Rural water usage in East Africa: Does collection effort really impact basic access?

JONATHAN E. MELLOR, DAVID W. WATKINS and JAMES R. MIHELCIC

Access to water for domestic use is a serious impediment to the development of East Africa. Throughout the region, it is common for rural residents to travel distances more than two kilometers every day in search of water sources. Such a burden has led many to the conclusion that per capita water usage must be correlated to water accessibility – those who have poor access will not use as much water. This paper aims to investigate this through a study of water usage in rural East Africa. The study queried participants in three districts of Uganda and one province of Kenya about their water usage habits. The first survey found that rural Ugandans use an average of 15.4 ± 0.5 liters per person per day regardless of their perceived effort in terms of collection times or distances travelled. Results are supported by two smaller studies in Kenya's Eastern Province and in Rakai District, Uganda. In all of these studies, there was no decline in water collected with increasing perceived collection effort. These results suggest that for these communities, the quantity of water used may not depend on the perceived collection effort. Instead, users collect water to fulfill their basic needs.

Keywords: rural water, Uganda, Kenya, collection effort

Two basic questions in development work are: how much water do people need to sustain themselves, and how does water use change as access becomes easier and less time consuming? A widely cited work on this subject is the paper by Howard and Bartram (2003). This document, written for the World Health Organization, discusses basic human water requirements by means of a literature review of the links between water and sanitation practices and improved health. The report suggests there is no direct linear relationship between health and water quantity used. Instead, the report defines four service levels and argues that it is these service levels, and not the specific quantity of water used, that tend to determine health benefits. One main contribution of the report is to describe water service levels in terms

Those who have poor access will likely not use as much water

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Table 1. Water service and access levels (as defined by Howard and Bartram, 2003)

Service level	*Access level*
No access (less than 5 l/p/d)	More than 1 km or 30 minutes collection time
Basic access (unlikely to exceed 20 l/p/d)	Between 100 m and 1,000 m or 5–30 minutes collection time
Intermediate access (average quantity 50 l/p/d)	Water delivered on site via a tap on plot or within 100 m or 5 min collection time
Optimal access (average quantity 100 l/p/d and above)	Water supplied through multiple taps

of both accessibility and volume of water used. Various access levels, summarized in Table 1, correspond to service categories of 'No access', 'Basic access', 'Intermediate access', and 'Optimal access', with typical water use rates ranging from 5 l/p/d to greater than 100 l/p/d. It is important to note that these usage rates are not measured values, but are rather rates that are typical of people with those service levels.

Another important study (Cairncross and Cliff, 1987) found that, in rural Mozambique, when water collection time dropped from 5 hours to 10 minutes, usage increased from 4.1 to 11.1 l/p/d, with 70 per cent of that additional water being used for bathing and washing clothes. More than half the time saved was spent on other, more productive household tasks. Cairncross and Feachem (1983) argued that once water collection times exceed a few minutes, water use decreases dramatically and levels out at a plateau. This plateau lasts from collection times of 5 to 30 minutes and distances of 100 m to 1 km. Beyond this, consumption rates are expected to decrease further. This expectation has been further established in a WHO/UNICEF (2005) publication in which a well-distributed figure shows that beyond 30 minutes, the amount of water collected decreases dramatically with increased collection time (Figure 11 in *Water for Life: Making it Happen*; WHO and UNICEF, 2005).

Once water collection times exceed a few minutes, water use decreases dramatically and levels out

Another study of water usage levels for different service levels was completed in Jinja, Uganda (WELL, 1998). Results from the WELL study support earlier studies, stating that households using communal water sources such as springs or hand pumps use around 15.8 l/p/d, while those who use communal stand-posts use around 15.5 l/p/d, and consumption levels increase dramatically for those who have a tap in their yard (50 l/p/d) and for those who have multiple connections within their home (155 l/p/d). Gleick (1996) stated that those who use public standpipes further than 1 km away would use less than 10 l/p/d, while those who had to travel less than 1 km would use about 20 l/p/d.

Several studies have investigated the relationship between water use and collection time or distance

A more recent study by Hadjer et al. (2005) found that per capita use increases from 14.6 l/p/d for those with no access to 21.2 l/p/d for those with intermediate access. They also found significant effects for a prosperity indicator: those classified as rich used more water (21.9 vs. 11.2 l/p/d) in towns, but not in rural settings (16.8 vs. 15.6 l/p/d). Finally, they also found that larger households use less water per capita than smaller ones.

Although several studies have investigated the relationship between water use and collection time or distance, few have performed extensive surveys in rural areas, and few have used multiple research sites. This study seeks to contribute to information from previous surveys through its large sample size and through the geographic and cultural diversity of those being studied.

Methods

A baseline survey was undertaken in February 2008 for a rainwater harvesting project targeting water-stressed regions of Uganda. The African Development Bank in collaboration with the Network for Water and Sanitation (NETWAS) Uganda, the coordinating NGO, funded the project. The purpose of this survey was to gather baseline socio-economic and water accessibility data in three districts of Uganda representing the eastern, central, and western regions of the country for the rainwater harvesting project. The three NGOs who performed the survey were the Joint Effort to Save the Environment (JESE), which operates in the western Ugandan district of Kamwenge; Open Palm Community Welfare Services (COWESER), operating in the central district of Rakai; and the Uganda Muslim Rural Development Association (UMURDA), operating in the eastern district of Bugiri. Despite the physical distance between the three districts, all three have a similar climate and rainfall patterns. Each receives approximately 1 m of rain per year. Also, the vast majority of residents in all regions are subsistence farmers located in remote communities far from urban centres.

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Of the 1,563 surveys carried out in Uganda, 375 were done in Rakai District, 611 in Kamwenge District, and 577 in Bugiri District. These districts were chosen to be part of the rainwater harvesting project that was targeting areas with particularly poor access to water resources. The data were recorded and transferred to the NETWAS office in Kampala. The survey itself was developed by NETWAS in collaboration with the three implementing NGOs and a professional consultant. For this research, the questions listed in Table 2 were analysed. Other questions asked, but not included in this analysis, included other socio-economic information and water use and sanitation practices and technologies.

Since the purpose of this project was to compare water usage in East Africa with earlier works that indicated typical usage values of 5, 20, and 50 l/p/d for those with 'no', 'basic', and 'intermediate' access, respectively, a priori power analysis was conducted to determine the sample size needed to identify significant differences from these water usage values. The analysis for an ANOVA test concluded that a sample size of just 18 households would be needed to achieve a power of 0.85 at the 0.05 confidence level.

The survey interviews were done at the household level and carried out in the local language by assistants

The survey interviews were done at the household level and were carried out in the local language by survey assistants with the head of household or the next available adult present. Surveying techniques and procedures were harmonized by the various NGOs before the study was undertaken at a collaborative workshop in Kampala. Within each district, communities with poor access to water resources were chosen to participate in the rainwater harvesting project. Within those communities, surveyors chose households along random transects by a random walk method. A starting household was first determined. Subsequent houses were selected as being the nearest eligible households along a transect in a pre-determined direction. Each survey took approximately 20 minutes, and all surveys were completed in all three districts within one month. Each household was visited only once.

To compare survey responses with the results of other studies, the number of jerry-cans was converted to litres, and the collection distance and time data were divided into the same service levels

Table 2. Questions asked in Ugandan survey

Question	*Possible answers*
Level of education	No schooling Primary Secondary Post-secondary
Observed household type of main dwelling	Hut Semi-permanent Permanent
Who collects water?	Free response
How far is the water source?	Free response
How long is the round-trip to fetch water?	Free response
How many jerry-cans of water do you use daily?*	Free response
How many people live in this household?	Free response

* Surveyors recorded the number of jerry-cans used in 20-litre equivalents in the event that a household used smaller jerry-cans

Each survey took approximately 20 minutes, and all surveys were completed in all three districts within one month

prescribed by Howard and Bartram (2003). This has the added advantage that the data can be treated more qualitatively (e.g. categorically). Data analysis was carried out using a combination of the Statistical Package for the Social Sciences (SPSS), Microsoft Excel, and custom designed programs written in the Perl programming language. Standard statistical methods were used, including Pearson's correlation, analysis of variance, and the Tukey-HSD test (e.g. George and Mallery, 2006; Salkind, 2007; Colman and Pulford, 2008). Throughout this paper, F is the ANOVA F-test statistic, defined as the ratio of between to within group variability; and p is the significance level, interpreted as the probability of the results occurring due to chance alone. All statistical tests and confidence intervals were done at the 95 per cent significance level.

Limited resources did not allow the researchers to confirm the distance or time estimates. However, the complementary study by Kennedy (2006) summarized in the Discussion section used a similar survey and found relative consistency between reported and measured collection distances and times.

Results

There is little correlation between perceived collection effort and per capita water usage in rural Uganda

The following results indicate that there is little correlation between perceived collection effort and per capita water usage in rural Uganda. The survey participants use, on average, 15.4 ± 0.5 litres per person per day.

Several analyses were carried out to determine the validity and reliability of the survey data. As indicated in Table 3, data show that all three regions are similar socio-economically in that they have similar house types and educational levels. An analysis was done to determine the correlation of the distance and time to source responses, as summarized in Figure 1 (Mellor, 2010). The measures were highly correlated (Pearson's $R = 0.474$, $p < 0.001$), indicating that respondents generally estimated distance and time measurements consistently, although there was significant

Table 3. Household types and education levels, which are indicators of socio-economic status within the three districts

District	*Household quality*			*School level obtained by household head*			
	Hut	*Semi-permanent*	*Permanent*	*No school*	*Primary*	*Secondary*	*Post-secondary*
Kamwenge	14	78	8	26	63	9	3
Rakai	13	62	25	27	61	9	3
Bugiri	32	41	27	18	60	20	2

Note: 'Hut' refers to a mud and wattle house with a thatched roof; 'semi-permanent' refers to a mud and wattle house with an iron roof; and 'permanent' refers to a house with an iron roof and brick walls

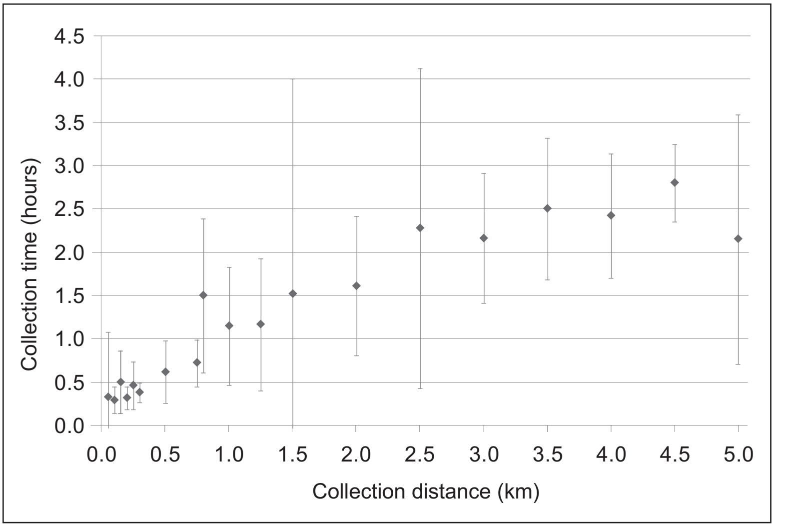

Figure 1. Mean reported collection time for each collection distance reported more than twice by respondents. Error bars represent +/- one standard deviation. As can be seen with this data, reported collection times did increase with distances. Standard deviations were reasonable for shorter collection distances, but grew for longer distances

variability in responses. Additionally, inter-district variation was found to be insignificant, as can be seen in Figure 2.

Results indicate that the majority (77.6 per cent, n = 1,180) of people are using less than the requisite 20 l/p/d for 'Basic access' and that only 52.4 per cent (n = 814) of households are located within 1 km of a water source. Data on water usage vs. distance to source is provided in histogram form in Figure 3 for the three service levels. Despite the variability in the responses, these data also indicate that average water usage remains relatively constant across these service levels.

There was no significant difference in mean per capita usage between perceived collection distances in wet or dry seasons

An analysis of both the distance and time to source data using ANOVA tests found the following results: $F_{(2,1538)} = 1.938$, $p = 0.14$ for distance in the wet season; $F_{(2,1539)} = 4.966$, $p = 0.007$ for time in the wet season; $F_{(2,1539)} = 1.244$, $p = 0.29$ for distance in the dry season; and $F_{(2,1539)} = 5.242$, $p = 0.005$ for time in the dry season. A post-hoc Tukey-HSD test also concluded that there was no significant difference in mean per capita usage between perceived collection distances in either the wet or dry seasons. The time measurements did show significant mean differences in both the wet and dry seasons between the 'intermediate' access regime and 'basic' and 'no' access regimes. However, there was no significant difference between 'basic' and 'no' access regimes in either the wet or dry seasons.

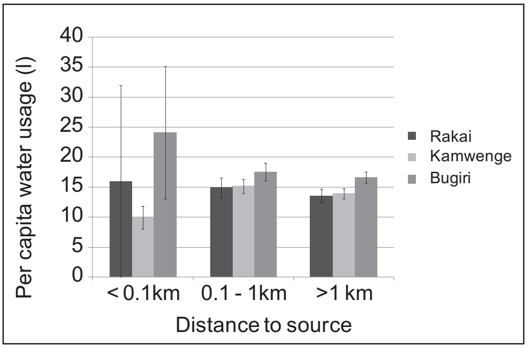

Figure 2. Per capita water usage across the three districts in Uganda. Error bars represent the 95 per cent confidence intervals. The large error bars for short distances are due to the small sample size for that distance range

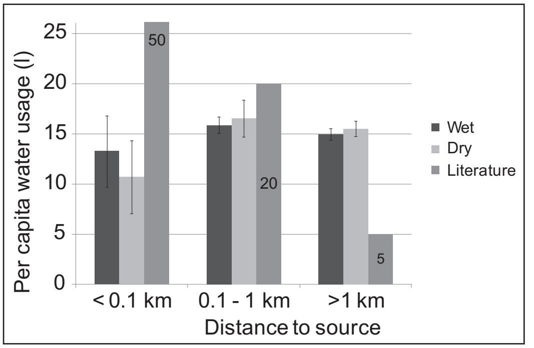

Figure 3. Per capita usage (in litres) vs. distance to source. Shown for comparison are the per capita use values suggested by Howard and Bartram (2003)

> Additional statistical analysis concluded that water usage was correlated to household size, education level, and household type

Additional statistical analysis concluded that water usage was correlated to household size, education level, and household type (Mellor, 2010). An analysis was performed to determine if any of those variables confounded the results. Household sizes were divided into three categories: small (<5 members), medium (5–10 members), and large (>10 members). Likewise, households were divided into three categories (hut, semi-permanent, and permanent) and respondents were divided into four education levels according to the highest level of schooling obtained by the household head (no school, primary, secondary, and post-secondary). Mean distance to source responses differed slightly and were 1.58, 1.64, and 1.72 km for the small, medium, and large household sizes, respectively. However, these differences were not significant ($F_{(2,1556)} = 0.851$, $p = 0.427$). Likewise, mean distance to source measurements varied between educational level and were 1.51, 1.64, 1.75, and 1.92 km for no education, primary education, secondary education, and post-secondary education levels, respectively; but this also did not represent a significant difference ($F_{(3,1552)} = 1.999$, $p = 0.112$). However, mean distance to source did vary significantly for household type. Mean distances to source were 1.85, 1.57, and 1.58 km for hut, semi-permanent, and permanent houses, respectively. Heterogeneity of variance forced the use of the more robust Welch ANOVA test, which found $F_{(2,651.004)} = 4.432$, $p = 0.012$. Thus, post-hoc analysis concluded that huts were further from the source than more permanent houses, which may be due to the fact that areas close to water sources are more valuable property or wealthy families used their money or influence to install water sources closer to their homes. Further analysis showed that, despite the variation in distance, there was no significant correlation between water usage and source distance within any of the three ranges, with Pearson's R of 0.069 (p = 0.219), 0.016 (p = 0.624), and 0.002 (p = 0.980) for the respective ranges. We can therefore conclude that none of the socio-economic variables confounded the results.

Discussion and conclusion

The results from the survey indicate that the established literature on the subject may be insufficient to explain water usage and associated collection behaviour in the context of Ugandan rural communities in water-stressed regions, at least for those with 'basic' or 'no' access to water. This can be seen in Figure 3, which compared results of this study with the water usage suggested by Howard and Bartram (2003).

Based on this survey of 1,563 households in three districts of Uganda, there seems to be little correlation between the per capita usage of water and a household's perceived effort in collecting it. Specifically, the results indicate that residents of rural Uganda use a fixed amount of water (15.4 ± 0.5 litres per person per day on average), regardless of perceived collection effort in terms of estimated collection time or distances.

There seems to be little correlation between the per capita usage of water and a household's perceived effort in collecting

Prior to this study, few investigations have been done that directly relate water consumption to perceived collection efforts. Some studies (i.e. Cairncross and Feachem, 1983; Hadjer et al., 2005) used direct observation, interviews, and known distances to water points, but these studies were confined to smaller geographic areas than this study. The study presented here goes beyond previous studies by surveying a large sample of residents across three distinct regions, representing a broad cross-section of different ethnic groups and customs with varying access to water and sanitation resources. The intra-district consistency check (Figure 2) was important because the survey was carried out in the three areas by three different organizations that employed different surveyors.

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Survey results were not completely consistent, or without surprises. An anomalous result was the collection amounts for households with 'intermediate access' 9.73 and 8.71 l/p/d for the wet and dry seasons, respectively, which are significantly below the overall average of 15.4 l/p/d. This may be due to a small sample size (N = 24) and high variability in the responses. Because the surveys were done only in water-stressed areas, there were very few households with intermediate access (within 100 m or 5 minutes collection time), which may have biased the study. However, as indicated by the wide 95 per cent confidence intervals in Figures 2 and 3, usage for those households is not statistically different from the other data, and the authors have no reason to believe that those households use less water.

Another surprising result was the consistency between survey responses for wet and dry seasons (Figure 3). This may be due to the nature of the water resources in southern Uganda. Most residents get their water from low-lying areas adjacent to wetlands that rarely dry up. Furthermore, seasonal rainfall fluctuations are not large compared with other parts of Africa.

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A remaining caveat associated with this analysis is that estimating distances and times may have been difficult for many survey participants; however, their answers to such questions indicate the perceived effort they must make to fetch water. The respondents were able to accurately estimate the number of jerry-cans used every day because it is well-known to all participating household members. Despite the fact that smaller jerry-cans are sometimes used for transporting water by young children, the 20-litre variety is the most common in Uganda, and the surveyors were instructed to record their answers in 20-litre equivalents.

Several of our other studies corroborate the main findings presented here. In a survey by Kennedy (2006) of 44 members of women's groups in two rural villages in the Eastern Province of Kenya, the average water use was reported to be 16.7 l per capita per day (including laundry) and 12.3 l/p/d (without laundry), and households collected similar amounts of water regardless of collection time. These results are similar to those reported here for rural Uganda, despite some differences in the study locations. For example, the Kenyan sites are at lower elevations, receive less rain, and the majority of unimproved water sources in the Kenyan sites are streams and springs. Furthermore, the majority of respondents in the Kenya study reported collection times of 120 minutes or less, although several reported collection times as high as 240 to 360 minutes.

Another study site of ours was located near Kalisizo Town Council in Rakai District, in south-western Uganda. Although this site was approximately 60 km from the region surveyed by NETWAS, it has abundant water resources owing to its proximity to Lake Victoria. That survey was conducted in a very similar manner to the one by NETWAS, using household surveys to elicit each respondent's estimation of the distance to the water source and their daily usage (Mellor, 2010). That study found an average usage rate of 12.6 ± 0.7 l/p/d. For the distance estimations an ANOVA test based on the same water access levels found $F_{(2,243)} = 0.116$, $p = 0.891$, indicating equal collection amounts regardless of collection distances.

The water usage 'plateau' appears to be longer than that reported by previous researchers

In each of these studies in Kenya and Uganda, the water usage 'plateau' appears to be longer than that reported by previous researchers. In fact, even for those reporting a need to travel more than 5 km, per capita usage seems to remain relatively constant. Data show that nearly all the Ugandan and Kenyan survey participants use more than 5 l/p/d, the suggested minimum usage for those who have to travel further than 1 km to collect water. This suggests that rural households require a certain amount of water for basic daily needs such as drinking, cooking, and hygiene and will collect that amount regardless of collection effort. This conclusion is corroborated by an extensive study carried out in East Africa that found that average usage for unpiped rural households in Uganda was 14.8 l/p/d (Thompson, 2001), which again is similar to the 15.4 ± 0.5 l/p/d found in this study. Although that study found a shorter average collection distance (622 m compared with 1.64 km estimated in this study) and a shorter collection time (25.3 minutes compared with 1.37 hours), these differences are likely to be due to paucity of water resources in the particular sub-regions surveyed in this study. All of these studies are further corroborated by Hadjer et al. (2005), who found similar per capita usage in rural settings.

Rural households require a certain amount of water and will collect that regardless of effort

Despite this study's overall finding that water use and collection effort may not always be closely linked, we want to emphasize the significant benefits that nearby water sources provide communities. Reducing collection time and effort allows communities, and particularly women and children, to spend their time doing more productive things to improve their lives in numerous other ways. For example, studies have shown that increased access to water improves households' reported food situations (Anderson and Hagos, 2008). It should also be noted that the time it takes to collect water includes not only the travel time from water source to home, but also the time a person lines up at a water source. Typically, when collecting water from a river, there is no delay. However, when collecting water from a spring, the flow can be low enough that a line forms. To improve quality of life, every effort should be made by all stakeholders to decrease collection efforts and times, including waiting times, in rural communities throughout the developing world.

Every effort should be made to decrease collection efforts and times, including waiting times, in rural communities

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