DOMESTIC WATER CONSUMPTION IN ACCRA

A PROJECT OF THE UNIVERSITY OF LEEDS ON BEHALF OF

WATER AND SANITATION FOR THE URBAN POOR

Heather Purshouse, Matthias Javorszky, Philip Antwi-Agyei, Andrew Sleigh, Barbara Evans

DRAFT

21-10-15

Acknowledgments

This research project and fieldwork for this report was funded by WSUP, Water and Sanitation for the Urban Poor.

The authors would like to thank all interviewed officials, the participants in focus group discussions and all surveyed households for their time and co-operation in conducting this research.

Contents

Table of figures

List of tables

List of abbreviations

DHS – Demographic Health Survey

GDP – Gross Domestic Product

GWCL – Ghana Water Company Limited

lpcd – litres per capita per day

WSUP – Water and Sanitation for the Urban Poor

1 Introduction

Despite access to adequate amounts of clean water being crucial to health and development, there are still 748 million people worldwide without access to improved sources of drinking water (WHO and UNICEF, 2014). Drafts of the post-2015 development goals indicate that improving access for these remaining people is a global development priority. However, fresh water resources in many regions are simultaneously coming under increasing pressure from factors such as pollution, population growth and climate change (Khatri et al., 2009). Cities in the developing world in particular are growing rapidly whilst their infrastructure struggles to keep pace with the numbers of people it is required to serve. Furthermore, as economies grow and standards of living rise, increasing numbers of people are looking to improve their level of water access and obtain connections to piped water networks (Nauges and Whittington, 2010). According to the Joint Monitoring Programme (JMP), '*approximately 70% of the 2.3 billion people who gained access to an improved drinking water source between 1990 and 2012 gained access to piped water on the premises*' (WHO and UNICEF, 2014). There is also increasing pressure worldwide on city utility companies to improve their coverage and quality of service (Banerjee and Morella, 2011). As yet it is unclear what effect these changes will have on city water resources, however it is important that projections are made to anticipate and prepare for their results.

This research project aims to quantify the relative impact of improved water service provision in slum areas within the context of a water basin serving a city. Impacts for consideration include the overall volume of water, energy use in water production and overall costs of production. For the purposes of this analysis we are interested in the implications of supply changes in housing areas where regular utility water supplies piped to the home are not available – hence the scope lies beyond slums and may incorporate low-cost public and private housing with legal land tenure in addition to informal and unplanned settlements and temporary shacks. The research question is therefore the following:

If a city improves water services in slum districts city-wide, what will be the increased water requirement, and what is the magnitude of this increase relative to other competing demands? How will the net increase in water requirement be affected by different implementation scenarios?

Improvements of water supply services can be broken down into two main dimensions: accessibility (e.g. whether the water source is located inside the home, in the yard, or elsewhere) and reliability (e.g. whether water is available for more or less than a certain number of days per week or hours per day, and whether or not these can be predicted in advance). This can be visualised in the table below, which was developed by water@leeds (2013) in order to portray different levels of water supply service and the steps that can be taken to improve them.

Table 1: Accessibility and reliability of water supplies (Source: water@leeds, 2013)

Water supply is…	Predictable		Unpredictable	
	Available > x days per week	Available < x days per week	Available > x days per week	Available < x days per week
At home	*Highest level of service*			
In the yard				*Increasing accessibility* ↑
Delivered to home				
Carried to home	←	*Increasing reliability*		*Lowest level of service*

In most low-income rapidly growing cities in the global south the impact of such improvements is likely to be high, given that a significant proportion of the population reside in slums and informal and low-cost housing areas with very low levels of service. In Dhaka for example it is estimated that as much as 65% of the population within the utility service area do not receive piped water at home from the water utility. A recent review of water infrastructure in Africa estimated that typically utilities provide service in only about 70% of their service area and that demand-side constraints result in fewer than 45% of the population actually connecting (Bannerjee and Morella, 2011).

Within this context, the main objectives of this project are: firstly, to understand the resultant changes in consumption when populations move between cells in Table 1; and secondly, to find how the population of a city is distributed within Table 1 at the moment. The effects of moving the population of the city around on Table 1 can then be simulated, and the results shown in the context of the city's water balance. For this study, the city of Accra has been selected for use as a case study to examine these objectives.

2 Background

Accra is the capital and largest city of Ghana. The Greater Accra Metropolitan Area had population of 4 million in 2010 and that figure is expected to double by 2030 (Government of Ghana, 2012; Adank et al., 2011). Accra's neighbourhoods are marked by economic and ethnic segregation (Agyei-Mensah and Owusu, 2010), which are important to any consideration of service and infrastructure disparities across the city (Lundehn and Morrison, 2007).

Ghana has been called a "model for democracy" in Africa by Barack Obama (Karimi 2012), and in recent years the country has also made significant economic strides. In 2012 its GDP growth rate was 7.4% (Ghana Statistical Service, 2013). Recently, Ghana declared success in halving the proportion of its population without access to improved water sources, in advance of the 2015 Millennium Development Goal target date (National Development Planning Commission, 2015). The country has abundant water resources which when managed properly could provide adequate water supply for its people. However, despite those abundant water resources, many cities including Accra experience chronic water shortages due to uneven distribution of rainfall, prolonged drought, and poor water resource management (Nsiah-Gyabaah, 2001).

Accra is supplied with potable water from two water treatment plants (WTPs): the Kpong WTP (supplying the eastern peripheries), which receives water from the Densu River; and the Weija WTP (supplying the western peripheries) which receives water from the Volta River. Accra's municipal drinking water system is run by the Ghana Water Company Limited (GWCL). However, the supplies are inadequate to meet the demand, both with regard to quality and quantity (Adank et al., 2011). The water supply systems in Accra is overwhelmed by population growth. Adank et al. (2011) reported that the water supply system in Accra was capable of meeting only 71 to 81% of demand in 2007. Piped network supplies reach about half of Accra's residents directly (Van-Rooijen et al., 2008; Ainuson, 2010), while the remaining population depends on intermediary providers such as water kiosks (Adank et al., 2011). Water shortages are not driven by lack of surface or ground water, but are attributable to production and distribution limits, poor governance and improper resource management (Nsiah-Gyabaah, 2001). The rate of non-revenue water in Accra is as high as 60% (Fichtner et al, 2010), with approximately half of these losses occurring through leakages (Abraham et al., 2007).

Water supply infrastructure in Accra has not been significantly expanded since the 1980s, despite considerable population growth. As a result, water rationing began when Ghana Urban Water Ltd. (a subsidiary of the GWCL) instituted a program for water distribution within city limits (Van-Rooijen et al, 2008). Water rationing varies by neighbourhood both geographically and socio-economically with users receiving water for five days a week on average (Stoler et al 2012).

Due to water rationing and lack of direct connections, a large portion of Accra's population rely on alternative sources of drinking water such as vendors or tankers (Stoler et al 2012). Harris and Morinville (2013) examined a low-income neighbourhood in Accra, and reported that 47% of households access water in this way. Only 4% of households in these areas were reported to have an in-home water connection, whilst 16% of households accessed water from an in-yard connection (Harris and Morinville, 2013).

It can be seen that there is considerable scope for improving the quality, quantity and equity of water supply services in Accra. However, the sustainability of any such improvements within the constraints of the city's water resources requires careful attention.

3 Methodology

3.1 Secondary data review

Secondary data was reviewed to identify spatial patterns of water access across Accra and to obtain general background information about the city. The review covered both academic and grey literature, and gathered two micro-datasets which are described below:

Ghana Population and Housing Census

The Ghana Population and Housing Census was most recently produced in 2010 by the Ghana Statistical Service. The census data is publicly available and can be disaggregated to a number of municipal and metropolitan areas making up the Greater Accra Metropolitan Area. As part of the census, households are asked to identify their main source of water from a number of options. Together with data from the Demographic Health Survey (DHS) (described below), this data was used to populate the simulation spreadsheet with the percentage of population using certain water access categories at the city level.

Demographic Health Survey - Ghana

The Demographic Health Survey (DHS) is designed to monitor health and population issues, and was most recently carried out in Ghana in 2008. A total of 1481 households were surveyed within the Greater Accra Metropolitan Area. As part of the survey, respondents were asked to specify their drinking water source, household-use water source, and the time taken to collect water. Micro-data can be disaggregated to household level and sorted by region. This data was used to triangulate water access patterns from census data and gain further information on access categories which were not covered in the census, such as water collected in sachets.

3.2 Fieldwork

Fieldwork was carried out in Accra for 3 weeks in March 2014. It was led by Dr Philip Antwi-Agyei from the University of Leeds who worked with a number of Ghanaian partners with local expertise and data collection experience. The purpose of the fieldwork was to ground-truth secondary data on spatial access patterns, and gather average consumption information and demographics for different water access categories. Fieldwork techniques included household questionnaires, interviews with utility staff and informal service providers and focus group discussions. Sample sizes were not large enough to be statistically representative of the entire city due to time and resource constraints. However, the results are still of indicative value and can be used to show trends as well as patterns in the data.

3.2.1 Household questionnaires

Ten neighbourhoods displaying different socio-economic characteristics and housing types were selected for inclusion in the study. The neighbourhoods covered were: Agbogba, Adenta, Abokobi, Ashaley Botwe, Ashongman, Haatso, Lapaz, Madina, Pantang; and Teiman.

Photos from some of the neighbourhoods studied are shown below in Figure 1 to Figure 4. Photos of the other neighbourhoods could not be obtained due to logistical constraints. Figure 5 shows the location of the neighbourhoods on a map of Accra.

Figure 1: Photos from Abokobi (source: author's own)

Figure 2: Photos from Adenta (source: author's own)

Figure 3: Photos from Agbogba (source: author's own)

Figure 4: Photos from Ashongman (source: author's own)

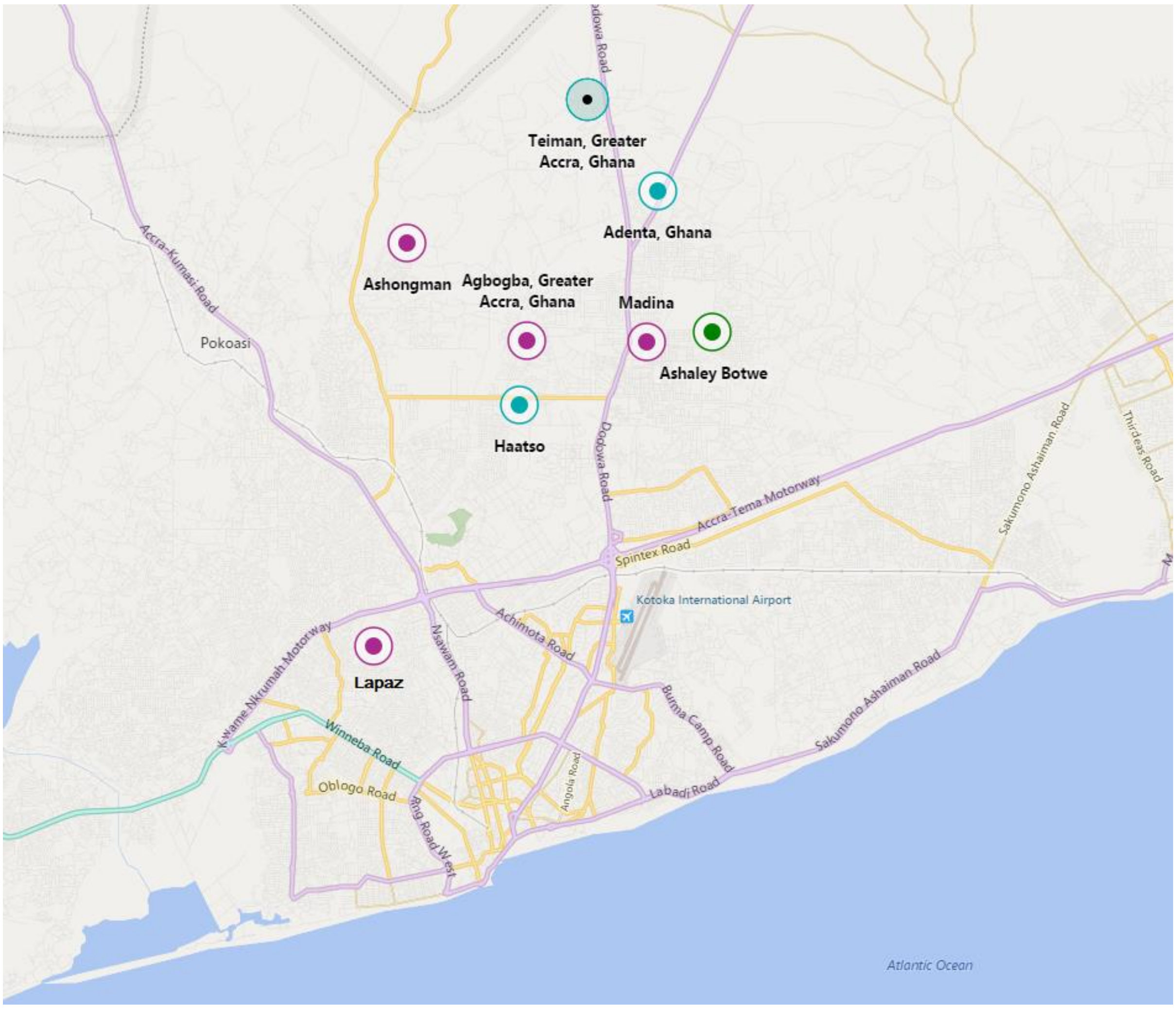


Figure 5: Map of Accra with studied locations (source: Bing maps)

A total of 97 household questionnaires were carried out in the ten neighbourhoods with the aim of gathering information on water accessibility, reliability and consumption patterns. Copies of the questionnaires used, interviewer guidelines and information sheets are given in Appendix 1. Questionnaires were written in English, but administered by persons fluent in both the local language and English.

Key variables gathered include:

- Demographics;
- Household characteristics;
- Primary, secondary and tertiary sources of water for drinking and household uses;
- Average daily consumption of water;
- Time taken and distance travelled to collect water;
- Cost of water;
- Water storage available within the household.

A full list of variables is provided in Appendix 2. Household wealth was approximated by completing a separate questionnaire based on the approach used in the most recent DHS survey of Accra, which gathered information on household wealth indicators.

The questionnaire includes a separate estimation of water use in the rainy and dry season. However, fieldwork was carried out during the dry season, and it is likely that respondents could not accurately recall their consumption behaviour in the rainy season. It was therefore decided to only analyse water consumption for the dry season.

As directly asking respondents about their water use in litres per day would likely not lead to accurate data, consumption for users collecting water was estimated by the interviewers by establishing the size of containers and the number of times they are filled per day. This was cross-checked and triangulated with the expenditure on water and daily or weekly water usage by activity. For users with household connections and yard taps, the consumption was calculated by estimating the size of storage containers and the number of times they are filled per day or week. It has been observed that many respondents with piped connections seemed unsure of their water consumption and found it difficult to make an estimation of average consumption off-hand. Therefore, consumption values for these groups were back-calculated using their average monthly water bills and the NCWSC tariff, and checked against stated consumption values, as well as water usage by activity. The interviewer guidelines on how to estimate quantities can be found in Appendix 1.

3.2.2 Household wealth assessment

Household wealth - as assessed using proxy variables of asset ownership – has been proven to be a more robust indicator of the financial stability of a household than income (Rutstein and Johnson, 2004), and was therefore the method chosen to estimate the finances of households for this study. The method involves asking households to identify which assets they own from a list, recording the number of people per sleeping room, and observing housing materials. The list of assets used as income indicators is termed the 'wealth index', and ranges from basics such as a bed, tables, and chairs to more expensive items such as washing machines and refrigerators. A wealth score for each household is derived from the wealth index by assigning weightings to each item through Principal Component Analysis, which is a statistical technique designed to identify underlying patterns in a large number of variables. These weightings are then multiplied with the value of the variable (which could be a binary value of '1' for 'owned' and '0' for 'not owned', or a numerical value such as '3 people per sleeping room') and the results are summed to produce the wealth score for each household.

It is important to acknowledge that the way in which an asset represents wealth can be very country-specific; for example, a bicycle may not have the same value in a mountainous country as in a flatter country (Rutstein and Johnson, 2004). For this study, the asset list for the income indicators questionnaire was taken from the most recent DHS survey in Ghana, to ensure that the list was appropriate for the country.

3.2.3 Focus groups

One focus group was carried out to gather qualitative information on perceptions and opinions relating to water supply in the studied neighbourhood.

3.2.4 Expert interviews

Expert interviews were conducted in order to ascertain information about the water network and planned improvements to it. The following people were interviewed:

- Regional Production Manager, Ghana Water Company Ltd;
- Regional Distribution Manager, Ghana Water Company Ltd;
- District Manager (Accra East District Office – Legon), Ghana Water Company Ltd;

- Five private water vendors.

3.3 Data analysis

Once data had been collected, the ranges and averages of variables (categorical and continuous) were checked and outliers flagged and/or removed. Consumption data was aggregated for each household and converted to units of litres per capita per day (lpcd).

Data analysis involved the following:

- Data cleaning and characterisation;
- Identifying correlations within consumption-related variables;
- Checking for statistical differences in consumption between access categories;
- Constructing regression models with consumption as the dependent variable;
- Calculating average consumption values for each level of access;
- Carrying out factor analysis on consumption-related variables to identify patterns; and
- Triangulating findings with previous work.

3.4 Scenario testing

A spatial picture of Accra's domestic water consumption can be constructed at a sub-city level using data on the percentages of Accra's population falling into different access categories, and the average consumption values of people within these access categories. Water supply improvement scenarios can then simulated by moving groups of the population from one access category to another. Scenario testing was carried out using a purpose-built spreadsheet created by the project team in Microsoft Excel 2013, containing macros written in Visual Basic for Applications (VBA). Screenshots of the spreadsheet are shown in Figure 6, 7 and 8.

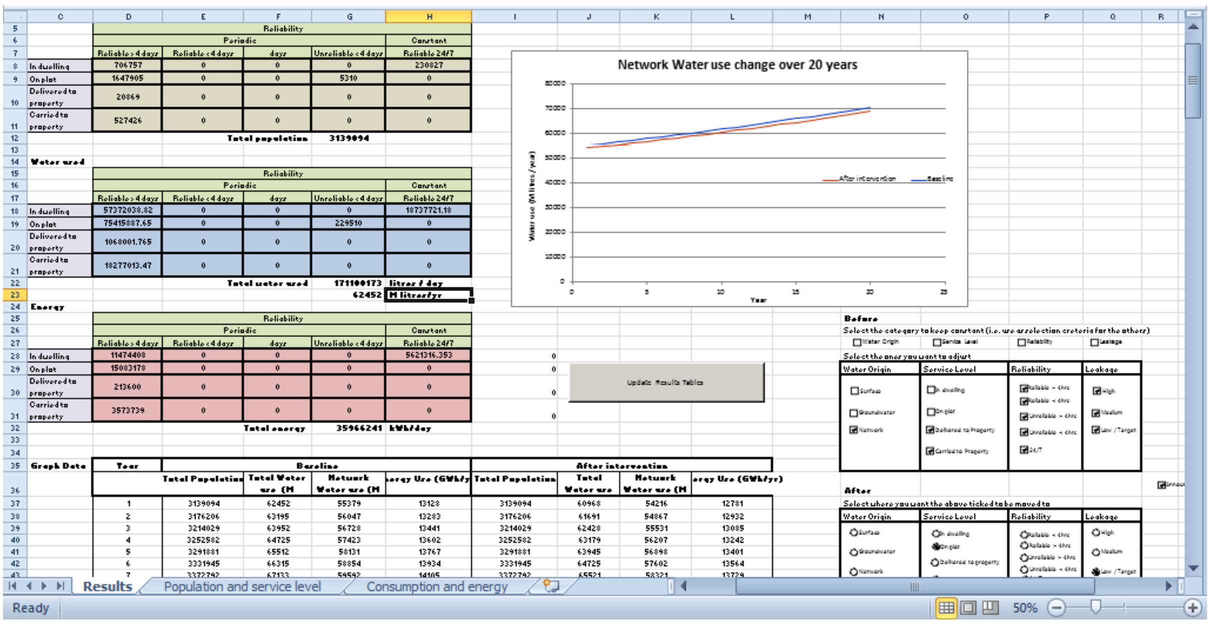
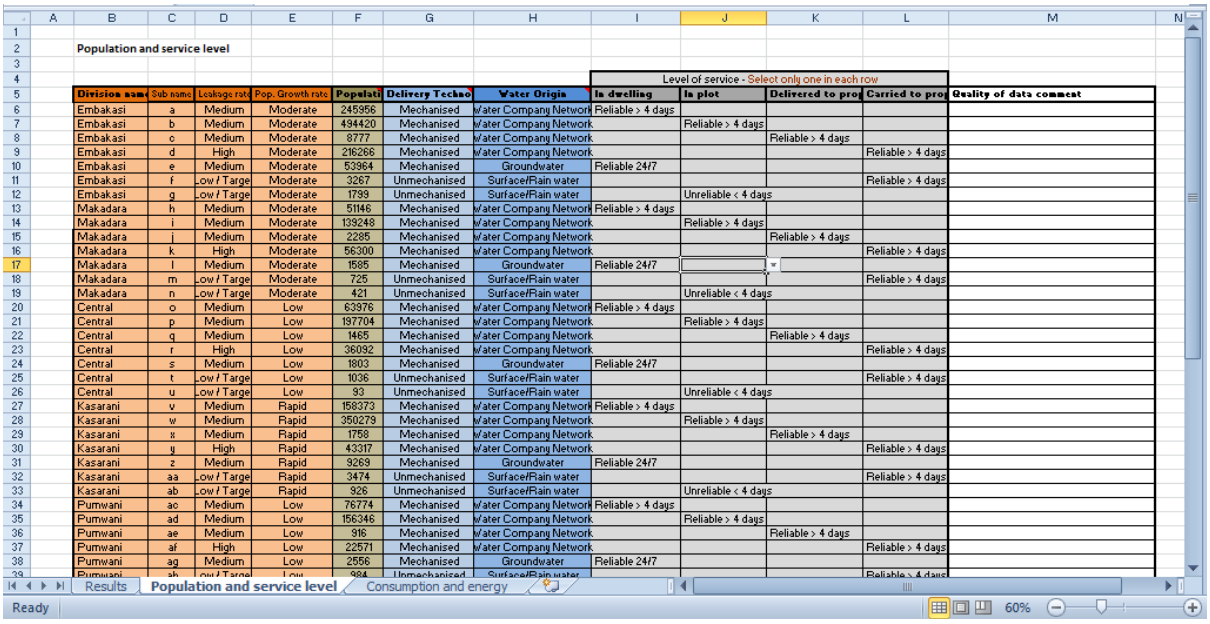
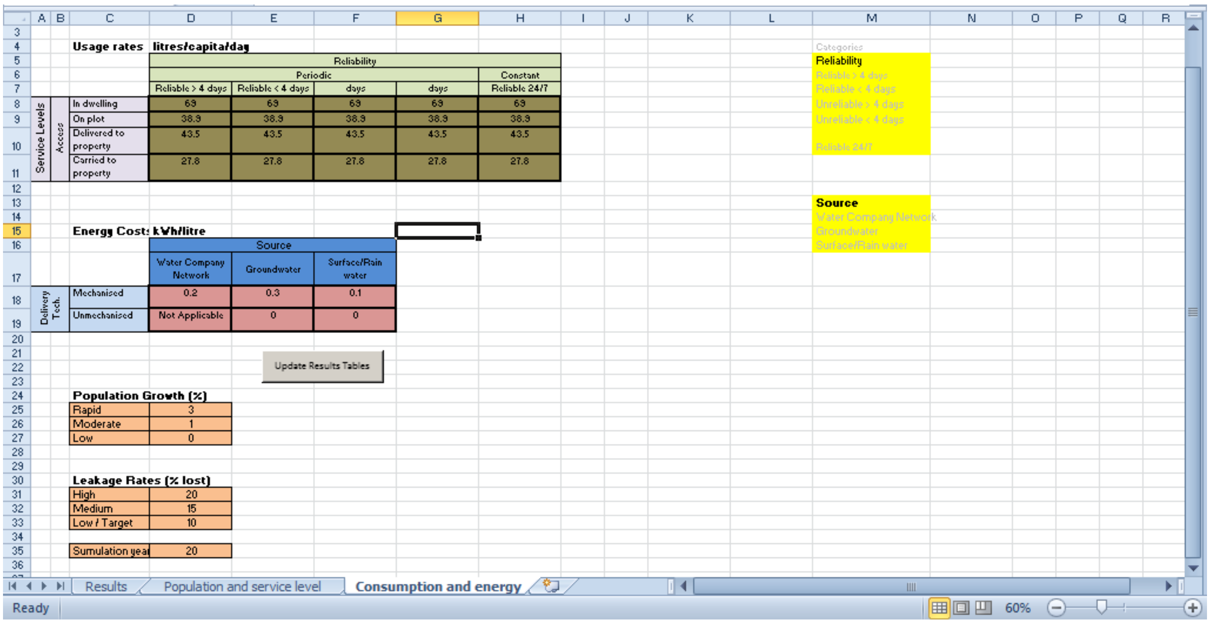


Figure 6: Simulation spreadsheet, results tab



							Level of service - Select only one in each row				
Division nam	Sub name	Leakage rat	Pop. Growth rate	Populati	Delivery Techno	Water Origin	In dwelling	In plot	Delivered to pro	Carried to pro	Quality of data comment
Embakasi	a	Medium	Moderate	245956	Mechanised	Water Company Network	Reliable > 4 days				
Embakasi	b	Medium	Moderate	494420	Mechanised	Water Company Network		Reliable > 4 days			
Embakasi	c	Medium	Moderate	8777	Mechanised	Water Company Network			Reliable > 4 days		
Embakasi	d	High	Moderate	216266	Mechanised	Water Company Network				Reliable > 4 days	
Embakasi	e	Medium	Moderate	53964	Mechanised	Groundwater	Reliable 24/7				
Embakasi	f	Low / Targe	Moderate	3267	Unmechanised	Surface/Rain water				Reliable > 4 days	
Embakasi	g	Low / Targe	Moderate	1799	Unmechanised	Surface/Rain water		Unreliable < 4 days			
Makadara	h	Medium	Moderate	51146	Mechanised	Water Company Network	Reliable > 4 days				
Makadara	i	Medium	Moderate	139248	Mechanised	Water Company Network		Reliable > 4 days			
Makadara	j	Medium	Moderate	2285	Mechanised	Water Company Network			Reliable > 4 days		
Makadara	k	High	Moderate	56300	Mechanised	Water Company Network				Reliable > 4 days	
Makadara	l	Medium	Moderate	1585	Mechanised	Groundwater	Reliable 24/7				
Makadara	m	Low / Targe	Moderate	725	Unmechanised	Surface/Rain water				Reliable > 4 days	
Makadara	n	Low / Targe	Moderate	421	Unmechanised	Surface/Rain water		Unreliable < 4 days			
Central	o	Medium	Low	63976	Mechanised	Water Company Network	Reliable > 4 days				
Central	p	Medium	Low	197704	Mechanised	Water Company Network		Reliable > 4 days			
Central	q	Medium	Low	1465	Mechanised	Water Company Network			Reliable > 4 days		
Central	r	High	Low	36092	Mechanised	Water Company Network				Reliable > 4 days	
Central	s	Medium	Low	1803	Mechanised	Groundwater	Reliable 24/7				
Central	t	Low / Targe	Low	1036	Unmechanised	Surface/Rain water				Reliable > 4 days	
Central	u	Low / Targe	Low	93	Unmechanised	Surface/Rain water		Unreliable < 4 days			
Kasarani	v	Medium	Rapid	158373	Mechanised	Water Company Network	Reliable > 4 days				
Kasarani	w	Medium	Rapid	350279	Mechanised	Water Company Network		Reliable > 4 days			
Kasarani	x	Medium	Rapid	1758	Mechanised	Water Company Network			Reliable > 4 days		
Kasarani	y	High	Rapid	43317	Mechanised	Water Company Network				Reliable > 4 days	
Kasarani	z	Medium	Rapid	9269	Mechanised	Groundwater	Reliable 24/7				
Kasarani	aa	Low / Targe	Rapid	3474	Unmechanised	Surface/Rain water				Reliable > 4 days	
Kasarani	ab	Low / Targe	Rapid	926	Unmechanised	Surface/Rain water		Unreliable < 4 days			
Pumwani	ac	Medium	Low	76774	Mechanised	Water Company Network	Reliable > 4 days				
Pumwani	ad	Medium	Low	156346	Mechanised	Water Company Network		Reliable > 4 days			
Pumwani	ae	Medium	Low	916	Mechanised	Water Company Network			Reliable > 4 days		
Pumwani	af	High	Low	22571	Mechanised	Water Company Network				Reliable > 4 days	
Pumwani	ag	Medium	Low	2556	Mechanised	Groundwater	Reliable 24/7				
Pumwani	ah	Low / Targe	Low	984	Unmechanised	Surface/Rain water				Reliable > 4 days	

Figure 7: Simulation spreadsheet, population and service levels tab



Usage rates litres/capita/day

		Reliability				
		Periodic				Constant
		Reliable > 4 days	Reliable < 4 days	days	days	Reliable 24/7
Service Levels – Access	In dwelling	69	69	69	69	69
	On plot	38.9	38.9	38.9	38.9	38.9
	Delivered to property	43.5	43.5	43.5	43.5	43.5
	Carried to property	27.8	27.8	27.8	27.8	27.8

Energy Cost: kWh/litre

		Source		
		Water Company Network	Groundwater	Surface/Rain water
Delivery Tech.	Mechanised	0.2	0.3	0.1
	Unmechanised	Not Applicable	0	0

Population Growth (%)

Rapid	3
Moderate	1
Low	0

Leakage Rates (% lost)

High	20
Medium	15
Low / Target	10

Sumulation year	20

Figure 8: Simulation spreadsheet, consumption and energy tab

The spreadsheet contains three tabs:

1. Results;
2. Population and service level information;
3. Consumption and energy information.

The tabs are described below in the order in which the user inputs information.

The third tab (Figure 8) contains set-up information concerning characteristic values of consumption, energy usage, population growth and leakage. All of these parameters can be modified, allowing the spreadsheet to be tailored to the characteristics of a particular area. Firstly, details of the average water consumption in lpcd for different levels of service and reliability are entered into a table. Information concerning the average energy cost in kilowatt hours per litre (kWh/l) for mechanised and un-mechanised methods of delivering water from three types of origin (water company network water, ground water and surface/rain water) is entered into a second table. Finally, values for three categorized rates of population growth and leakage (high, medium and low) can be defined.

The second tab (Figure 7) sets up a model of the population of the city with population groups assigned to different service levels, population growths, water leakage rates and water source origins. There is no limit to how much detail it is possible to include in this tab; the only constraint is the availability of data for accurate input. The model can be constructed at a city-level, district-level, or at smaller units of location. For each unit, a row is created to describe each unique mode of water access within that location. If the population of a location displays homogenous characteristics of water access (for example, everyone accesses water from the utility network at the same level of reliability and leakage, and the area has a relatively uniform population growth) then only one row is needed. However, if the population utilises a multitude of water access methods, with different levels of reliability, leakage and population growth then several rows are needed to describe all groups.

The first tab (Figure 6) displays the results of the simulation. Firstly, an overall view of which proportion of the city's population lies in each access category is shown. The model then takes each row of the second tab and multiplies the population present in that row by the characteristic water consumption and energy use for that row, as defined by the values in the third tab. The results are then aggregated to show the total water consumption for each category of accessibility and reliability. The same is done for energy consumption. City-wide water consumption (both from network water alone, and from network water, groundwater and surface or rain water) is shown in tabular and graphical form, and projected to a user-defined number of years into the future.

The first tab also contains macro functions which allow the user to move different groups of the population (as defined by water source origin, level of service, level of reliability and/or level of leakage) to different water origins, levels of service, levels of reliability and/or levels of leakage. Consumptions for the baseline scenario and any changed scenario are shown in tabular and graphical form from the present up to a user-defined number of years into the future.

A full list of scenarios tested using the spreadsheet model and the effects these different scenarios have on the city-wide water demand is given in Section 4.6.

4 Data analysis

4.1 Data cleaning and characterisation

After data cleaning, a total of 77 interviews were used in the final analysis. Out of the 77 interviews, 56 were conducted with female respondents and 21 with male respondents. The ages of respondents ranged between 18 and 70, with 35% of respondents falling into the fist age bracket of 18-30. Of all respondents, 17% rented their properties, 9% rented a room only, and 74% were owners. Primary and secondary water sources of respondents are shown in Table 2 and 3 below.

A more detailed investigation of the primary and secondary sources shows that almost all households who carry water to their property as their primary source get this water either from kiosks or from neighbours getting water from the piped network or from tankers. The volume of water from the primary source on average accounts for 91% of the overall volume consumed. This water from the primary source is supplemented by small amounts of water from the secondary source, which is water bought in sachets and carried home for more than 70% of respondents. Therefore most of the sampled households get the majority of their water for domestic activities from taps in the yard, standposts or water kiosks whilst purchasing small volumes of drinking water in sachets. This is a common phenomenon in West Africa, described for example by Stoler et al. (2013). A graphical representation of the combination between primary and secondary sources for the sampled population is given in Figure 9.

Table 2: Primary source of drinking water of sampled population

	Frequency	Percentage of sample
Carried to property	50	64.9
Delivered to property	5	6.5
In yard	19	24.7
In dwelling	3	3.9
Total	77	100

Table 3: Secondary source of drinking water of sampled population

	Frequency	Percentage of sample
Carried to property	67	87.0
Delivered to property	5	6.5
In yard	5	6.5
In dwelling	0	0.0
Total	77	100

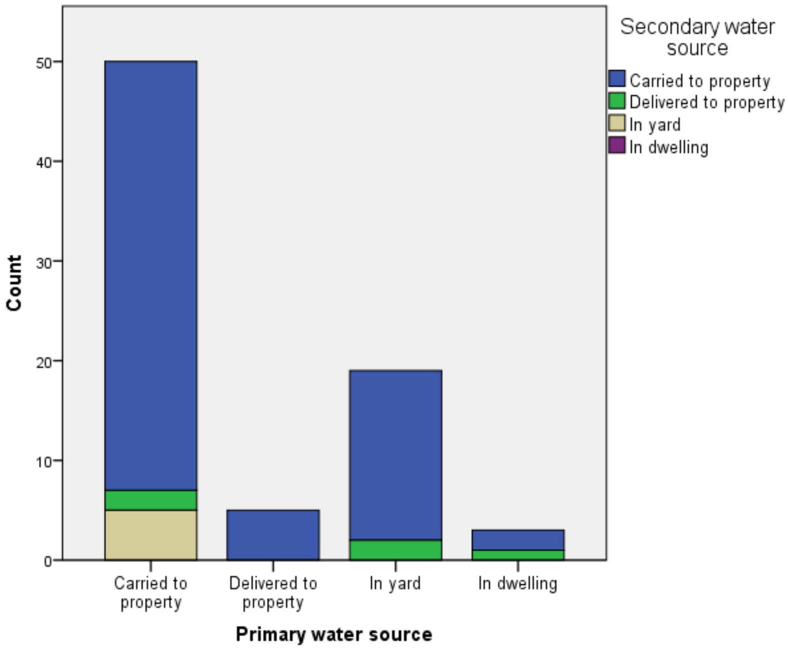


Figure 9: Combination of primary and secondary water sources

The calculated average consumption for all households has a mean value of 46.8 lpcd, a median value of 41.7 lpcd, and ranges from 5 to 128 lpcd. A histogram of average consumption is given in Figure 10 and shows that the distribution is slightly skewed to the left, with a skewness value of 1.167 and a kurtosis value of 1.789. Water consumption for the whole sample can be seen to follow a reasonably smooth distribution. Histograms disaggregated by the primary source is given in Figure 11. No histograms were produced for the groups of users getting water delivered to property and having a tap in their dwelling, as they only contained five and three responses, respectively. The two remaining distributions are relatively similar, although the distribution for users with a water source in the yard seems slightly more skewed to the right.

The reliability of water sources was found to be very high in the sampled population. More than 90% of respondents reported that their primary water source is reliable for seven days a week, whilst this proportion is even higher for the secondary water source, at 97%. The primary water source was reported to be available for either 12 or 24 hours a day by more than 85% of respondents, whilst all respondents said their secondary source was available for more than 12 hours a day. This high reliability can be explained by the fact that most of the sampled population use kiosks or other public sources as their primary water source. These kiosks usually store water and therefore water is available even though, as mentioned in Section 2, there is water rationing in Accra and most users of the piped network do not receive water for seven days a week. Furthermore it is likely that users know when water will be available at their kiosk, which increases the perceived reliability.

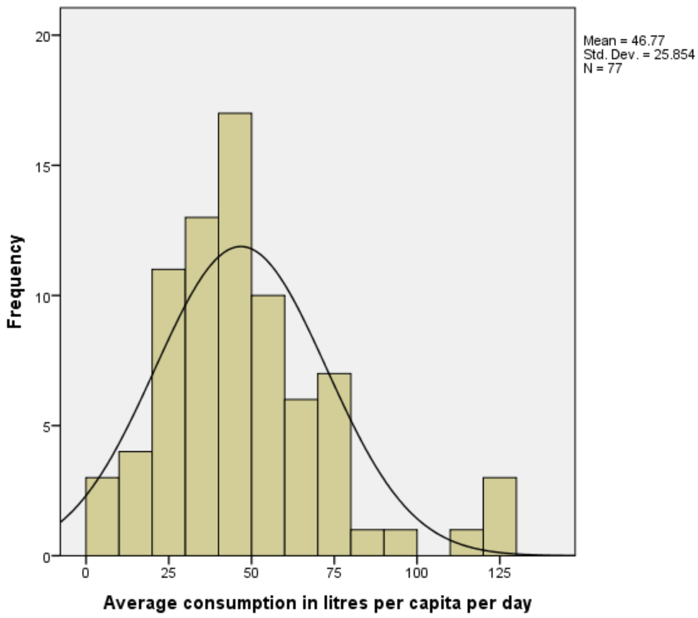


Figure 10: Histogram of average water consumption for entire sample

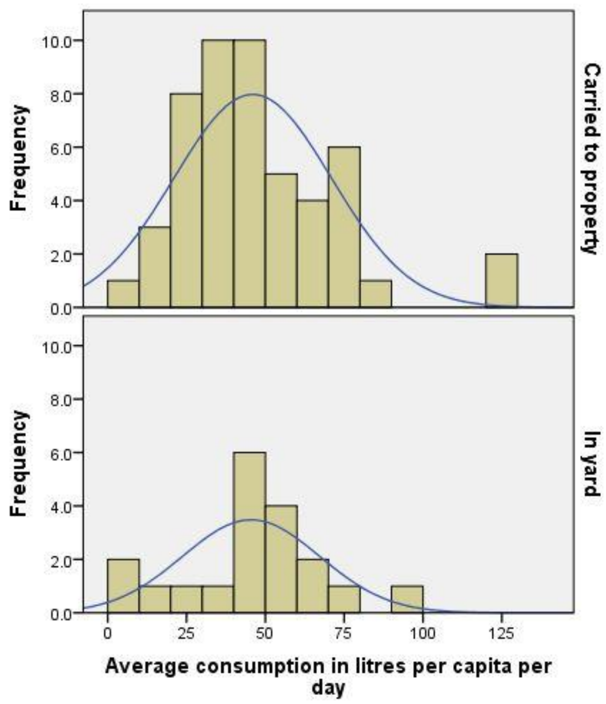


Figure 11: Histograms of average consumption by primary water source

The relationship between average consumption and household wealth score is shown in Figure 12. Markers are coloured by the primary household water source. There appears to be no obvious relationship between average consumption and wealth score, or of method of access and wealth score. However, the wealth score is constructed so as to measure relative variation in wealth within the sample and if there is a small amount of variation then the score does not contain a lot of information. As the sampled households showed relatively low variability regarding their socio-economic status, the wealth score constructed from the sample used in this study is not considered particularly meaningful. Therefore no association between wealth score and average consumption or accessibility is expected. Sampling a wider range of socio economic and geographical groups would enable a better analysis of the impact wealth has on accessibility and average water consumption. Due to these limitations, the wealth score constructed from the sample was not used in any further analysis of water consumption.

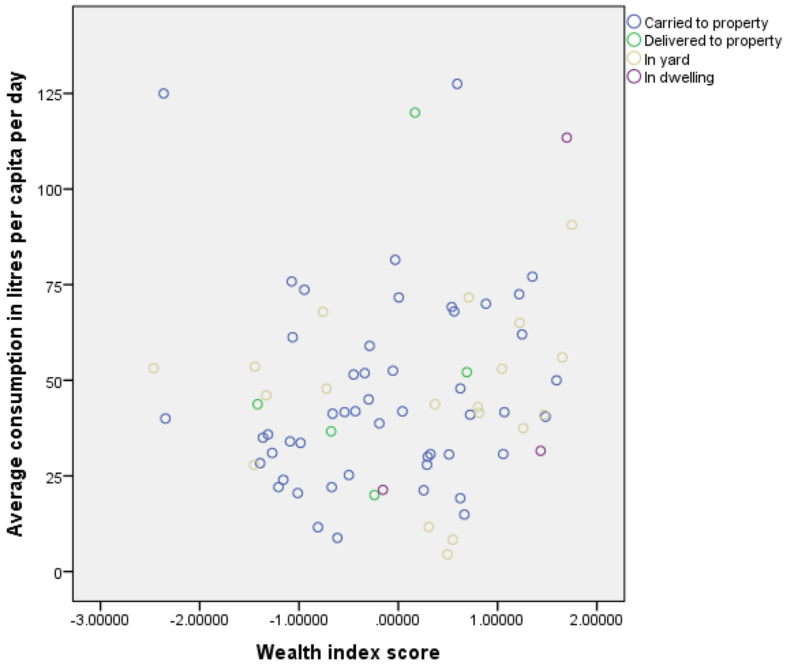


Figure 12: Scatterplot of wealth score and average water consumption, markers coloured by primary water source

4.2 Patterns within the data

A correlation matrix for the data gathered was produced and is given in Appendix 3. No relationships within the correlation matrix had a correlation coefficient greater than 0.8 which suggests that multi-collinearity is not likely to be a problem within the dataset.

Significant (i.e. $p<0.05$) negative correlations exist between average water consumption and: number of household members, and distance from the source. No correlation was noted between average consumption and water source, however given the small variety in water sources examined and the limited sample size for two of the categories (delivered to property and private tap) it is not necessary that any significant association would be detected.

Wealth score was noted to be significantly positively correlated with education category, primary water source ease-of-access category and presence of a toilet. It is significantly negatively correlated with insecurity of tenure status (as rated on a scale increasing with increased tenure insecurity). This is intuitively correct and shows that, although the wealth index of the sample does not explain water consumption patterns, it does capture the socio-economics of the sample to a certain extent.

Partial correlations were carried out between average consumption and distance from the source, whilst controlling for the water source category. The relationship was still found to be statistically significant.

4.3 Statistical differences between groups

To see whether differences in water consumption between water source category groups are greater than those occurring within groups and whether they are likely to have occurred by chance, a one-way analysis of variance (ANOVA) test was conducted for both primary and secondary water sources. The differences in means between the groups were not found to be statistically significant. However, given the small number of interviews conducted for all categories except 'water carried to property' and 'yard tap' it is not necessarily the case that any significant difference would be detected.

4.4 Regression model

A regression model was constructed with average water consumption in litres per capita per day as the dependent variable and the number of people in a household and the distance from the source as independent variables, as these two have been identified to be significantly correlated to average water consumption. A summary of the model is presented in Table 4. The regression model constructed was statistically significant (p=0.05) and did not display any degree of collinearity. However, it was not able to produce an adjusted R-squared value of greater than 0.3, indicating that the model struggled to explain the majority of variation in the data. Therefore the number of people in the household and the distance to source cannot be used to predict average water consumption. As discussed above, the wealth score constructed from the sample was not considered meaningful and therefore, no regression using it as an independent variable was conducted.

Table 4: Regression model for average water consumption

	Coefficient	Standard Error	p
Constant	74.619	13.034	0.000
Number of people in household	-2.085	2.055	0.326
Distance from source in metres	-0.072	0.034	0.050
Number of observations		77	
Adjusted R-squared value		0.240	
Model significance		0.050	

4.5 Characteristic consumption values

Average consumption values calculated from the collected primary data for different categories of accessibility are presented in Table 5. As mentioned above, the differences between the mean values is not statistically significant.

Table 5: Average consumption values by primary water source in lpcd

	Number of cases	Mean	Median	Standard Deviation
Carried to property	50	46.0	41.1	25.0
Delivered to property	5	54.5	43.8	38.5
In yard	19	45.5	46.1	21.8
In dwelling	3	55.5	31.6	50.5

These consumption values were compared to values for domestic water consumption found in secondary literature. The values for all access categories except household connection are confirmed by studies by Abraham et al. (2007). As only three households with taps in the household were sampled for this study, and the calculated average consumption for this group seems comparatively low, it was decided to use consumption values from literature for this water source in the water demand model. Abraham et al. (2007) estimate a water consumption of 90 lpcd for users of household connection in Accra, which is confirmed by Lampley (2010), whose study arrived at a range of 60 to 120 lpcd. Table 6 shows the consumption values used for the water use modelling tool in the following chapter.

Table 6: Consumption values used for water use modelling

	Consumption (lpcd)	Source
Carried to property	41	Survey results (supported by Abraham et al., 2007)
Delivered to property	44	Survey results (supported by Abraham et al., 2007)
In yard	46	Survey results (supported by Abraham et al., 2007)
Inside dwelling	90	Abraham et al., 2007; Lampley, 2010

Accra's population is 4,010,054 as per the 2010 Population and Housing Census (Government of Ghana, 2012). As the sample size used in this study is not representative of the entire city, the distribution of Accra's population within the four categories of accessibility were estimated using data from the most recent DHS survey. This distribution was used to estimate the total number of users for each access category for use in the model, as shown in Table 7.

Table 7: Household access to water according to DHS

	Percentage in DHS survey	Number of people in Accra
Carried to property	23.4%	938,353
Delivered to property	4.5%	180,452
In yard	42.8%	1,716,303
Inside dwelling	29.3%	1,174,946

4.6 Scenario testing results

Scenarios of changing service levels were assessed using the spreadsheet version 9A (Mac) produced by Dr Andrew Sleigh, which is described in Section 3.4.

The total water production in Accra gathered from key informant interviews with utility staff is around 158,045 Ml per year. Van-Rooijen (2008) report that commercial, industrial and institutional users account for about 20% of total water consumption, which brings the remaining water for domestic consumption to about 126,000 Ml. The baseline domestic network water consumption obtained in our model is around 104,000 Ml to 108,000 Ml, including the commonly cited 27% to 30% physical losses (Adank et al., 2011, Abraham et al., 2007), which leaves around 20,000 Ml unaccounted for. There are several explanations for the difference between the estimated consumption and the actual production. Leakage rates are notably hard to assess precisely and are often misreported (Frauendorfer & Liemberger, 2010), so the actual physical losses could be higher. There could also be commercial or industrial users which are not accounted for, thereby reducing the total amount available for domestic consumption. Another explanation is the large number of transient workers. Every day, a large number of people come to Accra to work as day labourers, which is a population not captured in the census population. Water consumption of this transient population is difficult to assess, however it can be assumed that they consume at least 2.5 lpcd for drinking, 4 lpcd for sanitation and 4.5 lpcd for cooking (The Sphere Project, 2011). Assuming a number of one million day labourers, their water demand on that basis would be around 400 Ml per year, which does not explain the difference between the total water demand obtained from our model and the water production gathered from key informant interviews.

Therefore a gap remains between the amount of water produced as gathered by interviews with utility staff and the results of our model. As explained above, higher leakage or unauthorised or unaccounted for commercial use could be one explanation for the gap. Furthermore, in the model all users of one accessibility category are assumed to use the same amount of water every day. In reality some households, especially in high-income neighbourhoods, might be using significantly higher quantities, which would lead to an underestimation of total water demand.

Despite this gap, it was decided to use the water use modelling tool with our estimated baseline consumption to assess the impacts of changing service levels for Accra's population. The scenarios examined are described below.

1. All households with yard tap connections were changed to have household connections;
2. All households with no connections (i.e. water is carried or delivered) were changed to have yard tap connections;
3. All households with no connections and yard tap connections were changed to have household connections;
4. All households with no connections and yard tap connections were changed to have household connections whilst physical losses were reduced to 15%.

The last scenario investigated is the strategy of increasing coverage whilst reducing leakage. Currently, physical losses amount to 27% (Adank et al., 2011), which is a value commonly found in water supply systems in developing countries. However, leakage can be reduced significantly by measures such as pressure management and leakage detection activities (Kingdom, Liemberger, & Marin, 2006). Therefore, one of the scenarios includes these measures which lead to a reduction of physical losses to 15%. As this scenario also includes a wide expansion of the current network, a reduction of overall physical losses is quite realistic even without targeted leakage reduction activities, as the newly laid pipes are less likely to leak. Results from all four investigated scenarios are shown in Figure 13.

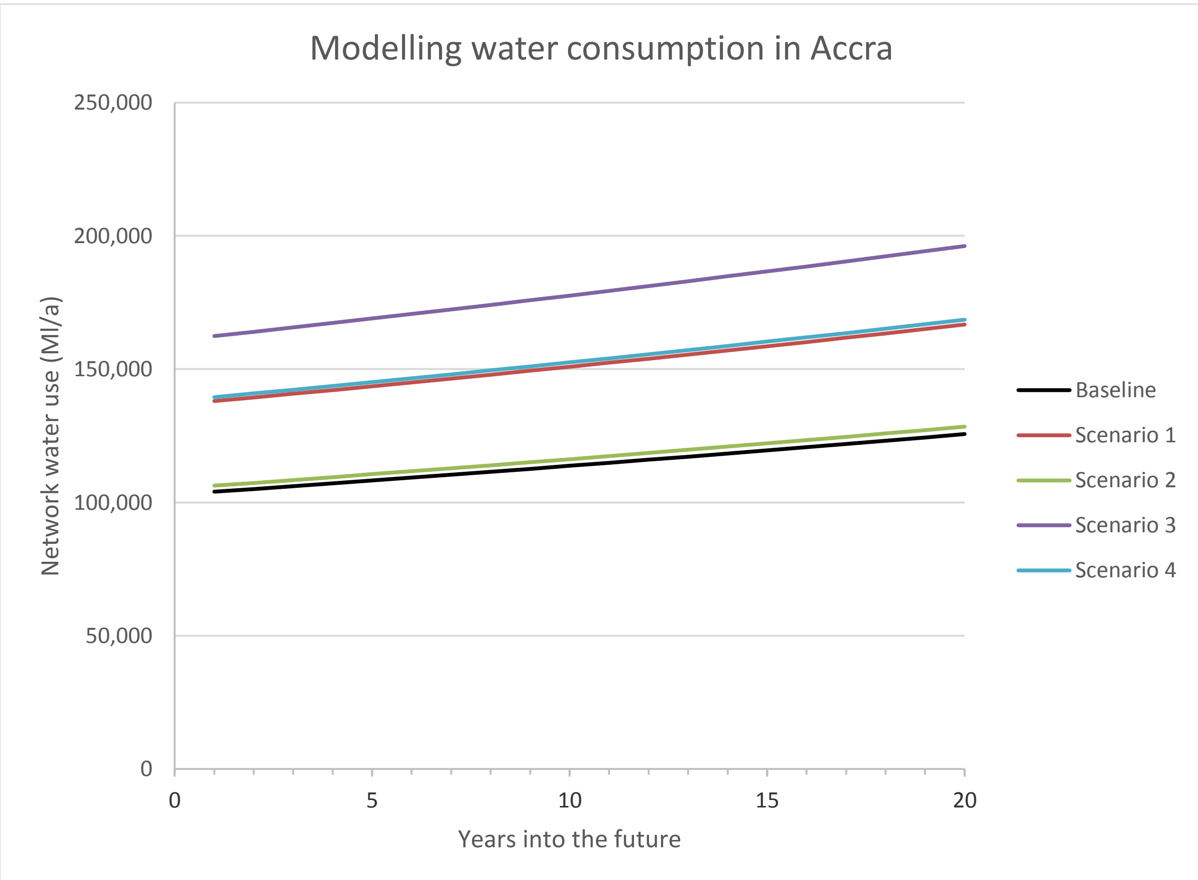


Figure 13: Scenario testing results

As shown in Figure 13, providing yard taps to all users who currently carry water home or get it delivered only increases total water demand by 2%, which is understandable as there is no statistically significant difference between the consumption values of these groups. This suggests that this measure could be a practical way to improve services for a large part of the population with only minor or negligible impact on the city-wide water resources.

Improving the service level for all consumers currently using yard taps by providing them with private connections would increase the overall water demand by 33%, shown as Scenario 1 above. Giving all consumers in the city access to a tap inside the dwelling has the largest effect on water consumption, causing a 56% increase of city-wide water demand. This however also corresponds to a significant increase in service for a large proportion of Accra's residents. If all users are provided with a private connection and physical losses are reduced to 15%, as simulated in Scenario 4, total water demand only increases by 34%. Therefore, the increase in total water demand can be effectively mitigated by efforts to reduce leakage. In this scenario more than 2.5 million residents gain access to a private household connection, which not only is a significant improvement in their standard of living, but also means that these people become paying customers to the utility. If steps would be taken to reduce commercial losses as well as physical losses, for example by improving bill collection efficiency, this scenario might be financially viable to the utility.

With all results above, it should be remembered that the model was populated with consumption values drawn from a small sample of households. Better estimates of water usage could be obtained through a larger-scale field study that is statistically representative of the entire city. The outcomes of this modelling exercise should therefore be seen as indicative results. They do however show that estimating impacts of changes to service levels on a city-wide scale can be relatively straightforward once the necessary primary data has been collected. This way, informed planning decisions can be made by analysing a number of scenarios for improving the city-wide water supply system and the impacts these improvements have on total water demand.

Additional measures to increase the accuracy of the model could be taken by:

- Correcting water access average values for self-selection using the two-step Heckman technique, as described by Briand et al. (2009);
- Using Monte-Carlo simulations within the spreadsheet to account for the distribution of water consumption values within the household tap category;
- Investigating the use of complexity techniques as a consumption predictor tool.

5 Conclusions

This report investigated water consumption in ten neighbourhoods in Accra, Ghana. A total of 97 household surveys were conducted to calculate average water consumption for different levels of accessibility. After data cleaning, 77 of the questionnaires were used in the final analysis. It was found that water from the primary source on average accounts for 91% of total volume of water consumed. Therefore, the respondents use a primary source, which can be a yard tap, water from kiosks or a private connection for domestic uses, and supplement this water with small quantities bought for drinking, mostly in sachets. Average water consumption was found to be significantly correlated to the number of people in a household and the distance to the water source. However, a regression model with these two variables was found not to explain most of the variability in the data. The average consumption values calculated from collected primary data range from 45.5 lpcd for users of yard taps to 55.5 lpcd for consumers with household connections. The differences in average consumption were found not to be statistically significant. Due to the very small number of respondents in the household connection category, the calculated consumption value for this group was not used for the modelling exercise but it was replaced by values from secondary literature.

A number of scenarios for improving service levels in Accra have been investigated using a specifically designed modelling tool. The indicative results suggest that providing users who currently do not have access to piped water with yard taps only increases total water demand by 3%. This is an almost negligible impact on city-wide water consumption but corresponds to a significant increase in service for a large part of the city. Providing household connections to all consumers has a major impact on water demand, as it increases city-wide water consumption by 56%. This increase could however be mitigated by efforts to reduce physical losses. If leakage is reduced from the current 27% to 15%, the impact of providing all consumers with household connections is an increase in total water demand of only 34%. Therefore, expanding coverage whilst reducing leakage might be a way for the utility to provide better services to the entire city with a smaller impact on water resources. If steps are taken to reduce commercial losses simultaneously, this scenario might be financially viable for the utility.

The limitations of this study are the very small sample size, which means results should be seen as indicative, as consumption values for one of the groups and ratios of users accessing source types had to be triangulated using secondary literature. Using the modelling tool with consumption data obtained from a more rigorous study that is statistically representative of the entire city would lead to more accurate results and enable planners to make informed decisions for improvements to the water supply in Accra.

References

Abraham EM, van Rooijen D, Cofie O, Raschid-Sally L. 2007. *Planning urban water-dependent livelihood opportunities for the poor in Accra, Ghana*. SWITCH scientific meeting.UK: University of Birmingham.

Adank M, Darteh B, Moriarty P, Osei-Tutu H, Assan D, van Rooijen D. 2011. *Towards integrated urban water management in the Greater Accra Metropolitan Area. Current status and strategic directions for the future*. Accra: SWITCH.

Agyei-Mensah, Samuel and George Owusu (2010). Segregated by Neighborhoods? A Portrait of Ethnic Diversity in the Neighbourhoods of the Accra Metropolitan Area, Ghana. *Population, Space, and Place* 16: 499–516.

Ainuson, K. G. 2010. Urban Water Politics and Water Security in Disadvantaged Urban Communities in Ghana. *African Studies Quarterly* 11, no. 4: 59–82.

AVRL/GWCL 2009. *Monthly water quality monitoring*. Accra: Aqua Vitans Rand Ltd/GhanaWater Company Ltd.

Briand, A., Nauges, C., Strand, J., & Travers, M. (2010). The impact of tap connection on water use: the case of household water consumption in Dakar, Senegal. *Environment and Development Economics*, *15*(01), pp.107-126.

Fichtner, HYSTA and Watertech (2010). *Annual Summary of Performance Report: Fourth Year Management Contract –Technical Audit Report*. Vol. 1 and 2.

Frauendorfer, R., & Liemberger, R. (2010). *The Issues and Challenges of Reducing Non-Revenue Water*. Manila: Asian Development Bank.

Government of Ghana. 2012. *2010 Population and Housing Census: Final Results.* Accra: Ghana Statistical Services.

Ghana Statistical Service 2013.*National Accounts Statistics: PROVISIONAL Gross Domestic Product 2013*. Ghana Statistical Service, Accra.

Harris, L and Morinville, C. 2013. *Improving Participatory Water Governance in Accra, Ghana*.Policy Brief No. 7.CIGI-Africa Initiative Policy Brief series.

Karimi, F. 2012. *Obama hails Ghana as 'model for democracy' in Africa*. CNN.[Online].[Accessed 20th December 2014]. Available at: edition.cnn.com/2012/03/08/world/africa/obama-ghana-president/

Kingdom, B., Liemberger, R., & Marin, P. (2006). *The challenge of reducing non-revenue water (NRW) in developing countries - how the private sector can help: a look at performance-based service contracting*. Washington DC: World Bank.

Lamptey, F. (2010) Determination of domestic water consumption patterns in Accra, unpublished MSc thesis report, KNUST, Kumasi, Ghana. Cited in: Adank M, Darteh B, Moriarty P, Osei-Tutu H, Assan D, van Rooijen D. 2011. *Towards integrated urban water management in the Greater Accra Metropolitan Area. Current status and strategic directions for the future*. Accra: SWITCH.

Lundehn, C. and G. Morrison.2007. An Assessment Framework for Urban Water Systems — A New Approach Combining Environmental Systems with Service Supply and Consumer Perspectives." In *Highway and Urban Environment: Proceedings of the 8th Highway and Urban Environment Symposium*, edited by Gregory Morrison and Sébastien Rauch. Pages 559–577. Dordrecht, The Netherlands: Springer.

National Development Planning Commission. (2015). *Ghana Millennium Development Goals: 2015 Report*. Accra: United Nations in Ghana.

Nsiah-Gyabaah, K. 2001.The looming national dilemma of water crisis in Peri- urban areas in Ghana. In: *Proceedings of the Second Workshop on Peri-Urban Natural Resource Management Project at the Watershed Level,* DFID, Kumasi, Ghana.

Rutstein, S. O. and Johnson, K. 2004. DHS Comparative Reports No. 6 – The DHS Wealth Index. [Online].The DHS Program.[Accessed 1 November 2014]. Available from: www.dhsprogram.com/

Stoler J, Fink G, Weeks JR, AppiahOtoo R, Ampofo JA, et al. 2012. When urban taps run dry: Sachet water consumption and health effects in low income neighborhoods of Accra, Ghana. *Health & Place* 18: 250–262.

The Sphere Project. (2011). *Humanitarian Charter and Minimum Standards in Humanitarian Response*. *Response* (3rd ed., Vol. 1). Rugby: Practical Action Publishing.

Taylor, P., Boussen, C.R., Awunyo-Akaba, J., Nelson, J., 2002.*Ghana Urban Health Assessment, Activity Report 114*. Office of Health and Nutrition, USAID, Washington, DC.

Van-Rooijen DJ, Spalthoff D, Raschid-Sally L. 2008.*Domestic water supply in Accra: How physical and social constraints to planning have greater consequences for the poor.* Accra, Ghana. 5p.

Appendix 1: Fieldwork Materials

WSUP Slum Water Supply Improvements Project

HOUSEHOLD QUESTIONNAIRE

NOTE TO INTERVIEWERS

Text in **bold** is a question or statement which should be read to the respondent exactly as it is written (as far as possible). Text in *italics* is an instruction or clarification for the interviewer. For the sections concerning WATER QUANTITY AND RELIABILITY values should be determined from discussion with the respondent using the accompanying guideline sheet and then filled in. Please ask about the season which is occurring at the time of the field trip (dry or rainy) first, and then the other.

Request to speak to the person responsible for the household water supply.

Hello, our names are __________ and we are working for <*name of in-country partner institution*> in partnership with the University of Leeds. We are doing a survey to learn more about households and water in this area. Your household has been randomly chosen to participate. This study is completely confidential and your name will not be disclosed at any time. You can withdraw at any point and decline to answer any particular questions if you wish. Would you be willing to participate and discuss your water supply with us?

Date of interview		City	
Interviewer		Location	
Household ID number		Sub-location	

Check:

- Consent to participate given? Y/N
- Respondent over 18? Y/N

GENERAL HOUSEHOLD INFORMATION

Firstly, I would like to ask some general questions about you and this household. We are defining a household as a group of people who live together and make decisions together, sharing things like money and food.

Gender of respondent:	F/M
Age band of respondent:	(18-30) (31-40) (41-50) (51-60) (61-70) (71-80) (80+)
Is the respondent the household head?	Y/N

How many people live in this household, including infants and children?

How many infants under 2 years old live in this household?

How many children who are 2-15 years old live in this household?

Do you carry out any commercial activity from this property? *If yes, please describe.*

What is the highest level of education achieved by anyone in this household?
Read the list aloud:

1. No formal education
2. Completed primary education
3. Completed secondary education *(note 'junior or 'senior' for Ghana)*
4. Completed post-secondary training
5. Completed university
6. Other - specify

Ownership of property:

Do you own this house? Y/N
If (N), **do you rent this house?** Y/N
If (N), **do you rent this room?** Y/N

How long has your family been resident in this property? *(Years)*
Refer to country timeline if needed.

WATER SUPPLY DURING THE RAINY SEASON

Now I would like to ask you some questions about where you get water from during the RAINY SEASON *(please check the months of the most recent rainy season for the city).*

What are your main sources of drinking water during the rainy season? *Number the sources in the order of importance to the respondent, i.e. the source where they get the most water will be marked (1) and so on. There is no need to number every single source – only complete as many as mentioned by the respondent. Please mark the first blank column in the table below.*

What are your main sources of water for other household uses during the rainy season? *Same as previous. Please mark the second blank column.*

What are your main sources of water for irrigation or commercial activities during the rainy season? *Only ask if commercial activity is carried out from the property. Same as previous. Please mark the third blank column.*

Water source	1	2	3	Source description

On property – piped (shared / not shared)				Piped water with a tap located on the property and used by the household only.	
				Piped water with a tap located in the yard and shared with other households.	
On property – not piped (shared / not shared)				Well/borehole located in the yard and used by the household only.	
				Well/borehole located in the yard and shared with other households.	
				Rain water	
Off property – piped/bottled				Standpipe	
				Water vendors / water kiosks *(where a container is filled up) – please indicate the source if known.*	Piped water
					Well/borehole
					Tanker
					Source unknown
				Purchased from neighbours – *please indicate the source if known.*	Piped water
					Well/borehole
					Tanker
					Source unknown
				Water from hand-pulled cart	
				Tanker	
				Sachets	
				Bottled water *(where a full, sealed container is purchased)*	
Off property – not piped				Surface water – river, pond, etc.	
Other				Please specify:	

WATER QUANTITY AND RELIABILITY DURING THE RAINY SEASON

Use the accompanying guideline sheet to have a discussion with the respondent about the quantity and reliability of water that they use. Use the section of the sheet that corresponds to their water source. After/during the discussion, note answers to the questions below:

PRIMARY WATER SOURCE
Refers to the water source marked (1) for drinking and household uses in the table above. If these are different please ask questions twice, once for each source.

For the primary source of water during the rainy season:

How much does the household consume per day?
What is the unit cost?
What is the reliability? (Days per week and hours per day)

How much time is spent collecting?

Can you broadly predict in advance when your primary water supply will be available? (Y/N/Sometimes)

SECONDARY WATER SOURCE

Refers to the water source marked (2) for drinking and household uses in the table above. If these are different please ask questions twice, once for each source. There is no need to complete this if respondent has not specified a secondary source.

For the secondary source of water during the rainy season:

How much does the household consume per day?
What is the unit cost?
What is the reliability? (Days per week and hours per day)
How much time is spent collecting?

TERTIARY WATER SOURCE

Refers to the water source marked (3) for drinking and household uses in the table above. If these are different please ask questions twice, once for each source. There is no need to complete this if respondent has not specified a tertiary source.

For the tertiary source of water during the rainy season:

How much does the household consume per day?
What is the unit cost?
What is the reliability? (Days per week and hours per day)
How much time is spent collecting?

WATER SUPPLY DURING THE DRY SEASON

Now I would like to ask you some questions about where you get water from during the DRY SEASON *(please check the months of the most recent dry season for the city).*

What are your main sources of drinking water during the dry season? *Number the sources in the order of importance to the respondent, i.e. the source where they get the most water will be marked (1) and so on. There is no need to number every single source – only complete as many as mentioned by the respondent. Please mark the first blank column.*

What are your main sources of water for other household uses during the dry season? *Same as previous. Please mark the second blank column.*

What are your main sources of water for irrigation or commercial activities during the dry season? *Only ask if commercial activity is carried out from the property. Same as previous. Please mark the third blank column.*

Water source	1	2	3	Source description
On property – piped (shared / not shared)				Piped water with a tap located on the property and used by the household only.
				Piped water with a tap located in the yard and shared with

				other households.	
On property – not piped (shared / not shared)				Well/borehole located in the yard and used by the household only.	
				Well/borehole located in the yard and shared with other households.	
				Rain water	
Off property – piped/bottled				Standpipe	
				Water vendors / water kiosks *(commercially run) – please indicate the source if known.*	Piped water
					Well/borehole
					Tanker
					Source unknown
				Purchased from neighbours *(not commercially run) – please indicate the source if known.*	Piped water
					Well/borehole
					Tanker
					Source unknown
				Water from hand-pulled cart	
				Tanker	
				Sachets	
				Bottled water *(where a full, sealed container is purchased)*	
Off property – not piped				Surface water – river, pond, etc.	
Other				Please specify:	

WATER QUANTITY AND RELIABILITY DURING THE DRY SEASON

Use the accompanying guideline sheet to have a discussion with the respondent about the quantity and reliability of water that they use. Use the section of the sheet that corresponds to their water source. After/during the discussion, note answers to the questions below:

PRIMARY WATER SOURCE
Refers to the water source marked (1) for drinking and household uses in the table above. If these are different please ask questions twice, once for each source.

For the primary source of water during the dry season:

How much does the household consume per day?
What is the unit cost?
What is the reliability? (Days per week and hours per day)
How much time is spent collecting?

Could you broadly predict in advance when your primary water supply will be available? (Y/N/Sometimes)

SECONDARY WATER SOURCE
Refers to the water source marked (2) for drinking and household uses in the table above. If these are different please ask questions twice, once for each source. There is no need to complete this if respondent has not specified a secondary source.

For the secondary source of water during the dry season:
- How much does the household consume per day?
- What is the unit cost?
- What is the reliability? (Days per week and hours per day)
- How much time is spent collecting?

TERTIARY WATER SOURCE
Refers to the water source marked (3) for drinking and household uses in the table above. If these are different please ask questions twice, once for each source. There is no need to complete this if respondent has not specified a tertiary source.

For the tertiary source of water during the dry season:
- How much does the household consume per day?
- What is the unit cost?
- What is the reliability? (Days per week and hours per day)
- How much time is spent collecting?

WATER STORAGE, HOUSING AND DISTANCE TO SOURCE

What is the total volume of water storage available within the property? *Ask to be shown the available storage and make an estimate. Please specify units.*

What is the total volume of water currently stored within the property? *Ask to be shown the water stored and make an estimate. If this is not possible (e.g. if they are stored in the bedroom), ask the respondent to estimate the number of containers, indicate how big they are, and how full they are. Please specify units.*

Who collects the water for the household? *Note gender and age.*

Observational notes on housing material:
(Type of housing material to be used as proxy for income.)
Add some observational notes about the number of rooms in the property and building materials for the walls, roof and floor. Note if the property has a toilet.

What is the distance to the primary source of water? *Ask to be shown the primary source of water; this may be off the property and involve a short walk. Observe the distance to the source, functionality of the source, and price currently charged to check statements made by the respondent.*

Thank the respondent for their time and reassure the confidentiality of their responses.

WATER QUANTITY AND RELIABILITY

Interviewer Guidelines

These guidelines are to help interviewers establish the quantity of water that is used by each household. The methods for estimating quantity depend on the supply that the household uses, and therefore a discussion with the respondent should be conducted to extract all relevant information. The discussion will be very context-specific and relies on the discretion of the interviewer.

SACHETS/BOTTLED

Try to establish the volume of water contained in each bottle/sachet usually purchased.
Try to establish how many bottles/sachets are purchased every day and every week.
Try to establish the cost per bottle/sachet.
Cross-check with approximate expenditure on water per week.
(Cross-check with water usage within the household.)

CARRIED TO HOME FROM OUTSIDE COMPOUND
(e.g. surface water, water vendors, kiosks.)

Try to establish the containers that are used to carry the water and estimate their size.
Try to establish how many containers are filled/carried every day and every week.
Try to establish the cost per filled container (or whatever volume is the common unit used – Nairobi usually uses 20 litres).
Cross-check with approximate expenditure on water per week.
(Cross-check with water usage within the household.)
Try to establish how often water is available from their preferred source. Can they be sure of being able to fill a container every day? Does water only come every other day? Try to establish how many hours per day / days per week water is available (whichever is more appropriate).

CARRIED TO HOME FROM WITHIN COMPOUND
(e.g. well, borehole or tap located within compound.)

Try to establish the containers that are used to carry the water and estimate their size.
Try to establish how many containers are filled every day and every week. *Household unlikely to be accurate on this.*
Check how they pay for this facility, and how much they pay. Is it included in rent?
Cross-check with water usage within the household. *Do this thoroughly as it is likely to be the best indicator.* How much is usually used for cleaning/laundry/cooking? How often are these activities performed?
Try to establish how often water is available from their preferred source. Can they be sure of being able to fill a container every day? Does water only come every other day? Try to establish how many hours per day / days per week water is available (whichever is more appropriate).

TAPS WITHIN THE HOME

Try to establish how much water the household stores and how they behave when they receive running water. Do they turn the taps on and fill up all their containers once a week? Once every couple of days? It couldn't hurt to examine water bills if there are any available, bearing in mind they may be inaccurate.
Try to establish how often water is available from their tap. Can they be sure of being able to receive running water every day? Does water only come every other day? Try to establish how many hours per day / days per week water is available (whichever is more appropriate).

Check whether the household has a flush toilet in their house/compound. Where do they get water for flushing from?

WSUP Slum Water Supply Improvements Project
INCOME INDICATORS

Taken from 2007 – 2008 DHS survey questionnaires for Kenya, Ghana and Zambia

Does the household own any of the following: *(Please tick)*	
	Electricity
	Clock or watch
	Radio
	Television (black & white)
	Television (colour)
	Refrigerator
	Freezer
	Electric generator
	Solar panel
	Telephone (mobile
	Telephone (landline)
	Washing machine
	Camera (digital)
	Camera (non-digital)
	Personal Computer
	DVD/VCD player
	Sewing machine
	Bed
	Table
	Cupboard or cabinet

What type of fuel does the household mainly use for cooking? *(Please tick)*	
	Electricity
	LPG / natural gas
	Biogas
	Kerosene
	Coal/lignite
	Charcoal
	Wood
	Straw/shrubs/grass
	Agricultural crop
	Animal dung
	No food cooked in household
	Solar power
	Other (please describe)

Is cooking usually done in the house, a separate building, or outdoors?

Does the house have a separate room which is used as a kitchen?

In the household, is food cooked on an open fire, an open stove or a closed stove?

Please observe and record the main material of the floor: *(Please tick)*	
	Earth/sand
	Dung
	Wood planks
	Palm/bamboo

	Parquet or polished wood
	Vinyl (PVC) or asphalt strips
	Ceramic tiles
	Cement
	Woollen or synthetic carpet
	Rubber carpet or linoleum
	Ceramic tiles
	Other (please describe)

Please observe and record the main material of the roof: *(Please tick)*	
	Thatch or palm leaf
	Rustic mat
	Bamboo
	Wood planks
	Cardboard
	Metal/iron sheets
	Tin cans
	Calamine/cement fiber (asbestors)
	Ceramic tiles / brick tiles
	Cement
	Roofing shingles
	Asbestos / sheet roofing tiles
	Mud tiles
	Other (please describe)
Please observe and record the main material of the walls: *(Please tick)*	
	Cane/palm/trunks
	Mud
	Bamboo with mud
	Stone with mud
	Plywood
	Cardboard
	Reused wood
	Cement
	Stone with lime/cement
	Bricks
	Cement blocks
	Covered adobe
	Wood planks / shingles

How many rooms in this household are used for sleeping?

Does the household own any of the following: *(Please tick)*	
	Bicycle
	Motorcycle or motor scooter
	Animal-drawn cart
	Car or truck
	Boat with a motor
	Banana boat

Does any member of this household own any agricultural land? If yes, how many acres / hectares / lima (*Zambia only)* / poles *(Ghana only).* *Please specify units.*

Does any member of this household own any herds, livestock, other farm animals or poultry? Y/N

Please indicate the numbers of herds, livestock, farm animals or poultry owned by the household: *(Please tick)*	
	Traditional/indigenous cattle
	Dairy cattle
	Beef cattle
	Horses, donkeys or mules
	Goats
	Sheep
	Pigs
	Rabbits
	Grasscutter (Greater Cane Rat)
	Chickens
	Other poultry (please specify)
	Other (please specify

Does any member of this household have a bank account? Y/N

WSUP Slum Water Supply Improvements Project

PARTICIPANT INFORMATION SHEET

What is the purpose of the project?

This project is investigating how people access and use water in Nairobi. The end goal is to understand how demand for water would change if more people are connected to the network.

What are the possible benefits of taking part?

Whilst there is no immediate benefit from participation, it is hoped that your answers will contribute to improving water supply for everyone in Nairobi.

Can I withdraw my answers at a later date?

You can withdraw at any time during the interview or at a later date by contacting the lead researcher at the email address below. You do not need to give a reason to withdraw. Your responses will be anonymous and you will never be identifiable in any data sets, reports or publications.

Who is funding and carrying out the research?

This research is funded by *Water and Sanitation for Urban Poor* – a non-profit partnership aimed at improving water and sanitation in urban areas. The research is being carried out by the *University of Leeds*.

Contact for further information:

Dr Dabo Guan
Senior Lecturer: Environmental Economics & Governance
School of Earth and Environment
University of Leeds, LS2 9JT, Leeds, UK
Phone: *+44(0) 113 34 37432*
Email: *d.guan@leeds.ac.uk*

Appendix 2: Variables Collected

Variable	Full Name	Description	Units / Input Format
Q_ID	Questionnaire ID	Questionnaire ID number.	first 3 letters of city name followed by a number.
Interview_date	Interview date	Date on which the interview took place.	day/month/year
City	City	City in which the interview took place.	text
Location	Location	Location in which the interview took place. NB - whilst not all cities may use locations/sub-locations, it would be useful for the purpose of this project to assign two levels of neighbourhood identification within the city, regardless of whatever administrative boundaries are used in reality.	text
Sub-location	Sub-location	Sub-location in which the interview took place.	text
Interviewer	Interviewer name	Name of the person who conducted the interview.	text
Gender	Gender	Gender of respondent.	m or f
Age_cat	Age category	Age band category which the respondent falls into. 1 = (18-30), 2 = (31-40), 3 = (41-50), 4 = (51-60), 5 = (61-70), 6 = (71-80), 7 = (80+).	category number
HH_head	Household head?	Binary variable indicating whether the respondent is the household head. 0 = NO, 1 = YES.	0 or 1
No_ppl	Number of people	The number of people living within the household.	number of people
No_infants	Number of infants	The number of infants living within the household.	number of infants
No_children	Number of children	The number of children living within the household.	number of children
Commercial	Commercial?	Binary variable indicating whether any commercial activity is carried out from the property.	0 or 1

		0 = NO, 1 = YES.	
Educ_cat	Education category	Highest education category achieved by any member of the household.	category number
Tenure_status	Tenure status	Tenure status category for the household.	category number
Length_resid	Length of residence	Length of time that the household has been resident in the property.	years
Rainy_drinking_1	Rainy season, primary drinking source category	Category of primary drinking water source used in the rainy season.	category number
Rainy_drinking_2	Rainy season, secondary drinking source category	Category of secondary drinking water source used in the rainy season.	category number
Rainy_drinking_3	Rainy season, tertiary drinking source category	Category of tertiary drinking water source used in the rainy season.	category number
Rainy_hh_1	Rainy season, primary household uses source category	Category of primary water source used for household uses in the rainy season.	category number
Rainy_hh_2	Rainy season, secondary household uses source category	Category of secondary water source used for household uses in the rainy season.	category number
Rainy_hh_3	Rainy season, tertiary household uses source category	Category of tertiary water source used for household uses in the rainy season.	category number
Rainy_irrcom_1	Rainy season, primary irrigation or commercial uses source category	Category of primary water source used for irrigation or commercial uses in the rainy season.	category number
Rainy_irrcom_2	Rainy season, secondary irrigation or commercial uses source category	Category of secondary water source used for irrigation or commercial uses in the rainy season.	category number
Rainy_irrcom_3	Rainy season, tertiary irrigation or commercial uses source category	Category of tertiary water source used for irrigation or commercial uses in the rainy season.	category number
Rainy_prim_quant	Rainy season, primary source, daily quantity	Quantity of water consumed by the household daily from the primary source in the rainy	number of litres

	consumed	season (for drinking and household uses).	
Rainy_prim_cost	Rainy season, primary source, cost	Cost of 20 litres of water paid by the household for their primary source during the rainy season.	cost in Ksh
Rainy_prim_dwreliab	Rainy season, primary source, days per week reliability	The average number of days per week from which the household can usually access their primary source of water during the rainy season.	number of days
Rainy_prim_hdreliab	Rainy season, primary source, hours per day reliability	The average number of hours per day from which the household can usually access their primary source of water during the rainy season.	number of hours
Rainy_prim_time	Rainy season, primary source, time spent collecting	The average number of hours per day which the household spends collecting water from the primary source during the rainy season.	number of hours
Rainy_prim_pred	Rainy season, primary source, predictability	The household is asked whether they are broadly able to predict in advance when their primary water source is available (during the rainy season). 0 = NO, 1 = YES, 2 = SOMETIMES.	0, 1 or 2
Rainy_sec_quant	Rainy season, secondary source, daily quantity consumed	Quantity of water consumed by the household daily from the secondary source in the rainy season (for drinking and household uses).	number of litres
Rainy_sec_cost	Rainy season, secondary source, cost	Cost of 20 litres of water paid by the household for their secondary source during the rainy season.	cost in US$ - use the conversion rate in place at the time of the survey.
Rainy_sec_dwreliab	Rainy season, secondary source, days per week reliability	The average number of days per week from which the household can usually access their secondary source of water during the rainy season.	number of days
Rainy_sec_hdreliab	Rainy season, secondary source, hours per day reliability	The average number of hours per day from which the household can usually access their secondary source of water	number of hours

		during the rainy season.	
Rainy_sec_time	Rainy season, secondary source, time spent collecting	The average number of hours per day which the household spends collecting water from the secondary source during the rainy season.	number of hours
Rainy_sec_pred	Rainy season, secondary source, predictability	The household is asked whether they are broadly able to predict in advance when their secondary water source is available (during the rainy season). 0 = NO, 1 = YES, 2 = SOMETIMES.	0, 1 or 2
Rainy_tert_quant	Rainy season, tertiary source, daily quantity consumed	Quantity of water consumed by the household daily from the tertiary source in the rainy season (for drinking and household uses).	number of litres
Rainy_tert_cost	Rainy season, tertiary source, cost	Cost of 20 litres of water paid by the household for their tertiary source during the rainy season.	cost in US$ - use the conversion rate in place at the time of the survey.
Rainy_tert_dwreliab	Rainy season, tertiary source, days per week reliability	The average number of days per week from which the household can usually access their tertiary source of water during the rainy season.	number of days
Rainy_tert_hdreliab	Rainy season, tertiary source, hours per day reliability	The average number of hours per day from which the household can usually access their tertiary source of water during the rainy season.	number of hours
Rainy_tert_time	Rainy season, tertiary source, time spent collecting	The average number of hours per day which the household spends collecting water from the tertiary source during the rainy season.	number of hours
Rainy_tert_pred	Rainy season, tertiary source, predictability	The household is asked whether they are broadly able to predict in advance when their tertiary water source is available (during the rainy season). 0 = NO, 1 = YES, 2 = SOMETIMES.	0, 1 or 2
Dry_drinking_1	Dry season, primary	Category of primary drinking	category number

	drinking source category	water source used in the dry season.	
Dry_drinking_2	Dry season, secondary drinking source category	Category of secondary drinking water source used in the dry season.	category number
Dry_drinking_3	Dry season, tertiary drinking source category	Category of tertiary drinking water source used in the dry season.	category number
Dry_hh_1	Dry season, primary household uses source category	Category of primary water source used for household uses in the dry season.	category number
Dry_hh_2	Dry season, secondary household uses source category	Category of secondary water source used for household uses in the dry season.	category number
Dry_hh_3	Dry season, tertiary household uses source category	Category of tertiary water source used for household uses in the dry season.	category number
Dry_irrcom_1	Dry season, primary irrigation or commercial uses source category	Category of primary water source used for irrigation or commercial uses in the dry season.	category number
Dry_irrcom_2	Dry season, secondary irrigation or commercial uses source category	Category of secondary water source used for irrigation or commercial uses in the dry season.	category number
Dry_irrcom_3	Dry season, tertiary irrigation or commercial uses source category	Category of tertiary water source used for irrigation or commercial uses in the dry season.	category number
Dry_prim_quant	Dry season, primary source, daily quantity consumed	Quantity of water consumed by the household daily from the primary source in the dry season (for drinking and household uses).	number of litres
Dry_prim_cost	Dry season, primary source, cost	Cost of 20 litres of water paid by the household for their primary source during the dry season.	cost in Ksh
Dry_prim_dwreliab	Dry season, primary source, days per week reliability	The average number of days per week from which the household can usually access their primary source of water during the dry season.	number of days

Dry_prim_hdreliab	Dry season, primary source, hours per day reliability	The average number of hours per day from which the household can usually access their primary source of water during the dry season.	number of hours
Dry_prim_time	Dry season, primary source, time spent collecting	The average number of hours per day which the household spends collecting water from the primary source during the dry season.	number of hours
Dry_prim_pred	Dry season, primary source, predictability	The household is asked whether they are broadly able to predict in advance when their primary water source is available (during the dry season). 0 = NO, 1 = YES, 2 = SOMETIMES.	0, 1 or 2
Dry_sec_quant	Dry season, secondary source, daily quantity consumed	Quantity of water consumed by the household daily from the secondary source in the dry season (for drinking and household uses).	number of litres
Dry_sec_cost	Dry season, secondary source, cost	Cost of 20 litres of water paid by the household for their secondary source during the dry season.	cost in Ksh
Dry_sec_dwreliab	Dry season, secondary source, days per week reliability	The average number of days per week from which the household can usually access their secondary source of water during the dry season.	number of days
Dry_sec_hdreliab	Dry season, secondary source, hours per day reliability	The average number of hours per day from which the household can usually access their secondary source of water during the dry season.	number of hours
Dry_sec_time	Dry season, secondary source, time spent collecting	The average number of hours per day which the household spends collecting water from the secondary source during the dry season.	number of hours
Dry_sec_pred	Dry season, secondary source, predictability	The household is asked whether they are broadly able to predict in advance when their secondary water source is available (during the dry season). 0 = NO, 1 = YES,	0, 1 or 2

		2 = SOMETIMES.	
Dry_tert_quant	Dry season, tertiary source, daily quantity consumed	Quantity of water consumed by the household daily from the tertiary source in the dry season (for drinking and household uses).	number of litres
Dry_tert_cost	Dry season, tertiary source, cost	Cost of 20 litres of water paid by the household for their tertiary source during the dry season.	cost in Ksh
Dry_tert_dwreliab	Dry season, tertiary source, days per week reliability	The average number of days per week from which the household can usually access their tertiary source of water during the dry season.	number of days
Dry_tert_hdreliab	Dry season, tertiary source, hours per day reliability	The average number of hours per day from which the household can usually access their tertiary source of water during the dry season.	number of hours
Dry_tert_time	Dry season, tertiary source, time spent collecting	The average number of hours per day which the household spends collecting water from the tertiary source during the dry season.	number of hours
Dry_tert_pred	Dry season, tertiary source, predictability	The household is asked whether they are broadly able to predict in advance when their tertiary water source is available (during the dry season). 0 = NO, 1 = YES, 2 = SOMETIMES.	0, 1 or 2
Vol_stored_avail	Volume of storage available	The number of litres of storage capacity available within containers owned by the household.	number of litres
Vol_stored_curr	Volume of storage currently used	The number of litres of water which were being stored by the household at the time of the interview.	number of litres
Collects_gender	Collection gender	The gender of the person who most commonly collects water in the household.	m or f
Collects_agecat	Collection age category	The age category of the person who most commonly collects	category number

		water in the household.	
Toilet	Toilet?	Binary variable indicating whether the household has a toilet. 0 = NO, 1 = YES.	0 or 1
Dist	Distance from source	Distance between the household and the primary source, in metres.	number of metres
Flag	Flag?	Binary variable indicating whether there is anything about the household that might cause the researcher to suspect it might be an outlier in any way, or if very large estimates were made. Put a 1 here if, for instance, it was impossible to estimate the total storage volume, or if the household conducts commercial activity from the property that consumes an extremely large amount of water. Otherwise, put 0.	0 or 1

Variable	Full name	Category Number	Value
Age_cat	Age category	1	18-30
		2	31-40
		3	41-50
		4	51-60
		5	61-70
		6	71-80
		7	80+
Educ_cat	Education category	1	No formal education
		2	Competed primary education
		3	Completed secondary education
		4	Competed post-secondary training
		5	Completed university
		6	Other

Tenure_status	Tenure status	1	Household owns the property.
		2	Household rents the property.
		3	Household rents a room in the property.
Water category related variables	Water source category	1	Piped water with a tap located on the property and used by the household only.
		2	Piped water with a tap located in the yard and shared with other households.
		3	Well/borehole located in the yard and used by the household only.
		4	Well/borehole located in the yard and shared with other households.
		5	Rain water
		6	Standpipe
		7	Water vendors / kiosks - piped source
		8	Water vendors / kiosks - well/borehole source
		9	Water vendors / kiosks - tanker source
		10	Water vendors / kiosks - source unknown
		11	Purchased from neighbours - piped source
		12	Purchased from neighbours - well/borehole source
		13	Purchased from neighbours - tanker source
		14	Purchased from neighbours - source unknown
		15	Water from hand-pulled cart
		16	Tanker
		17	Sachets
		18	Bottled water
		19	Surface water
		20	Other
Collects_agecat	Collection age category	1	Child
		2	Adolescent
		3	Adult
		4	Older person

Appendix 3: Correlation matrix

		Wealth index score	Age category of respondent	Number of people	Number of infants	Number of children	Education category	Tenure status	Length of residence (years)	Dry season, primary source, cost (US$ per 20 litres)	Dry season, primary source, days per week reliability	Dry season, primary source, hours per day reliability	Dry season, primary source, hours per day collecting	Average consumption in litres per capita per day	Volume of storage available (litres)	Toilet?	Distance from source (metres)	Dry primary drinking source - recode	Dry secondary drinking source - recode
Wealth index score	Pearson Correlation	1	-.169	-.100	-.198	.032	.547**	-.292**	.065	-.009	-.038	.096	.327	.138	.211	.471**	.271	.230*	.082
	Sig. (2-tailed)		.141	.386	.084	.781	.000	.010	.572	.940	.750	.431	.253	.231	.067	.000	.277	.044	.479
Age category of respondent	Pearson Correlation	-.169	1	.057	-.242*	.218	-.125	.224	.173	-.006	.078	-.084	.110	-.017	-.053	-.146	-.013	.182	.038
	Sig. (2-tailed)	.141		.623	.034	.057	.278	.050	.131	.962	.510	.491	.709	.884	.652	.208	.959	.113	.743
Number of people	Pearson Correlation	-.100	.057	1	.151	.580**	-.039	-.168	.456**	-.034	-.113	-.178	.157	-.355**	.107	-.166	.281	.003	-.030
	Sig. (2-tailed)	.386	.623		.191	.000	.734	.144	.000	.775	.338	.144	.591	.002	.358	.151	.259	.980	.799
Number of infants	Pearson Correlation	-.198	-.242*	.151	1	-.176	.020	.037	-.186	.166	-.073	-.031	-.143	-.124	-.006	.077	-.107	-.123	-.017
	Sig. (2-tailed)	.084	.034	.191		.125	.860	.747	.105	.160	.537	.802	.626	.284	.962	.506	.672	.288	.882
Number of children	Pearson Correlation	.032	.218	.580**	-.176	1	-.100	.077	.336**	.008	-.173	-.227	.248	-.187	.076	-.271*	.550*	.107	-.060
	Sig. (2-tailed)	.781	.057	.000	.125		.388	.508	.003	.947	.140	.060	.392	.104	.513	.018	.018	.354	.606
Education category	Pearson Correlation	.547**	-.125	-.039	.020	-.100	1	-.211	-.190	-.031	.063	.041	-.149	.208	.294**	.345**	.386	.133	.129
	Sig. (2-tailed)	.000	.278	.734	.860	.388		.066	.097	.797	.594	.736	.611	.070	.010	.002	.114	.250	.262
Tenure status	Pearson Correlation	-.292**	.224	-.168	.037	.077	-.211	1	-.134	.080	.121	.012	-.148	.004	-.142	-.229*	-.073	.037	-.124
	Sig. (2-tailed)	.010	.050	.144	.747	.508	.066		.245	.503	.304	.919	.613	.973	.222	.047	.774	.750	.284
Length of residence (years)	Pearson Correlation	.065	.173	.456**	-.186	.336**	-.190	-.134	1	-.015	.075	-.182	-.070	-.111	-.048	-.127	-.331	-.193	.032
	Sig. (2-tailed)	.572	.131	.000	.105	.003	.097	.245		.899	.524	.134	.813	.339	.683	.273	.180	.092	.784
Dry season, primary source, cost (US$ per 20 litres)	Pearson Correlation	-.009	-.006	-.034	.166	.008	-.031	.080	-.015	1	.033	-.309*	-.141	-.040	-.080	-.013	-.125	-.321**	-.145
	Sig. (2-tailed)	.940	.962	.775	.160	.947	.797	.503	.899		.782	.010	.631	.734	.506	.915	.633	.006	.221
Dry season, primary source, days per week reliability	Pearson Correlation	-.038	.078	-.113	-.073	-.173	.063	.121	.075	.033	1	.198	-.999**	.086	-.512**	-.172	-.044	.009	-.216
	Sig. (2-tailed)	.750	.510	.338	.537	.140	.594	.304	.524	.782		.103	.000	.464	.000	.146	.868	.937	.064
Dry season, primary source, hours per day reliability	Pearson Correlation	.096	-.084	-.178	-.031	-.227	.041	.012	-.182	-.309*	.198	1	.103	-.040	-.020	.061	.384	.521**	.025
	Sig. (2-tailed)	.431	.491	.144	.802	.060	.736	.919	.134	.010	.103		.726	.744	.871	.619	.175	.000	.838
Dry season, primary source, hours per day collecting	Pearson Correlation	.327	.110	.157	-.143	.248	-.149	-.148	-.070	-.141	-.999**	.103	1	-.166	.606*	.229	-.338	-.122	-.113
	Sig. (2-tailed)	.253	.709	.591	.626	.392	.611	.613	.813	.631	.000	.726		.571	.022	.451	.662	.678	.701
Average consumption in litres per capita per day	Pearson Correlation	.138	-.017	-.355**	-.124	-.187	.208	.004	-.111	-.040	.086	-.040	-.166	1	.043	.060	-.532*	.035	.038
	Sig. (2-tailed)	.231	.884	.002	.284	.104	.070	.973	.339	.734	.464	.744	.571		.714	.606	.023	.763	.741
Volume of storage available (litres)	Pearson Correlation	.211	-.053	.107	-.006	.076	.294**	-.142	-.048	-.080	-.512**	-.020	.606*	.043	1	.258*	.438	-.074	.190
	Sig. (2-tailed)	.067	.652	.358	.962	.513	.010	.222	.683	.506	.000	.871	.022	.714		.026	.069	.524	.100
Toilet?	Pearson Correlation	.471**	-.146	-.166	.077	-.271*	.345**	-.229*	-.127	-.013	-.172	.061	.229	.060	.258*	1	.091	.013	.045
	Sig. (2-tailed)	.000	.208	.151	.506	.018	.002	.047	.273	.915	.146	.619	.451	.606	.026		.718	.910	.703
Distance from source (metres)	Pearson Correlation	.271	-.013	.281	-.107	.550*	.386	-.073	-.331	-.125	-.044	.384	-.338	-.532*	.438	.091	1	.325	-.115
	Sig. (2-tailed)	.277	.959	.259	.672	.018	.114	.774	.180	.633	.868	.175	.662	.023	.069	.718		.188	.649
Dry primary drinking source - recode	Pearson Correlation	.230*	.182	.003	-.123	.107	.133	.037	-.193	-.321**	.009	.521**	-.122	.035	-.074	.013	.325	1	-.078
	Sig. (2-tailed)	.044	.113	.980	.288	.354	.250	.750	.092	.006	.937	.000	.678	.763	.524	.910	.188		.500
Dry secondary drinking source - recode	Pearson Correlation	.082	.038	-.030	-.017	-.060	.129	-.124	.032	-.145	-.216	.025	-.113	.038	.190	.045	-.115	-.078	1
	Sig. (2-tailed)	.479	.743	.799	.882	.606	.262	.284	.784	.221	.064	.838	.701	.741	.100	.703	.649	.500	