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Assessment of household's willingness to pay for improved water supply services in emerging nations: a case study of Adama City, Ethiopia

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ABSTRACT

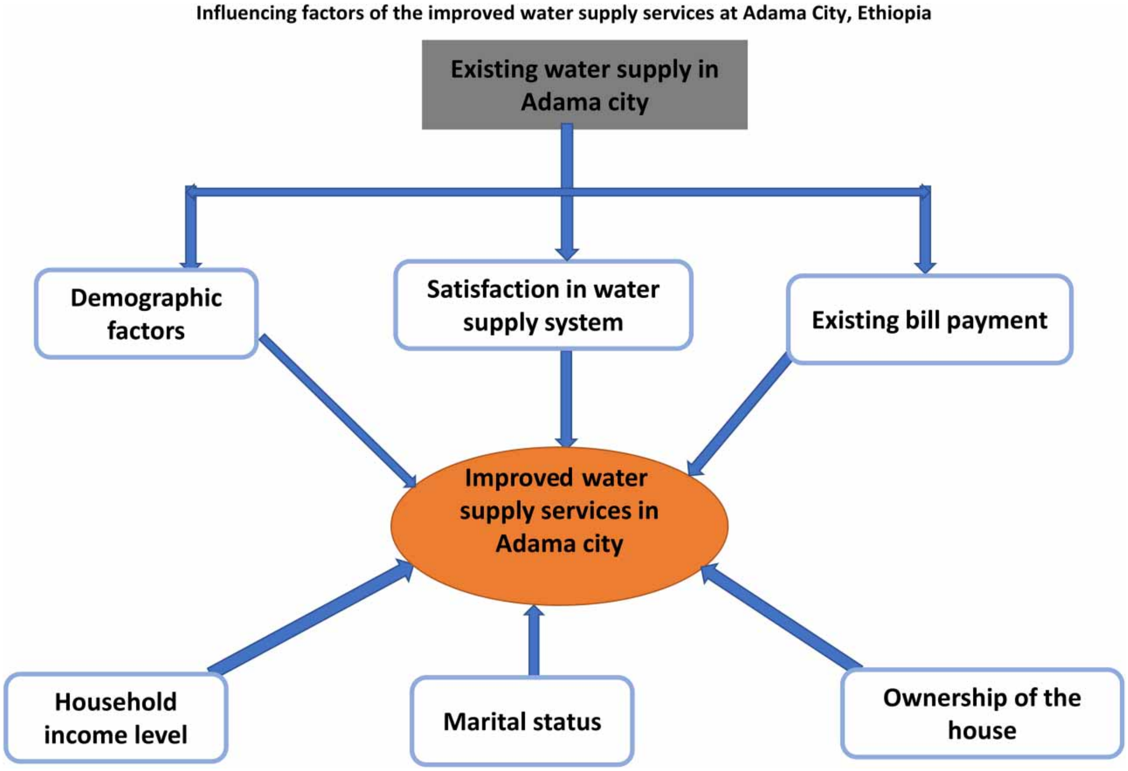
Adama City grew rapidly due to its proximity to Addis Ababa, resulting in increased industrial, urban activities, and population growth. However, this expansion has resulted in drinking water shortages, which is a critical community's concern. The aim of this study was to determine households' willingness to pay (WTP) for improved water supply services in Adama, with factors influencing WTP. To quantify households' WTP, a contingent valuation (CV) technique was used and data from 435 respondents was gathered through field surveys, KII, and HHs interviews. A binary logistic model was utilized to examine variables that have a significant impact on households' WTP. The analysis revealed several independent variables, such as gender, age, marital status, education level, and monthly income, additionally, water quantity, quality, availability, and affordability. The study found that 39.77 and 26.21% of residents of the city were dissatisfied with the quality and quantity of available water supply, respectively. The study discovered that 92% of households were willing to pay an additional $7.26 USD above their average monthly water cost of $3.58 USD to improve water delivery services. Factors that influence households' WTP for improved water supply services should be considered. The study's findings can help legislators and water supply companies to design sustainable projects that meet community needs.

Key words: binary logistic model, contingent valuation, water supply service, willingness to pay

HIGHLIGHTS

- A total of 435 respondents were studied to enhance consistency and precision in the study; however, the minimum sample size is 275 based on the statistical analysis.
- 92% of the households were willing to pay toward the program.
- Households were willing to add $7.26 USD above their current monthly water bill.
- Age, education, marital status, house owner and monthly income were influencing factors toward households' WTP.

GRAPHICAL ABSTRACT



1. INTRODUCTION

In the face of ever-increasing water stress, rapidly dwindling water reserves, depleting aquifers, and the sleeping giant of climate change, authorities face a very difficult task of providing adequate potable water for human consumption, agriculture, and industry (Cacal & Taboada 2022; Tayyab *et al.* 2022). Freshwater ecosystems worldwide are suffering as a result of disproportionate pressure from drainage, abstraction, dredging, blockading, contamination, silting, and bellicose species (Agashua *et al.* 2022). The WHO UNICEF World Bank (2022) underlines the global issues associated with access to better drinking water sources, with 785 million people still lacking such access. Significant expenditures in water-related infrastructure are required, with estimates ranging from \$6.70 trillion in 2030 to \$22.60 trillion in 2050. If water resource management is not improved, national growth rates might be reduced by up to 6% of global domestic product (GDP) by 2050 (UNICEF and WHO 2021).

Numerous studies in Africa have been conducted to determine residents' willingness to pay (WTP) for water services in order to determine their participation in water supply projects, with positive results. For example, Anteneh *et al.* (2019) found that 95% of residents were willing to pay for the management of the water supply catchment used by Addis Ababa city, whereas Kiprop & Sumukwo (2017) reported 80% WTP for improved water supply in Marakwet County, Kenya. Eridadi *et al.* (2021) reported a 66% WTP for improved water supply in Sebeta town, Ethiopia. Desta & Befkadu (2020) investigated whether Adama's water demand is met by available supplies. Furthermore, a recent study in the area revealed that current water distribution systems do not supply enough water (Desta *et al.* 2022). The efficient water supply system necessitates funds, and operation and maintenance are dependent on cost recovery. In this regard, community participation is one of the most important factors in ensuring the success of water supply systems. In Ethiopia, non-functioning distribution networks have resulted in poor maintenance and repair procedures, limiting urban residents' access to safe drinking water.

In Adama City community facing challenges with the existing water supply services, such as water shortage, unavailability, unreliable, and unpleasant water (Desta & Befkadu 2020). To solve this problem, adequate infrastructure and community participation are vital to solve the water supply challenges (Tadesse *et al.* 2013; Akeju *et al.* 2018; Eridadi *et al.* 2021; Tenaw & Assfaw 2022). Community participation in the aspect of cost recovery is the most influential component in designing and developing a sustainable water supply system (Agashua *et al.* 2022; Cacal & Taboada 2022; Tayyab *et al.* 2022).

The WTP for water supply services varies widely globally, depending on factors such as income levels, cultural practices, and the level of development (Kim *et al.* 2021; Islam *et al.* 2022). Developed countries generally have higher WTP, while low- and middle-income countries usually have lower WTP due to affordability issues (Mugabi *et al.* 2010; Kim *et al.* 2021). However, there are significant variations within regions and countries, depending on factors such as access to financing, infrastructure, and the level of awareness on the importance of safe and reliable water supply services (Tussupova *et al.*, 2015; Kim *et al.* 2021; Nguyen *et al.* 2022).

WTP for water supply services is generally low in Africa, particularly in Ethiopia, where many households cannot afford the cost of services (Tenaw & Assfaw 2022). This situation is exacerbated by inadequate infrastructure, limited access to financing, and a lack of understanding of the significance of safe and dependable water supply services (Eridadi *et al.* 2021). The Government of Ethiopia has set ambitious targets to achieve universal access to safe and reliable water supply services by 2030, and there have been significant efforts to improve cost recovery and encourage WTP (Tenaw & Assfaw 2022). These efforts include implementing pro-poor tariff systems that consider the affordability of water supply services for low-income households, community-based management, and public–private partnerships (Eridadi *et al.* 2021).

The purpose of this research was to find out how community involvement can improve water supply services in Adama, Ethiopia. The study's objectives were to (i) collect demographic data in the study area, (ii) analyze the influence of demographic factors, (iii) determine households' WTP for improved water services, and (iv) analyze and optimize factors influencing households' water payment decisions. The initiative's goal is to provide an adequate supply of water in sufficient volume, coverage, consistency, and quality to meet current and future needs for residential, commercial, public, and industrial use.

2. MATERIALS AND METHODS

2.1. The water supply situation in the study area

Adama is a city in the Oromia National Regional State's East Shoa Zone, about 100 km southeast of Addis Ababa. It is located between 8°27′N and 8°36′N, and 39°12′E and 39°20′E (Figure 1). The present-day Adama City consists of six sub-cities, namely Abageda, Boku, Dabe, Bolle, Lugo, and Dembella, with a total area of 29.86 km^2. Within these sub-cities,

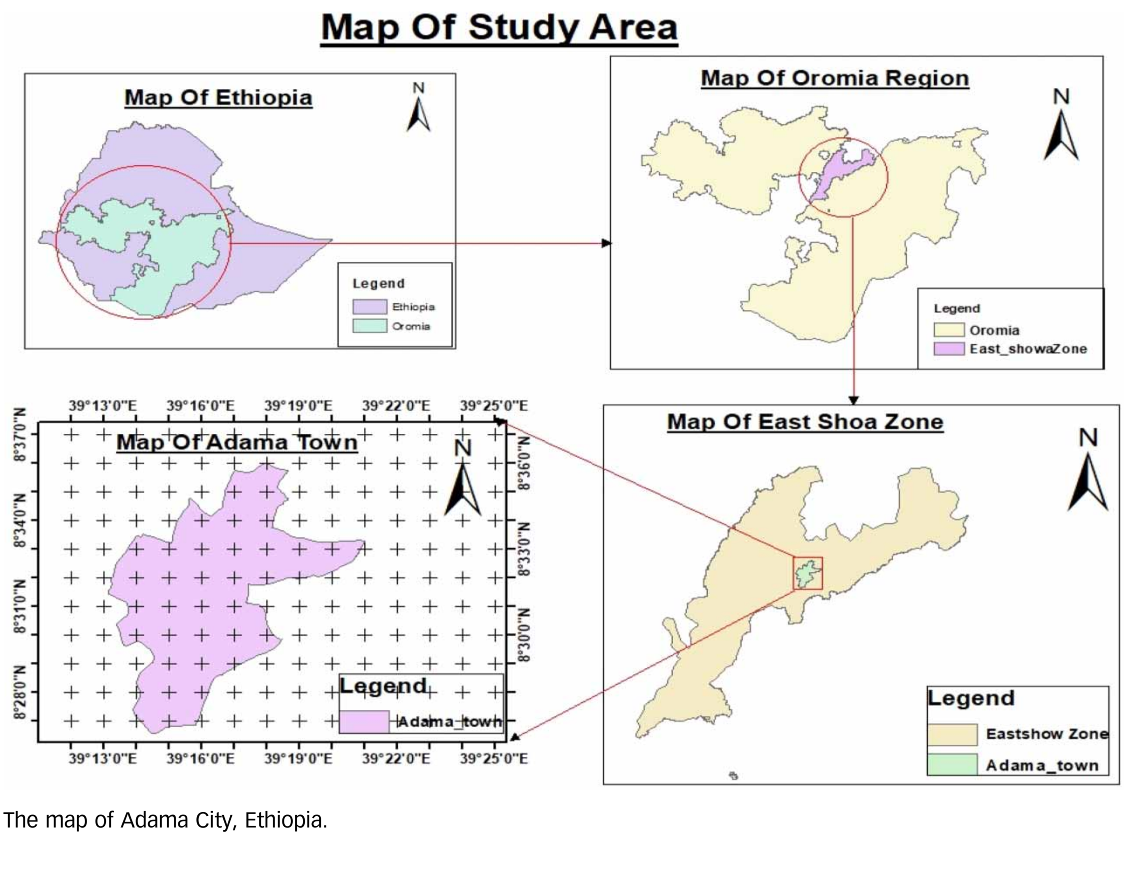


Figure 1 | The map of Adama City, Ethiopia.

there are 18 kebeles (Siraj *et al.* 2019). Adama City is one of the fastest growing cities after Addis Ababa City in Ethiopia (Gebremedhin *et al.* 2023) and a previous study mentioned that the city is facing challenges with water supply services (Beker & Kansal 2023).

Adama's water treatment plant employs a traditional treatment process that includes coagulation, flocculation, sedimentation, and rapid sand filtration to remove impurities and ensure the safety of the water supply. The water is then chlorine-treated before being distributed to the residents of the town (Desta *et al.* 2022).

The distribution system is divided into five pressure zones due to the city's topography to ensure that all areas of the city receive adequate water pressure. A network of pipes, valves, and pumps transports treated water from service reservoirs to households, businesses, and public facilities (Desta *et al.* 2022).

Adama has seven service reservoirs of varying sizes that store treated water for distribution to the residents of the city. These reservoirs are strategically placed throughout the city to ensure that all areas have access to water. In addition, as shown in Table 1, the city has three booster stations with additional reservoirs to provide water to communities located in elevated areas of the city where water pressure may be lower. BokKu Shaenaen, Dhaekaa Adi, and Hangatu are among the elevated areas (Wakjira Debela 2021).

Adama has 75,859 water customers, according to the annual report of Adama City Water supply service Enterprises, and the current water supply coverage is 78%. The town's water supply system consists of over 560 km of pipeline ranging in size from DN 40 m to 600 mm. This system transports treated water from the treatment plant to homes, businesses, and public facilities. According to the Ethiopian Central Statistical Agency (CSA), Adama had a total population of 220,212 in 2007, with 108,872 men and 111,340 women, and an area of 29.86 km^2 (Table 2).

Adama's projected population in 2021 is based on a 4.30% annual growth rate since the 2007 census. This rate of growth is higher than the national average of around 2.70% per year. Population growth is caused by factors such as migration from rural areas, natural population growth, and urbanization. Adama City's projected population in 2021 is 374,332, with an estimated 89,127 households.

2.2. Procedures of data collection

The study collected data using various methods, including reconnaissance surveys, field observations, key informant interviews, and household surveys. Data were collected over a 1-month period, from April to May 2022. The study aimed to ensure the validity and reliability of the data as well as to obtain a more complete picture of the study topic by employing multiple data collection methods.

2.3. Contingent valuation survey

The application of the CV method in various studies determines the WTP or acceptance for non-market goods in various fields. Globally, studies have been conducted to assess community WTP for improvements to water supply services

Table 1 | Details of the existing water supply services reservoirs, pump stations, capacity and purpose

Description	Long (m)	Lat (m)	Elev (m)	*H* (m)	Size	Purpose
Clear water tanks at Koka TP	519,795	937,310	1,560	5	1,800 m^3 (800 and 1,000)	Distribute water to Abageda and Lugo Reservoir
Lugo Reservoir	529,025	940,546	1,685	5	6,000 m^3 (2,000 & 4,000)	Distribute to customers & Boku reservoir
Aba Gada reservoir	525,885	943,783	1,757	5	4,000 m^3	Distribute water to Pioneer tank at ASTU, to 02 Pump Station and customers
Pioneer tank at ASTU	531,976	945,905	1,720	5	1,500 m^3	Distribute water to customers
02 Pump Station	530,205	945,920	1,658	5	1,500 m^3 (1,000 & 500)	Transfers water from Abageda to Dhaka Adi reservoir
Dhaka Adi	532,321	947,945	1,746	5	1,000 m^3	Distribute water to customers
Boku pump station	531,048	939,372	1,632	5	25 m^3	Transfers water from Lugo to Boku reservoir
Boku reservoir					500 m^3	Distribute water to customers

Table 2 | Demographic data and reservoir sources in the Adama City WSSE

Administrative unit in Adama City	Population 2021	Residential area 2021 (ha)	Density 2021 (Pop/ha)	Received water from reservoir	
Current name					
Gooroo	29,080	198.72 81.26	36.58 268.41	Abageda (Majority) Lugo (Small portion)	
Migiraa	20,773	100.39	206.92	Lugo	
Gaara Luugoo	30,347	150.84	201.19	Lugo	
Dhaddacha Araaraa	30,949	70.14 66.93	308.89 138.72	Abageda (Majority) Lugo (Small portion)	
Dagaagaa	29,217	74.78	390.71	Abageda (50/%) Lugo (50%)	
Gurmuu	10,765	9.47	1,136.37	Lugo	
Badhaatuu	17,760	21.09	842.18	Lugo	
Odaa	16,769	21.66	774.07	Lugo	
Irreechaa	33,653	133.69	251.73	Lugo	
Biiqqaa	27,250	89.78	303.51	Lugo	
Barreechaa	28,632	77.97	367.23	Lugo	
Gadaa	16,374	30.67	533.87	Lugo	
Caffee	16,639	51.52	322.96	Lugo	
Hangaatuu	32,075	142.46 76.35	202.64 42.01	Lugo (half part) Abageda (half part)	
Bokkuu Shanan	9,899	347.56 297.24	28.48 0	Lugo	
Kebele-D/solloqqee	Daabee Solloqqee	13,251	186.07 165.84	71.22	Lugo
Kebele-M/adaamaa	Malkaa Adaamaa	6,289	158.02 192.03	39.80	Abageda and Lugo
Kebele-Dh/adii	Dhakaa Adii	4,610	166 530.66	27.77	Dhaka Adi/ Abageda
	374,332	2,910.46			

(Amondo *et al.* 2013; Bui *et al.* 2022; Islam *et al.* 2022). Wright *et al.* (2014) discovered, for example, that 92.60% of respondents in Rubona and Kigisu, Uganda, were willing to pay for a better water supply. Similarly, Magashi (2014) found that 83.30% of Tanzanians were willing to pay for domestic water supply improvements. These findings indicate that many African communities are willing to pay for better water services. For example, 66% of households in Sebeta, Ethiopia, were willing to pay for improved water supply services (Eridadi *et al.* 2021). In Shashemene, Ethiopia, it was discovered that 73.4% of households would pay more for better solid waste management (Bamlaku *et al.* 2019). Similarly, Anteneh *et al.* (2019) discovered that 95% of respondents in Addis Ababa were willing to pay for the intervention program for the Legedadie-Dire catchments.

A CV survey was conducted in a city between April and May 2022, with 435 households interviewed. The study's goal was to gather information from different households about their perceptions of current water supply services and to know the WTP for the improved water supply system. The interviews were conducted to gather household opinions and comments on the drinking water services provided by Adama Water Supply and Sewerage Enterprises (AWSSE) in terms of quality, quantity, reliability, and the number of hours per day water is available at the tap.

2.4. Sampling plan

The scouting survey responses aided in identifying current water issues in the region and in developing questionnaires for conditional qualitative and quantitative (CV) assessment research. The survey was conducted with the assistance of a qualified scientific employee in order to improve data quality. Furthermore, secondary data from the company's offices, as well as the Adama City Office of Administrative Planning and the Bureau of Economic Development, were used to determine the sample size and develop the Household Data Collection Questionnaire. An in-depth examination of various documents, such as reports from governments and international organizations, the internet, and magazine articles, yielded additional information about the city and its community.

An exploratory survey is used to develop the semi-structured and structured household questionnaire. It has been pre-tested to ensure the data's validity and reliability. The city is divided into 18 concentric circles. All kegs were chosen at random. In Equation (1) (Cochran 1977), the minimum sample families (households) were determined using the following formula:

$$N = \frac{Z^2 * p(1-p)}{d^2} \tag{1}$$

where N is the number of households surveyed in the study and Z is a value representing the 95% confidence level derived from the normal standard deviation, $Z = 1.96$ (Taherdoost 2017). Assuming high heterogeneity and therefore $p = 0.5$, which corresponded to 50% of the unknown population (Makwinja *et al.* 2019). In order to obtain a more representative household sample size, a margin of error (d) of 0.059 was assumed to improve the reliability of the interview results. The minimum sample size of 275 was found from the formula; however, to ensure accuracy, a sample size of 435 people was used (Table 3). The finite population adjustment formula was used to find representative samples of 89,127 households in the city of Adama.

A questionnaire was developed in English and later translated into Amharic and Oromiffa, which are widely spoken in Ethiopia, specifically in Adama town, to ensure that all participants could understand and respond to the questions. The study relied on randomly chosen households, and research assistants were carefully chosen based on their language proficiency, social and technical skills, and survey experience. These data collectors were trained to pretest and administer the questionnaire in the community, ensuring that participants understood the questions and provided honest responses. The data collection process used electronic devices with the Kobo toolbox to collect responses from participant households, allowing for efficient and accurate data collection. The survey was held for 1 month, during which time the research team closely monitored and ensured that all participants understood the questions and responded truthfully.

For 3 weeks, the researchers conducted field observations and key informant interviews. Field observations were conducted by visiting different Kebeles at different times of the day to observe the availability of water at household access points. Key informant interviews were conducted with AWSSE staff to identify the enterprise's water supply issues. These interviews provided valuable insights into the study area's water supply challenges and opportunities.

2.5. WTP analysis

The questionnaire interview data were analyzed using both econometric models and descriptive statistics. The information gathered included the demographic and socioeconomic characteristics of the respondents, their perceptions of water management institutions, and their WTP for improved water supply. The mean, standard deviation, variance, median, mode, range, minimum, maximum, and sum were computed as descriptive statistics. The International Business Machines (IBM) Statistical Package for the Social Sciences, version 2022, was used for the analysis. This software is commonly used in social science research for statistical analysis.

2.6. Econometric regression model

A binary logistic regression model was used in the study to examine the relationship between WTP for improved water supply services (dependent variable) and a set of independent variables. The independent variables were characteristics of households that could potentially influence their WTP, such as demographic and socioeconomic characteristics. In accordance with similar studies, the regression model was expressed as a mathematical formula, as shown in Equation (2) (Gidey &

Table 3 | The piped water available in Adama City per household per day

	# of respondent	Mean ± Std error (hours)	Min–max (hours)
Hours	435	14.06 ± 5.75	1–24

Zeleke 2015; Makwinja *et al.* 2019). This approach enabled us to identify the significant predictors of WTP and estimate the magnitude and direction of their effects on households' WTP for improved water supply services.

$$\mathrm{WTP}_i = \ln\left[\frac{pi}{1-pi}\right] = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} \text{---} + \beta_k X_{ni+ei} \tag{2}$$

where WTP will be a dichotomous dummy variable (where 1 = WTP for the program and 0 = not WTP for the program), i refers to a household, p is the probability of the households' WTP for the program, β_0 is a constant coefficient, and β_1, β_2, β_3, ..., β_i, are the regression coefficients of independent variables; X_1, X_2, X_3, ..., X_i. The bivariate Pearson correlation was applied to determine the correlation between the independent variables. This analysis was to find out statistically significant relationships between the variables, strength, and direction of the relationship. How goodness of fit was used for the significance of the model is stated in the following equation (Zoran 2016; Eridadi *et al.* 2021).

$$\mathrm{HL} = \sum_{g=1}^{G}\left(\frac{(O_g - N_g\pi_g)_2}{N_g\pi_g(1-\pi_g)}\right) \tag{3}$$

where O_g is the total observations of subjects in the gth group, N_g is the total observations of event outcomes in the gth group, and π_g is the mean estimated probability of an event outcome for the gth group. HL is estimated by a chi-square with the number of groups-2 degrees of freedom. The model used a range of explanatory variables, including dummy, categorical, and continuous independent variables, such as demographic and socioeconomic variables. Other variables related to people's perceptions and practices in water use were also included in the analysis.

2.7. Statistical approach

The study asked households if they would be willing to pay for improved water supply services without specifying a dollar amount. Respondents were encouraged to be honest during the interviews and to think about their current expenses, including their water expenses. The answer to the first question from home determined whether they were in the positive or negative category. For both literate and illiterate participants, the questionnaire was designed to be simple and easy to understand. The study then asked households that responded positively to estimate how much they could contribute to the program in a year. Following similar studies (Gidey & Zeleke 2015; Eridadi *et al.* 2021), the study summed up the households' WTP amounts and divided the sum by the total number of households willing to pay to obtain the mean WTP, as shown in Equation (4). This enabled us to calculate the average household WTP for improved water supply services.

$$\text{Mean WTP} = \frac{\sum_{i=1}^{n} \mathrm{WTP}_i}{n} \tag{4}$$

where i stands for the amount that a household is WTP and n stands for the sample size of households whose WTP is positive.

3. RESULTS AND DISCUSSIONS

3.1. Household's demographic and socioeconomic

The research is expected to target a sample size of 445 respondents in Adama City. However, only 435 households provided complete responses to the questionnaire in line with the research objectives. This represents a high response rate of 97.8%, which is significantly higher than the 80% response rate reported in the study conducted by Eridadi *et al.* (2021). Table 4 provides a summary of the characteristics of the variables used in the study, including their names, classification, and descriptive statistics, such as the number, percentage, mean and standard mean error, mode, and minimum and maximum values. As shown in Table 4, the study collected data from 435 households spread across 18 different Kebeles in Adama. 63.22% (275) of respondents were female, while 36.78% (160) were male. Previous studies in the field of water supply have also revealed a higher proportion of female participants than males. A study in Sebeta town, Ethiopia, for example, reported 60.4% female participants (Eridadi *et al.* 2021), whereas studies in Kenya and Uganda reported 56.3 and 51.0% female interviewees, respectively (Wright

Table 4 | Demographic and socioeconomic characteristics of the households

Variables	Categories	Frequency	Percentage	Mean ± St. Err	Min–Max
Sex	Male	160	36.78		
	Female	275	63.22		
Age				37.19 ± 12.51	18–80
Marital status	Married	360	82.76		
	Unmarried	75	17.24		
Occupation	Formal	111	25.52		
	Informal	324	74.48		
Level of education	Illiterate	142	32.64		
	Primary	76	17.47		
	Secondary	108	24.83		
	Graduate	94	21.61		
	Post-graduate	15	3.45		
Household size				5.41 ± 3.47	1–7
Home type	Owner	296	68.05		
	Rent	139	31.95		
Monthly income in ETB	Low (<5,000)	189	43.45		
	Medium (5,000–10,000)	174	40		
	High (>10,000)	72	16.55		
Monthly expenditure in ETB	Low (less than 3,000)	136	31.26		
	Medium (3,100–5,000)	164	37.70		
	High (5,100–10,000)	82	18.85		
	Highest (>10,000)	53	12.18		
Average payment per month for water in ETB				200.72 ± 44.25	2–2,000
Piped water access in 24 h				14.06 ± 5.75	1–24
Main source of water	Individual piped water	374	85.98		
	Shared water connection	34	7.82		
	Public fountain	26	5.98		
	Public water taps	1	0.23		

et al. 2014; Brouwer *et al.* 2015). The study's higher proportion of female participants indicated that in Sub-Saharan Africa, women are frequently the primary water collectors and are more likely to be found at home than men (Graham *et al.* 2016).

According to the study data, the average age of the respondents was 37.19 years, with a range of 18–80 years. The average age of 45 years was taken in a previous study conducted in Addis Ababa as the study area (Anteneh *et al.* 2019). This disparity can be attributed to variations in the respondents' minimum and maximum age ranges. Notably, the mode of the age distribution was 28 years, indicating that the vast majority of respondents were young and active.

According to the survey results, married people made up the majority of households (82.76% or 360), while widowed, divorced, separated, or single people made up the remaining households (17.24% or 75). The study also discovered that the average household size was 5.41, slightly higher than Ethiopia's national average of 4.6 members per household (CSA & ICF 2016).

The monthly income of the sampled population is 43.45% (189) as low, 40% (174) as medium, and 16.55% (72) as high. On the other hand, the sampled population's monthly expenditure was 31.26% (136) low (less than $53.61 USD), 37.70% (164) medium ($53.61 – $89.35 USD), 18.85% (82) high, and 12.18% (53) greater than $178.70 USD. This indicated that there is a direct relationship between Adama residents' monthly income and expenditure. According to the survey, 44.37% of the respondents rated water quality as average, 15.86% as good, and 39.77% as poor. During focus group discussions, some households reported receiving turbid water during the rainy season, which could explain why 44.37% of participants rated the quality as poor. This could be one of the reasons for the participants' low level of quality satisfaction.

In the operational definition for evaluating water supply system performance, the terms 'poor,' 'average,' and 'good' are used to indicate different levels of performance for each indicator. In terms of quantity, poor reflects insufficient supply to meet community needs, while average indicates adequacy with occasional shortages, and good denotes consistent supply meeting or exceeding requirements. Regarding quality, poor signifies water below WHO quality standards, average represents meeting basic water quality regulations with occasional concerns, and good indicates consistent adherence to WHO water quality standards. Availability is characterized as poor when access is inconsistent, average when generally reliable with occasional interruptions, and good when water is consistently accessible. Finally, reliability is poor with frequent breakdowns, average with occasional interruptions, and good with consistent and dependable operation (Cabrera & García-Serra 1999; Mesalie *et al.* 2021; Kansal *et al.* 2022).

In terms of water quantity, 26.21% of respondents reported poor water delivery due to a lack of supply, while only 32.64% reported adequate quantity. Table 5 shows that 30.8% of respondents thought that the current water services were unreliable. Water availability was rated as poor by 28.74%, average by 45.29%, and good by 25.98% of participants. Due to water scarcity, residents were dissatisfied with the existing water services. According to Table 5, piped water was available in the community for an average of 14.06 h per day, but it was mostly delivered at night, which was inconvenient for residents.

3.2. Analysis of current residents' expenditure on water services

Table 6 summarizes a review of monthly household water expenditure in relation to current water supply conditions. The study found that the average monthly water expenditure was $3.59 USD, with a standard error of $4.37 USD and a median of $1.79 USD, from all 435 respondents who provided estimates of their monthly water expenditure. Furthermore, the data analysis revealed that monthly water expenditure represented 3.10% of the average monthly income of individuals in the community. Similar research in Nebelet and Sebeta, Ethiopia, found that households spent 4 and 3.30% of their monthly income on water, respectively (Gidey & Zeleke 2015; Eridadi *et al.* 2021). Individual income levels are closely related to the affordability of improved water supply. In this context, our study's finding that households spent 3.10% of their monthly income on water falls within the range of 3–5% recommended by the affordability index used by many developing countries (Smets 2009), but is lower than the World Bank's recommendation of 5% (Gidey & Zeleke 2015).

3.3. WTP toward the program

Figure 2 indicated that out of the 435 respondents, 400 (92%) expressed a willingness to contribute to the improvement of the area's water supply. The results of a statistical analysis of the WTP for improving the water supply situation in the study area are presented in Table 7. This differs from the monthly bills that residents are currently paying for their water usage. The study's findings, as shown in Table 7, indicate that the minimum amount of WTP for improving the area's water supply

Table 5 | Respondents' perception regarding quantity, quality, availability and reliability

Variables	Performance term indicators	No. of response	Percentage
Quantity	Poor	114	26.21
	Average	179	41.15
	Good	142	32.64
Quality	Poor	173	39.77
	Average	193	44.37
	Good	69	15.86
Availability	Poor	113	25.98
	Average	197	45.29
	Good	125	28.74
Reliability	Poor	134	30.8
	Average	228	52.41
	Good	73	16.78

Table 6 | Current monthly expenditure of households on water services

Variable	# of Respondents	Mean ± Std ($USD)	Mode ($USD)	Median ($USD)	Min–Max ($USD)
Payment/month	435	3.59 ± 4.37	1.79	2.32	0.04–35.74

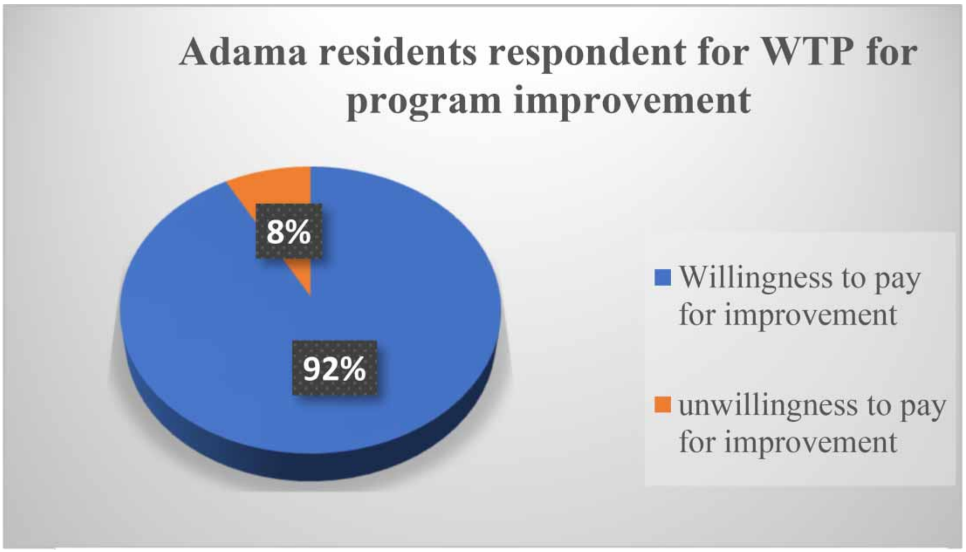


Figure 2 | Willingness to pay for water supply service improvement.

Table 7 | Willingness to pay (WTP) analysis of HHs to improve water supply services in Adama

Variable	Number of respondents	Mean ± St.er ($USD)	Mode ($USD)	Median ($USD)	Min–Max
Payment/year	435	7.26 ± 43.42	1.79	3.57	0.18–89.35

conditions over the next 10 years was $0.179 USD per year, exclusive of residents' monthly water bill payments. The highest WTP amount was $89.50USD, with an average yearly contribution of $7.26USD and a median of $3.57USD. The modal payment of $1.79USD/year indicates that over half of the residents were willing to contribute this amount to the program.

Further analysis of WTP data versus schedule per month, as shown in Table 7, indicates that Adama residents were willing to pay an average of $7.26USD in addition to their current monthly water bills, with a median of $3.57USD. As a result, the total monthly payment from households toward water supply improvement would be $10.85USD/month, a threefold increase over the previous water billing payment per month. As a result of the challenges associated with the area's current water supply, particularly water availability at night, residents are willing to contribute to the program aimed at improving water supply services.

3.4. Analysis of variables in the binary logistic regression model

A multicollinearity test was performed on the data to ensure the reliability and validity of the binary logistic regression model. The correlation matrix of the explanatory variables revealed that there were no issues with multicollinearity. The correlation coefficients between the variables, as shown in Table 8, were all less than the widely accepted threshold of 0.50, indicating a weak correlation (Schober *et al.* 2018). These findings indicate that the explanatory variables were appropriate for use in the binary logistic regression model. As a result, the findings of the analysis are trustworthy.

3.5. Analysis of influencing factors about WTP

Table 8 shows that the likelihood ratio (LR) test produced a chi-square value of 61.87 for the logistic regression model, indicating statistical significance and that at least one predictor variable has a significant influence on WTP. The small *p*-value of 0.00 supports this conclusion even more, indicating that the observed chi-square value is unlikely to have occurred by chance alone. The log-likelihood value of −87.19 indicates that the model fits the data well, with a negative value implying that the model fits better than a null model with no predictors. The pseudo R^2 value of 0.36 represents the proportion of variance in WTP that can be explained by the model's predictor variables and should not be interpreted in the same way as R^2 values in other models.

Table 8 | Factor analysis for WTP – willingness to pay for water supply service

Variables	Odds ratio	Std. Err.	z	P > z	(95% Conf. interval)	
Sex						
Female	1.3650	0.6631	0.6400	0.5220	0.5268	3.5370
Marital status						
Unmarried	0.2498	0.1451	−2.3900	0.0170	0.0799	0.7801
Occupation						
Informal	0.8534	0.5322	−0.2500	0.7990	0.2514	2.8970
Education level						
Primary school	0.2512	0.1831	−1.9000	0.0580	0.0602	1.0484
Secondary school	0.2561	0.1978	−1.7600	0.0780	0.0564	1.1630
Graduate	0.4112	0.3283	−1.1100	0.2660	0.0860	1.9660
Home type						
Rent	0.5874	0.2646	−1.1800	0.2370	0.2430	1.4200
Monthly income						
Medium (5,000–10,000)	0.3341	0.3885	−0.9400	0.3460	0.0342	3.2619
High greater than 10,000 ETB	1,357,779	1.68×10^9	0.0100	0.9910	0.0000	0.0000
Monthly expense						
Medium (3,100–5.000)	7.6600	9.2389	1.6900	0.0910	0.7202	81.4556
Higher 5,100–10, 000_	2.9977	3.6400	0.9000	0.3660	0.2775	32.3783
Highest (>10,000)	4.42×10^{-7}	0.0006	−0.0100	0.9910	0.0000	.
Main source of water supply						
Shared water connection next to you	3.5349	4.8459	0.9200	0.3570	0.2407	51.9094
Quantity						
Average	4.4525	3.0208	2.2000	0.0280	1.1779	16.8307
Good	2.3748	2.0456	1.0000	0.3150	0.4390	12.8472
Quality						
Average	1.5847	1.1300	0.65	0.5180	0.3917	6.4107
Good	0.7615	1.0350	−0.2000	0.8410	0.0530	10.9312
Availability						
Average	0.213	0.1467	−2.2500	0.0240	0.0566	0.8184
Good	2.3240	2.9499	0.6600	0.5060	0.1931	27.9707
Reliability						
Average	3.9295	2.6262	2.0500	0.0410	1.0604	14.5617
Good	0.5037	0.5313	−0.6500	0.5160	0.0637	3.9820
_cons	17.7543	15.5269	3.2900	0.0010	3.1981	98.5630

Note: ** indicates the significance at 1%. * indicates the significance at 5% while ns shows non-significance.
Overall statistics: LR chi^2 (21) is 61.87, Prob > $chi^2 = 0.0000$; log-likelihood = −87.198114; pseudo R^2 (neglected R^2) = 0.3619.

The study identifies significant independent variables that influence WTP in households. Unmarried households, for example, have a lower WTP (OR = 0.25; $p = 0.017$) than married households. Households with good water availability have a higher WTP (OR = 4.45; $p = 0.028$) than those with poor water availability, while those with average availability have a lower WTP (OR = 0.22; $p = 0.024$) than those with good availability. The likelihood chi-square test (Paul *et al.* 2013) was used to determine the goodness-of-fit test, where the model fitness is determined by the insignificant value at $p > 0.05$. In this study, the *p*-value of the test was insignificant ($p > 0.05$). The independent variables' *p*-values of house owner, gender, age, and literacy were statistically insignificant at $p > 0.01$ and $p > 0.05$, respectively.

Table 9 | Correlation matrix table of the variables

Variables	Sex	Mr_stat	Occup	edu_lev	Home type	M_incom	M_expen	Water obtain	Main source	Quantity	Quality	Availability	Reliability
Sex	1												
Mr_stat	−0.1062	1											
Occup	0.319	0.1694	1										
edu_lev	−0.1952	0.2976	−0.3239	1									
Home_type	0.0217	0.1571	−0.0173	0.0731	1								
M_income	−0.0855	0.1439	−0.2821	0.5114	0.0026	1							
M_expense	−0.1443	0.1667	−0.3245	0.5634	0.0519	0.8496	1						
Water_obta	−0.0708	0.0052	0.0917	0.0743	−0.0166	−0.1326	−0.0172	1					
main_sourc	−0.0636	−0.0039	0.1135	0.0452	−0.004	−0.1574	−0.0584	0.9369	1				
Quantity	0.0954	−0.0862	0.1597	−0.1982	−0.0448	−0.1924	−0.3057	−0.2008	−0.203	1			
Quality	0.0320	−0.1212	0.0109	−0.2869	−0.0891	−0.309	−0.3447	−0.1123	−0.106	0.5052	1		
Availability	0.0865	−0.1735	0.1075	−0.2193	−0.0923	−0.2516	−0.3165	−0.1075	−0.1055	0.6478	0.6641	1	
Reliability	0.0393	−0.1035	0.0893	−0.2334	−0.0913	−0.3018	−0.3369	−0.0576	−0.0658	0.4761	0.7294	0.6938	1

The insignificance values of these variables (gender, age of respondents, sex, occupation, and education) revealed that they have no influence over households' decisions to pay for water supply improvement programs in the area. The relationship between the dependent variable (WTP) and the marital status of the household was statistically significant at p 0.01, with a negative correlation regression coefficient of 0.017 and a Z of −2.39. The study's findings were comparable to those of Rotich *et al.* (2018). The findings were related to a study conducted in Kenya by Rotich *et al.* (2018) in which respondents' decision to pay for proper water project management was influenced by their marital status. Although Gidey & Zeleke (2015) and Eridadi *et al.* (2021) found a similar relationship between WTP and marital status, married people were more WTP than unmarried people. All of the above findings, however, contradicted those of Shemelis & Lamessa (2016), who reported that the respondent's gender had no influence on WTP for improved water supply in Jigjiga town, Ethiopia.

The age of the respondents was insignificant in terms of WTP. Kiprop & Sumukwo (2017) reported similar results in their study conducted in Kenya's Marakwet county. This is because most young people are uninterested in learning how government projects are carried out.

Expectations regarding the relationship between average monthly income and WTP have been realized. At the 1% level of significance, the coefficient value was positive and statistically significant. This implies that higher-income households are more likely than lower-income households to pay for improved water supply. The findings were consistent with previous research, which found that household income had a positive impact on WTP decisions (Gidey & Zeleke 2015; Akeju *et al.* 2018; Dika *et al.* 2019). However, the income-WTP relationship was statistically insignificant with $p > 0.05$ (Amondo *et al.* 2013).

As expected, the WTP for the improvement of the water supply had a positive effect on the literacy level of the respondents. The variable level of literacy was significant at 1%. An educated person is believed to be better informed about several key sectors of the community and the world in general (Dika *et al.* 2019; Eridadi *et al.* 2021). Therefore, the literate community in Adama was more WTP than the illiterate. Previous research has found that education has a significant influence on the WTP's decision to use services (Dauda *et al.* 2015; Makwinja *et al.* 2019).

The independent variables of marital status, water quantity, water availability and reliability were significantly influencing the household's WTP at p 0.01 and 0.05 whereas the independent variables of age and education were significantly influencing the household's WTP at significant at 1%. Therefore, age, education, marital status, water quantity, water availability and reliability were significantly influencing households' WTP to improve water supply services in Adama (Table 9).

4. CONCLUSIONS AND RECOMMENDATION

The study concluded that Adama City residents were dissatisfied with the existing water supply services in terms of quality (39.77%), quantity (26.21%), availability (25.98%), and reliability (30.8%). The 296 of 435 respondents (68.05%) contributed the most to existing water supply services. The findings also revealed that households were willing to pay an additional $7.26 USD/month on top of their current monthly water bill of $3.58 USD, which equates to less than 0.5% of the average household income. The study discovered that 92% of households were willing to pay an additional $7.26 USD above their average monthly water cost of $3.58 USD to improve water delivery services. Income level, marital status, and ownership were found to be significant influencing factors in Adama City's WTP for improved water supply service. As a result, the study's findings can assist policymakers and water supply providers, such as Adama water supply sewerage services enterprise, in developing and implementing programs that meet the community's needs and desires while also being financially feasible and environmentally sustainable. This research looks at the impact of demographic factors on improved water supply services. The effective technical aspects of the water supply system must be studied in order to design a sustainable water supply system.

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AUTHOR CONTRIBUTIONS

The author designed the research, data collection, data analysis, and wrote the manuscript. Prof. Dr Ing: Esayas Alemayehu provides guidance on this research work. Dr Daniel was greatly involved in every stage of the manuscript writing and study tools development technical inputs.

DATA AVAILABILITY STATEMENT

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

CONFLICT OF INTEREST

The authors declare there is no conflict.

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