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Households' reluctance to collect potable water from improved sources, Ethiopia

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ABSTRACT

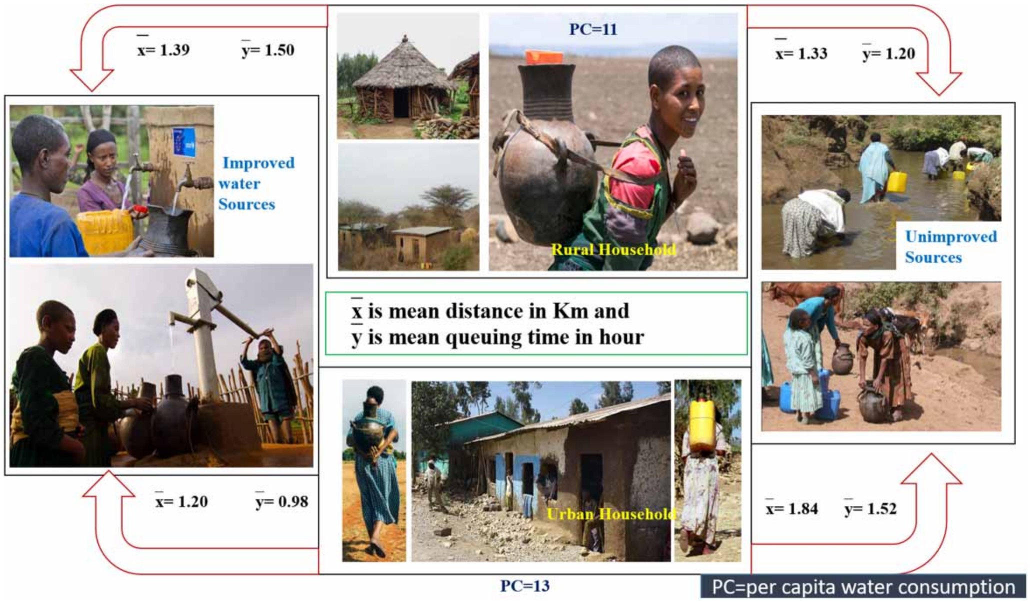
Water resources development and management are central to economic growth and poverty reduction. Despite considerable efforts, many households still rely on unimproved water sources. This research aimed to understand the reasons behind household reluctance to collect potable water from improved sources in urban and rural settings. Sixteen water points were selected purposively and a household survey conducted on the selected improved water source users. The result shows that in the urban areas people were satisfied with the water services provided. However, the poor could not afford the high cost of water and households sought unprotected alternative sources. Seventy-seven per cent of the urban and 65% of the rural households collect water from unimproved sources. Family size was the determinant factor for household water consumption from improved sources. Reliability, queuing time, high quality, and distance were associated with households' reluctance to collect potable water from improved sources. In conclusion, households' dependency on unprotected sources had a direct impact on the sustainability of schemes. Social factors are also fundamental when thinking about the sustainability of schemes.

Key words: potable water, reluctance, social factors, sustainability, unimproved sources, water management

HIGHLIGHTS

- Explains the existing water use trend of households that represent the majority of people in Africa.
- Indicated the significance of social factors that are not considered by decision makers and water infrastructure planners.
- People are traveling to search unprotected sources that indicated water is a matter of survival or death than in need.
- Improved sources to save life and productive time of women and children.

GRAPHICAL ABSTRACT



INTRODUCTION

Access to safe drinking water and sanitation services is vital for economic development as well as poverty alleviation. Social development and health care have been strongly linked to safe and adequate supplies of water and sanitation services (WHO & UNICEF 2017). With a growing population and urbanization, the demand for water is affected by climate change, creating an imbalance between nature and utilization of human water consumption (Olsson 2021). In the face of rising demand, governmental and non-governmental organizations made efforts to install improved sources to provide access to safe and potable water. An improved water source is defined as a form of water facility or water delivery point that protects the source of water from external contaminants due to the nature of its construction.

Globally, it is understood that 2.8 billion people will face water stress in 48 countries by 2025 (GWP/OECD 2015). The number of countries suffering from water scarcity or deficits will rise to 54 by 2050, with a total population of 4 billion by 2050, about 40% of the current global population of 9.4 billion and a further increase to 44% by 2095 (Gardner-Outlaw & Engleman 1997; Hejazi *et al.* 2014). However, the problem is worsening in developing countries (WHO 2006). Rural communities around the globe represent 84% of the total population and they collect water from unimproved sources.

According to UNICEF & WHO (2019), 884 million and 663 million people used unimproved water sources in 2010 and 2015, respectively. The services' provision in rural areas of sub-Saharan Africa is among the lowest, covering about 330 million people (IDA 2019). In 2013, Ethiopian rural water supply coverage was estimated at 39%, unlike South Africa, with 91% in the same year (Butterworth *et al.* 2013). With the rapid increase in population, an estimated 42 million people are still without access to safe drinking water supply and 94 million have no access to improved sanitation (IDA 2019). A low level of access to water and sanitation services results in people exposed to water-borne disease.

People who are most vulnerable to water-related diseases are exposed to open and polluted drinking water sources. Seventy-five per cent of all diseases in developing countries result from low drinking water quality in springs and wells (Amy *et al.* 2000). These water sources are contaminated with *Escherichia coli* and diarrheal diseases which are the second leading cause of death (Centers for Disease Control and Prevention 2015; IHME 2016; WHO & UNICEF 2017). In addition, collecting unsafe water from unimproved water points makes children vulnerable to health problems and miss the opportunity to attend school. At the same time, women spend 10–50% of their daytime fetching water from polluted water points, losing time on productive activities (Crow 2001).

In the study area with rugged landscapes, water supply sources are inconvenient for households. Women and children travel long distances carrying large water cans on steep slopes (Bimla *et al.* 2003; Asaba *et al.* 2013). Long waiting time, inadequate supply, lack of quality, low reliability of water and non-functionality of schemes are the characteristics of many improved water sources (Admasu *et al.* 2003). Due to these factors, households are forced to seek out alternative unimproved water sources.

In order to improve access to clean water supply systems for urban and rural households, assessing the current services that provide clean and safe water to families remains fundamental. This research attempted to determine the overall challenges related to household potable water consumption and available water supply services in Simada district. Therefore, the objective of the study was to investigate the reason behind the decision of households continuing to use unimproved water sources rather than available improved water points and household water management systems in the study area.

MATERIALS AND METHODS

Study area description

The study area, Simada, is found in the South Gondar Zone of Amhara regional state (Figure 1). The area lies between 11°2′19″N and 11°36′17″N latitude and 38°6′0″E and 38°38′36″E longitude. It covers an area of 2,245 km^2. The study site is located 774 km north of Addis Ababa and 209 km southeast of Bahir Dar (regional capital). The elevation of the district ranges from 1,196 m above sea level (m.a.s.l) to 3,525 m.a.s.l. The district has one urban and thirty-nine rural kebeles categorized under three agro-climatic zones: 30% Woynadega (intermediate elevation), 10% Dega (highland), and 60% Kolla (lowland below). The climate is monsoonal and varies with elevation. The primary wet season extends from April to October. Among these months, July and August are the wettest. The annual rainfall is between 900 and 1,100 mm and the mean annual temperature is 23 °C.

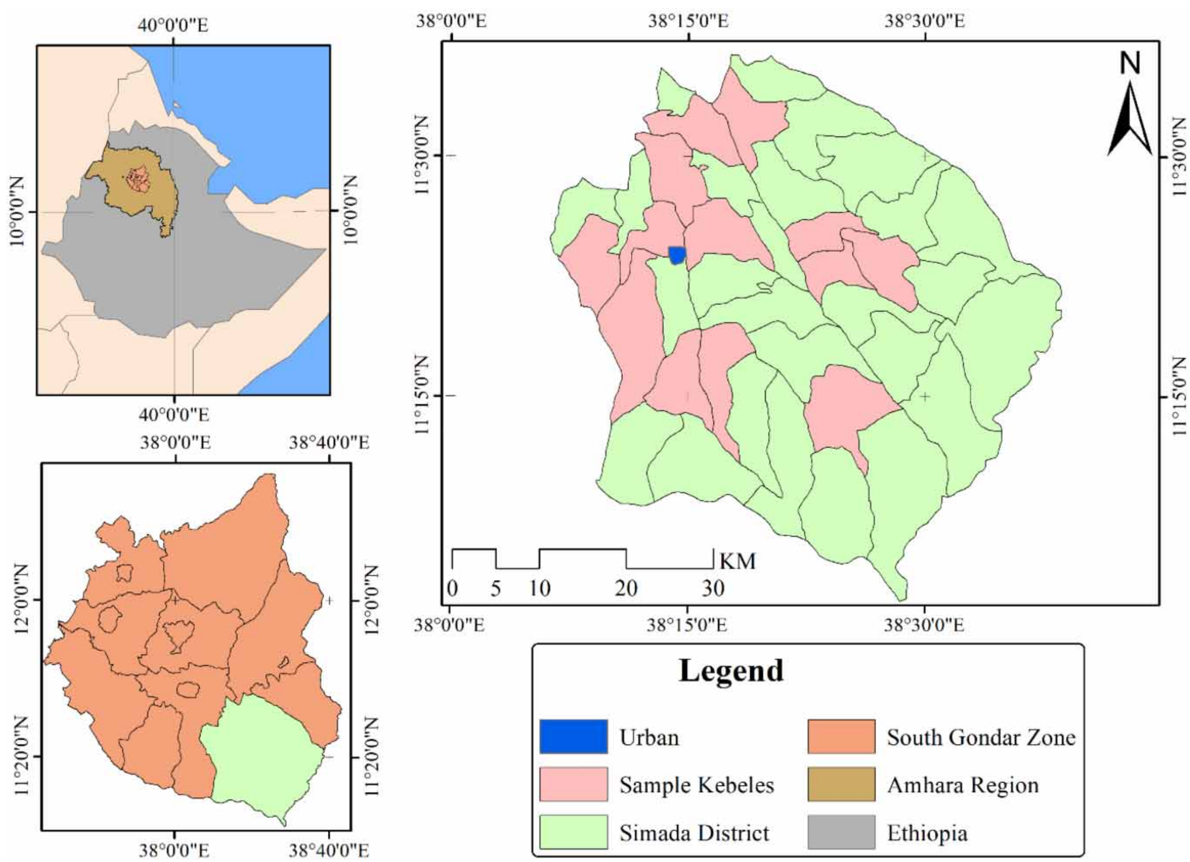


Figure 1 | Location map of the study area; Ethiopia with Amhara regional state and South Gondar zone with the district Simada in the left upper and lower corners, respectively. The sample locations are indicated in the district. *Source*: Map developed by the researcher with the help of ArcGIS (10.3).

According to the Central Statistical Agency (CSA) (2007), the district has a total population of 228,207, of whom 113,274 were men and 114,933 women, with an increase of 22% from the 1994 Census. In 2015, the estimated population of the district was 247,372. The report indicated that the district has an average of 4.2 persons per household. The rural community accounts for 95% of the population.

Data collection methods

A cross-sectional survey design was used to collect both qualitative and quantitative data types. Both probability and non-probability sampling techniques were employed. Stratified and simple random sampling techniques were applied to select the study locations and sample households, respectively. The sampling areas were stratified as urban, rural market centers and rural non-market centers (villages). Owing to the variation in living standards and accessibility of facilities in the rural scenarios, this classification represents the rural settings. Villages are rural settlements without a market or any public facilities, whereas market centers have a minimum of public facilities like markets, shops, high schools, health centers, etc. Therefore, each division was used as a sampling frame with market centers and without market centers. At the first stage, 13 water points were selected purposively from all market centers and the nearby non-market centers. Hence, seven and six water points were selected from all rural market centers and nearby rural non-market centers, respectively. We lowered the number of the non-market centers sample by one due to the non-functionality of the scheme.

In the second stage, household heads were selected for interview. The sample size was determined by assuming 10% of the total households from the one urban and 13 rural kebeles. The total number of households served from the selected schemes were 440 from the urban three schemes and 1,160 from 13 rural schemes. Therefore, we selected 44 households from urban and 116 households from rural households. The number of households using a single water point in the market centers was greater by about 30% than the non-market center discussed with the rural water use experts (District Water Office of Simada 2019). As a result, 65.5% of the respondents were drawn from market centers and 34.5% from non-market centers. According to Arkin & Colton (1950), the sampling calculation was determined at the confidence level of 95% with the margin of error (8% within the acceptable range). The Z-score value used at 95% was 1.96.

In the third stage, household heads, with due emphasis on women responsible for water collection, were interviewed. The instruments of the data collection were structured and semi-structured questionnaires and open-ended discussions with water use committees. Essentially, cross-sectional primary data were collected from households about their water use practices and their decision on reluctance to collect water from improved sources. In addition, socio-economic and water utilization trends of households were assessed. For accuracy, the measured values such as distance from the source to the house, time taken to collect water, average slope, elevation, and locations were taken using a stopwatch and GPS points by averaging the residential center and the water source. Secondary data were collected about the source management from the district water office experts, rural water office, and water user committees. As well, on-site observation on the status of each water point was completed.

Data analysis

The number of factors that affect users' reluctance to use improved water sources and water collection trends were analyzed. Data analysis was completed using descriptive statistics, chi-square test, and linear regression using SPSS version 20 software.

The chi-square test was used to analyze an association between reluctance to collect water from improved sources and the identified variables. The test is selected because of its robustness to data distribution, ease of computation, detailed information, when parametric assumptions cannot be met, and flexibility. A chi-square test is commonly used to test the independence of two attributes (McHugh 2013). In addition, Cremer's V was used to observe the strength of significant variables. Variables selected included walking distance within 1 km (distance), queuing time, quality of the sources, reliability, income, and satisfaction. These factors influence households in participating in collecting water from improved water supply sources.

Waiting time, distance, availability of alternative sources, and income forces the community to seek unimproved water sources. In addition, the quality and reliability of the water also made a contribution. Waiting time and distance were interpreted regarding WHO (2004) standards of 15 min and 1.0 km. The formula gives the χ^2 (chi-square) statistic:

$$\chi^2 = \sum_{i-1}^{r} \sum_{j=1}^{c} \left[\left(\frac{Oij_j - ei_j}{ei_j} \right)^2 \right] \sim x^2(r-1)(c-1) \quad (1)$$

where *Oij* is the number of units that belong to the category of *i* of reluctance and *j* of the other variables; *eij* is the expected frequency that belongs to the category of *i* of reluctance and *j* of the other variables.

The null and alternative hypothesis may be tested as H0: no association between reluctance to collect water from improved sources and other selected variables, and H1: there is an association between reluctance and other variables. The decision rule states to reject the H0 for independence at the significance level if the calculated value of χ^2 exceeds the tabulated value with the degree of freedom equal to (r – 1) (c – 1).

The water use patterns of the community within a given water source vary from one household to another. The significant determinants of water use (total and per capita water consumption) include household size, income, distance from the source to the house, education level, and queuing time. These independent variables in the water use behavior were identified based on published literature and the actual conditions in the area useful to explain the variations in the dependent variables (Arouna & Dabbert 2010). A linear regression model was selected to analyze the relationship between these variables. The equation used the linear combination of variables X_1, X_2, X_3, ……X_n, which is presented as:

$$Z = B_0 + B_1X_1 + B_2X_2 + \ldots\ldots\ldots B_nX_n \quad (2)$$

where Z is the dependent variable per capita water consumption, B_0 is a regression constant, $B_1 - B_n$ are the regression slopes or coefficients of variables and $X_1 - X_n$ are the independent variables. In this context, X_1 is total family size, X_2 is education level, X_3 is total household income, X_4 is average queuing time, and X_5 is the average distance covered per round trip.

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents

Understanding households' socio-economic characteristics was crucial in determining water use behavior, as shown in Table 1(a). Socio-economic characteristics of households are expressed in terms of age, family member, household

Table 1 | Socio-economic characteristics of respondents

(a)

Description		Sites	Mean	Std. dev.	Min.	Max.
Age		Urban	35	11.2	20	64
		Rural	37	12.2	18	85
Family members		Urban	3	1.34	1	7
		Rural	4	1.8	1	8
Income sources (ETB)	Livestock	Urban	124	395	0	1,800
		Rural	2,232	3,074	0	10,500
	Crop production	Urban	886	1,280	0	5,450
		Rural	2,056	2,295	0	10,250
	Non-Agricultural	Urban	2,134	2,766	0	10,200
		Rural	1,161	2,104	0	14,400

(b)

Description	Category	Frequency		Valid (%)	
		Urban	Rural	Urban	Rural
Sex	Male	8	36	18.2	31
	Female	36	80	81.8	69
Marital status	Married	17	66	38.6	56.9
	Unmarried	27	50	61.4	43.1
Education background	Illiterate	25	77	56.8	66.4
	Read and write	10	18	22.7	15.5
	Grade 1–8	6	19	13.6	16.3
	High school and above	3	2	6.8	1.8
	Total	44	116	100	100

Source: Field data collection.

income, sex, marital status, and educational background. These variables are directly or indirectly related to the water use behavior of a household. The results showed that the mean age of households in urban and rural areas was 36 years old (Table 1(a)). The minimum and maximum age range from urban areas was 20 and 64 and for the rural kebeles 18 and 85, respectively. The age range proportion increased the likelihood of capturing and understanding the community water consumption behavior well. The mean household size from the urban and rural area was almost similar. Household income from non-agricultural and agricultural production is presented in Table 1(a). The mean annual income of a household from urban residents was lower than households living in rural areas in all forms of livelihood activities except in non-agricultural practices. The income value was significant to evaluate households' willingness to pay for the service. Particularly, in the urban areas, households collect from tap water which costs per container. The cost of water hinders the poor in collecting water from improved sources.

Of the sampled respondents, 37% of urban and 57% of the rural households had spouses. Female sample households from urban and rural areas were 82 and 69%, respectively. The more significant percentages of female respondents' participation were due to two reasons. First, the study gave a strong impression to women to sense the burden of fetching water. Second, the data had been collected during crop harvesting season when male farmers were busy with field work so that females were more available at home for an interview than men. Hence, women's participation was believed central in realizing the challenges and suggesting solutions. Furthermore, the survey results revealed that about 57% of urban and 66% of the rural respondents were not attending school and 23% of urban and 15% of the rural respondents could read and write (Table 1(b)). There were households who could read and write without attending formal education. The reason was those households were engaged in informal education centers such as churches, mosques, and uncertified primary education. Even though the higher percentage of the respondents both in urban and rural were illiterate, most of them had a better understanding of the status of water source service.

Household water consumption trend

The household water consumption behavior was studied from primary and secondary or alternative water supply sources. Despite dealing with household water consumption from improved sources, unimproved secondary sources were included. From the total respondent households, about 77% of urban and 65% of the rural households had one or more alternative unimproved water sources. Women and children were the prominent responsible household members to collect water. As a result, 71% of women and 18% of women and children from urban areas were involved in water collection. In rural areas, however, 45% of women and 40% of women and children fetch water (Supplementary Material, Table S1). This indicated that other family members supported the participation of water collection load from rural areas, whereas children from rural areas spent more time collecting water than children who lived in urban areas.

Water collection material was the most crucial component of household water consumption. As a result, clay pots and jerricans were the two most common items used. Thus, about 96% of urban and 80% of the rural households used jerricans for water collection (Supplementary Material, Table S1). Due to the undulating nature of the topography, households had to travel up and down slopes. Accordingly, the study revealed that respondents traveled about an average gradient of 10% slopes. These slopes were considered the average slope from the homestead to the destination water point; individuals frequently travel up and down between these ranges. Therefore, introducing jerricans has two advantages in such locations. First, it reduces the burden of carrying heavy containers being made from light plastic material. Second, it minimizes post-contamination possibilities as water is used by tilting jerricans instead of dipping cups. Studies have shown that the level of water contamination is higher at the point of consumption than the point of collection (Tiku *et al.* 2003), which may be attributed to the mode of drawing water in the container. This was supported by health extension services included with the 11 sanitary packages.

Statistical t-test was employed to evaluate whether there is a significant difference between households' water use patterns from improved and unimproved sources. From the improved sources, except FWCD, the other variables like AQT ($p < 0.014$), ADs ($p < 0.011$), and total hours spend per day (THD) ($p < 0.021$) were significant (Supplementary Material, Table S2). From unimproved sources, except AQT, others like AFCD ($p < 0.025$), ADs ($p < 0.00$), and THD ($p < 0.021$) were statistically significant (Supplementary Material, Table S2). The mean frequency of water collection from improved and unimproved sources was 1.2 for the urban and 1.5 for the rural areas (Tables 2 and 3). To observe the difference between the urban and the rural areas access to water supply using AWT, ADs, AQT, and PCWC are discussed below. The AWT taken by households from the urban and rural areas to collect water from improved sources was 0.36 and 0.4 hr, respectively. From

Table 2 | Households' water consumption trend from improved sources

	Urban				Rural			
Description	**Mean**	**Std. dev.**	**Min**	**Max**	**Mean**	**Std. dev.**	**Min**	**Max**
FWCD	1.5	0.76	1.0	4.0	1.6	0.8	1.0	4.0
AWT (hr)	0.36	0.0	0.37	0.37	0.40	0.19	0.13	0.67
AQT (hr)	0.98	0.69	0.0	2.0	1.5	0.64	0.25	2.0
ADs (km)	1.2	0.08	1.2	1.2	1.39	0.54	0.54	2.6

Table 3 | Households' water consumption trend from unimproved sources

	Urban				Rural			
Description	**Mean**	**Std. dev.**	**Min**	**Max**	**Mean**	**Std. dev.**	**Min**	**Max**
FWCD	1.05	0.22	1.0	2.0	1.3	0.5	1.0	3.0
AWT (hr)	0.50	0.00	0.5	0.5	0.39	0.17	0.23	0.75
AQT (hr)	1.52	0.55	0.00	2.0	1.20	0.8	0.25	2.0
ADs (km)	1.84	0.00	1.48	1.48	1.33	0.75	0.36	2.26
PCWC (lts)	12.97	7.78	4.0	45	10.7	5.3	2.5	30.0

Source: Field data collection (Tables 2 and 3).

FWCD is frequency of water collection per day; AWT is average walking time taken in hours; ADs is average distance covered in km; AQT is average queuing time in hours; and PCWC is the per capita water consumption in liters.

the improved sources, the ADs covered by the urban households was 1.2 km, whereas it was 1.4 km for the rural households. On the contrary, the ADs had a parallel difference between the urban and rural villages from unimproved sources with 1.84 km for the urban and 1.33 km for the rural. This indicated relatively improved sources were close to the urban areas and the unimproved sources were found in close proximity to the rural households. The AQT from improved sources was better for urban than rural users. This could increase the use of tap water in the urban areas rather than the hand-dug wells used by most of the rural households. The total hours spent in collecting water from the urban areas were relatively less than the rural households. Based on the time taken by ADs and AQT, the urban households spent 9.3 hr per week rather than the 13.3 hr per week spent by the rural households. This indicated that households lost productive working days equivalent to 1 day for the urban and 1.67 days for the rural, of a woman or child per week. From this constructive time loss, it was possible to conclude that households in the study district were challenged by water collection activities. For comparison, according to Roy *et al.* (2005), water collection times in Kenya were an average of more than 4 hr per day in dry seasons and 2 hr per day in wet seasons. In addition, 4–6 hr were necessary to collect water in Burkina Faso, Botswana, and Cote D'Ivoire (Roy *et al.* 2005). The same source reports water collection times of 17 hr per week for Senegal and 15 hr for Mozambique in the dry season. This was only the time taken to collect water from the source to the house. When it includes the queuing time according to the definition of access to improved water sources, the time taken exceeded 5 hr, which is equivalent to about 13 hr. This report from the study area was similar to the study in western Kenya (Roy *et al.* 2005).

In the unimproved sources, the queuing time taken to collect water for the urban areas was 1.5 hr, which was greater than the 1.3 hr for rural areas. The main reason for that was the availability of unimproved sources in the vicinity of the rural regions was more accessible than urban areas. The PCWC trend of the urban areas was better than the rural with 13 and 11 L, respectively. Generally, the result failed to address the threshold level of the World Health Organization (WHO 2004) standards. Concurring with Howard *et al.* (2020), such sources are classified under unhealthy or unimproved because they did not meet the standards of less than 1 km distance cover, 30 minutes of queuing time, and about 20 L of per capita water consumption. The per capita water consumption was lower as indicated in Table 3. The amount of water consumption was minimum because households used the water only for cooking and drinking purposes. For most of the rainy season households look for alternative water from rivers for washing clothes.

Determinants of per capita household water consumption

The regression results of the comparison of the household per capita water consumption in the study area are presented in Table 4. As expected, an increase in household size increases the probability of collecting more water than smaller households. The result indicated a positive relationship between household size and total water consumption. However, the per capita water consumption decreased with an increase in household size. This was because all household members shared the available water perhaps a single household could access per day. In addition, low level of access and inadequate water supply at the sources remain a challenge for a large household to meet the needs of daily water consumption. The result showed that there was a negative relationship between household size and per capita water consumption. In every one-unit increase in the household size, there is a decrease in the per capita water consumption by 1.9 for the urban and 1.7 for the rural households. Relatively, the urban households consume more water for hygiene than the rural and is the reason why the decrease in water consumption was greater in the urban areas. In addition, the average queuing time was also a significant factor for urban areas which was negatively correlated with per capita water consumption. Hence, for a unit increase in queuing time there was a decrease in per capita water consumption by 4.2 times. The reason for this is, the longer the queuing time the less time to access the required amount of water for daily consumption.

Households' willingness to use improved sources

As indicated in the above household water consumption trend section, respondent households were still dependent on unimproved water sources (Supplementary Material, Table S1 and Figure 2). Chi-square test was run to see the association between households' reluctance to collect water from improved sources and factors that were assumed to trigger the decision not to use improved sources. Table 5 shows factors such as income, distance, quality, reliability, queuing time, and satisfaction were variables considered in the test. The results show that in urban areas income and queuing time significantly affected the use of improved water sources ($p < 0.05$). In the rural areas there was a relationship between reluctance and distance from the source to the house, queuing time, quality of the water, and the adequacy of the source. Households in urban areas paid for the service. However, the poor were unable to afford the cost and, therefore, found alternative unimproved sources of water. Queuing time in both the urban and rural areas was a factor that forced households to find alternative sources. Distance from the homestead to improved sources increased rural households' preference to collect water from nearby unimproved sources. However, Cramer's V, which is the most common strength test used when a significant chi-square

Table 4 | Determinants of per capita household water consumption

	Unstandardized coefficients		Standardized coefficient		
Description	**B**	**Std. error**	**Beta**	**t**	**Sig.**
Urban					
Total household income	0.001	0.001	0.339	1.828	0.089
Family size	−1.941	0.543	−0.593	−3.577	0.003
Education background	0.825	1.332	0.113	0.619	0.546
Average queuing time	−4.248	1.521	−0.466	−2.793	0.014
Average walking distance	−6.719	7.686	−0.147	−0.874	0.397
Rural					
Constant	18.46	1.98		9.31	0.0
Total household income	-4.2×10^{-5}	0.0	−0.04	−0.36	0.72
Family size	−1.66	0.28	−0.59	−6.02	0.00
Education background	0.23	0.42	0.05	0.54	0.52
Average queuing time	−0.85	0.71	−0.10	−1.20	0.23
Average walking distance	-4.4×10^{-5}	0.00	−0.00	−0.08	0.94

Source: Field data collection.
Note: at a significance level of 95%.

Figure 2 | Unimproved water sources: (a) a woman carrying a child and fetching water, and cattle using the same source and (b) girl fetching water beneath the rock and the other girl waiting. *Source*: Photographs taken by the researcher.

Table 5 | Chi-square tests on reluctance to collect water from improved sources

Variables	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Cramer's V
Urban					
Income	20.952	1	0.0	0.0	0.0
Distance	2.683	1	0.101	0.239	0.153
Quality	–	–	–	–	–
Reliability	0.853	1	0.356	1	0.545
Queuing time	4.701	1	0.03	0.053	0.039
Satisfaction	–	–	–	–	–
Rural					
Income	3.14	1	0.076	0.133	0.16
Distance	4.79	1	0.029	0.036	0.20
Quality	4.79	1	0.029	0.036	0.21
Reliability	18.31	1	0.000	0.00	0.37
Queuing time	41.16	1	0.000	0.00	0.60
Satisfaction	0.76	1	0.382	1.0	0.03

Source: Field data collection.

result has been obtained (McHugh 2013), indicated that queuing time and reliability had a more robust relationship with reluctance in rural areas, 60 and 37%, respectively. The Cremer's V convinces that even though distance and quality matters, queuing time and reliability undermine the rural households traveling long distances to collect water. In order to reduce the problem of queuing time, households collect water at midnight with no street lights. The presence of alternative unimproved sources was considered a benefit when the improved sources could not provide adequate amounts of water, especially during the holidays when a household consumes more water than normal.

As discussed with key informants and in group discussions, sometimes households indicated a preference to collect water from unimproved sources. The reason for this was that households trusted manual cleaning of the water sources since water office specialists had a very limited time to inspect the closed improved sources once they were installed. This was not a problem in urban areas. Rural households set up a water management strategy to distribute the available water for all user households evenly. Some of these strategies included: setting a fixed time to collect water such as twice a day, mostly early in the morning and late afternoon, allowing a predetermined amount of water collected per day per household, such as four jerricans per day per household; classifying the total households into groups. In addition, increasing the rate of payment per month for the service for those who came from outside the territory, e.g., users paid 3 birr per month while outsiders paid 20 ETB per month (1 USD = 35 ETB); labeling the water sources for drinking and cooking and personal hygiene from improved and unimproved water sources, respectively. All these activities ultimately affected the households' water consumption behavior and the availability of limited sources made them search for alternative sources. Households who collect from unimproved sources were undoubtedly vulnerable to water-borne disease. For example, Figure 2 shows that livestock consumes water from open water sources and contaminates the sources with feces (Gurmessa & Mekuriaw 2019; Figure 2(b)). This needs further research with a continuation to this work or by other researchers.

CONCLUSION

The study advances an understanding of the existing household water consumption behavior, determinants of per capita water consumption, and the reason behind households' decision not to collect water from improved sources. The use of plastic pots for water collection is a good practice that reduces the heavy load and level of contamination. Although many efforts have been made so far, rural households still depend on unimproved sources. The presence of alternative unimproved sources increases the chance of household dependency on these water sources without considering the associated health impacts. The per capita water consumption was significantly and negatively affected by household size. The increase in household size decreased the amount of water used by individual household members. The positive relationship between income, queuing time, distance, reliability, and quality of water from unimproved sources were the main factors affecting households' reluctance to collect water from improved sources. It was possible to assume how many households were impacted by water-related disease. Therefore, installing additional water points near the existing alternative sources could reduce the possible losses of time for productive activities and households' dependency on unimproved sources. In addition, technical supports should be part of the program to reduce the non-functionality of schemes and community awareness for sustainable use of improved sources. Finally, such findings could advance potential assignments and solutions to the decision-makers to consider social factors while planning the installation of water supply schemes.

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DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

REFERENCES

Admassu, M., Kumie, A. & Fantahun, M. 2003 Sustainability of drinking water supply projects in rural of North Gondar. *Ethiopia. Ethiopian Journal of Health Development* **17** (3), 221–229. Available from: https://www.ajol.info/index.php/ejhd/article/view/9843

Amy, G., Bull, R., Craun, G. F., Pegram, R. A. & Siddiqui, M. & World Health Organization 2000 *Disinfectants and Disinfectant by-Products*. World Health Organization, Geneva, Switzerland.

Arkin, H. & Colton, R. R. 1950 *Tables for Statisticians*. Barnes and Noble, New York, USA.

Arouna, A. & Dabbert, S. 2010 Determinants of domestic water use by rural households without access to private improved water sources in Benin: a seemingly unrelated Tobit approach. *Water Resources Management* **24** (7), 1381–1398.

Asaba, R. B., Fagan, H., Kabonesa, C. & Mugumya, F. 2013 Beyond distance and time: gender and the burden of water collection in rural Uganda. *Journal of Gender and Water* **2** (1), 31–38. Available from: http://mural.maynoothuniversity.ie/6626/

Bimla, G. S., Dilbaghi, M. & Raina, K. 2003 Rural women carry the load of fetching water. *Indian Journal of Social Work* **64** (1), 65–75.

Butterworth, J., Welle, K., Hailu, T., Boestoen, K. & Schaeffer, F. 2013 Monitoring access to rural water supplies in Ethiopia. In: *Background Paper at the IRC Symposium Monitoring Sustainable WASH Service Delivery*, Addis Ababa, Ethiopia, pp. 9–11.

Centers for Disease Control and Prevention 2015 *Diarrhea: Common Illness, Global Killer*. Department of Health and Human Services, Washington DC, USA. Available from: https://www.cdc.gov/healthywater/pdf/global/programs/globaldiarrhea_asia_508c.pdf

Central Statistics Agency (CSA) 2007 *Summary and Statistical Report of the 2007 Population and Housing Census, Population Size by age and sex*. Federal Democratic Republic of Ethiopia Population Census Commission, Addis Ababa, Ethiopia.

Crow, B. 2001 *Water: Gender and Material Inequalities in the Global South*. Working paper series, Center for Global, International and Regional Studies, University of California, Santa Cruz, CA, USA. Available from: https://escholarship.org/uc/item/0rq308jc

District Water Office of Simada (DWOS) 2019 *Water Supply Coverage of Simada District, Ethiopia*. DWOS, Simada, Ethiopia.

Gardner-Outlaw, T. & Engleman, R. 1997 *Sustaining Water, Easing Scarcity*. Population Action International, Washington DC, USA.

Gurmessa, B. & Mekuriaw, A. 2019 What determines the operational sustainability of rural drinking water points in Ethiopia? The case of woliso woreda. *Journal of Water, Sanitation and Hygiene for Development* **9** (4), 743–753. https://doi.org/10.2166/washdev.2019.067.

GWP/OECD 2015 *Securing Water, Sustaining Growth*. University of Oxford, Oxford, UK.

Hejazi, M., Edmonds, J., Clarke, L., Kyle, P., Davies, E., Chaturvedi, V., Wise, M., Patel, P., Eom, J. & Calvin, K. 2014 Integrated assessment of global water scarcity over the 21st century under multiple climate change mitigation policies. *Hydrology and Earth System Sciences* **18**, 2859–2883. doi: 10.5194/hess-18-2859-2014.

Howard, G., Bartram, J., Williams, A., Overbo, A. & Geere, J. A. & WHO 2020 *Domestic Water Quantity, Service Level and Health*. World Health Organization, Geneva, Switzerland.

Institute for Health Metrics and Evaluation (IHME) 2016 Global Burden of Disease, 'Ethiopia,'. Available from: http://www.healthdata.org/ethiopia

International Development Association (IDA) 2019 *One Wash – Consolidated Wash Account Project*. Report No. PAD3016, Ethiopia. Available from: https://www.gtai.de/:PRO201906195011

McHugh, M. L. 2013 The chi-square test of independence. *Biochemia Medica* **23** (2), 143–149. https://doi.org/10.11613/BM.2013.018.

Olsson, G. 2021 Urban water supply automation – today and tomorrow. *AQUA – Water Infrastructure, Ecosystems and Society* **70**, 420–437.

Roy, J., Crow, B. & Swallow, B. 2005 Getting access to adequate water: community organizing, women and social change in Western Kenya. In: *International Workshop on African Water Laws: Plural Legislative Frameworks for Rural Water Management in Africa*, pp. 26–28. Available from: http://dlc.dlib.indiana.edu/dlc/handle/10535/5058

Tiku, S., Legesse, W., Endale, H. & Faris, K. 2003 Factors affecting drinking water quality from source to home in Tehuledere Woreda, Northeast Ethiopia. *Ethiopian Journal of Health Sciences* **13** (2).

UNICEF & WHO 2019 *Progress on Household Drinking Water, Sanitation and Hygiene 2000–2017: Special Focus on Inequalities*. New York, USA. Available from: https://www.who.int/news-room/detail/18-06-2019-1-in-3-people-globally-do-not-have-access-to-safe-drinking-water-unicef-who

WHO 2004 *Guidelines for Drinking-water Quality*, 3rd edn. World Health Organization, Geneva. Available from: https://www.who.int/water_sanitation_health/dwq/GDWQ2004web.pdf

WHO 2006 *Water, Sanitation, and Health*. World Health Organization, Geneva, Switzerland. Available from: https://www.who.int/water_sanitation_health/publications/en/

WHO & UNICEF 2017 *Progress on Drinking Water, Sanitation and Hygiene: Update and SDG Baseline*. Available from: https://www.un.org/africarenewal/documents/progress-drinking-water-sanitation-and-hygiene-2017-updates-and-sdg-baselines

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