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Article

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Determinants of rural households' willingness to pay for improved potable water supply in Central Rift Valley Ethiopia: contingent valuation method approach

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ABSTRACT

Access to improved water is a global issue aligned with sustainable economic development. Ethiopia plans to enhance access to safe water through low-cost tech and community mobilization. However, finance is crucial for rural water construction and rehab, and the price mechanisms through users' contributions can improve the cost recovery of rural water supply. Hence, the objective of this study is to investigate rural households' willingness to pay (WTP) for improved potable water supply using the contingent valuation method (CVM). Data collected from a randomly selected 272 sample households were analyzed using descriptive and econometrics analysis. The seemingly unrelated bivariate probit (SUBP) econometric model was used to calculate the mean WTP and identify the determinant factors. The results show that 70.96% of the households were willing to pay the initial bid. The results show that sex, annual farm income, off-farm income, the average time it takes to fetch water, use of water treatment and monthly water expense have a positive and significant effect. Yet, household size, perceptions of the quality and reliability of the existing water supply, and bid values have a negative and significant effect. The mean value for improved potable water supply was 1.80 ETB per 20 liters of *Jerrican*[1]. Rural households in the study area are willing to contribute up to 7.4% of their annual income. To ensure the financial sustainability and cost recovery of rural water supply, it may therefore be possible to intervene and adopt a new water price system.

IMPACT STATEMENT

The objective of this study was to estimate rural households' willingness to pay improved potable water supply using contingent valuation method. The study reveals the critical need for improved water supply in rural areas, highlighting the significant demand for safe and reliable water supply. It emphasizes the importance of community involvement in water management and provides a platform for collaborative solutions to address water supply challenges. This research provides valuable insights into the willingness of rural households to invest in improved potable water supply, indicating the potential for cost-recovery initiatives and community-driven solutions. The outcome of this study provides relevant information for making sound and well-informed decisions and is essential for developing an optimal pricing strategy which helps to ensure financial sustainability of the rural water supply. It can serve as a baseline data to undertake an appropriate cost-benefit analysis and provide empirical evidence for further researcher on related topics.

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1. Introduction

Water is one of the most fundamental human necessities, and because it is necessary for practically all socioeconomic activity, it is also seen as a crucial element for permitting sustainable economic development (WWAP (UNESCO World Water Assessment Program), 2019). Since it is one of the

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sustainable development goals (SDGs) of the 2030 Agenda, access to improved water continues to be a problem on a worldwide scale (Evan & Christian, 2018). Even though billions of people have had access to basic drinking water over the past 20 years, there is still insufficient improved water available. Almost 26% of the world's population does not have access to properly managed drinking water as of 2020, with 83% of them residing in rural areas (WHO/UNICEF, 2021). Especially, most people without access to properly managed drinking water reside in rural areas in developing nations (Eludoyin & Olanrewaju, 2021).

Lack of access to water has a range of detrimental repercussions, such as reduced output, low enrolment of girls and fatal infections associated with the use of water (Andres et al., 2018). Particularly, women and children suffer disproportionally in rural Sub-Saharan Africa since they are often in charge of collecting water. They travel long distances and spend hours each day collecting water, which creates a significant opportunity cost in terms of time that could have been used for work, education, or other income-generating activities that would have helped them diversify their sources of income and reduce their vulnerability to gender-based violence (Rolfe, 2019).

Ethiopia has been referred to as the water tower of Africa because of the abundance of freshwater and groundwater resources that exist there. About 80% of the country's potential groundwater serves the current water sources (FAO (Food & Agriculture Organization), 2018). Despite this potential, there has been a lack of access to safe drinking water in Ethiopia's rural sector, where 77.8% of the population lives (Florence, 2019). Access to basic drinking water is available to about 39.2% of the overall population, 29.9% of the rural population and 77.2% of the urban population. Also, in Ethiopia, half of the population now lives within 1.5 km of a source of clean water (WB (The World Bank), 2019). Ethiopia has improved water availability significantly, increasing it from 42.1% in 2015 to 49.6% in 2020 (WHO/UNICEF, 2021). Even though access to improved water has significantly improved, some people are still getting their water from unimproved sources, thus there is still a need for more service.

The main obstacles to accessing better drinking water in many parts of Ethiopia, especially in rural areas, included poor supply chains for obtaining spare parts, low levels of scheme functionality, insufficient financial allocation and inadequate sub-sector ability (Florence, 2019). One of the biggest obstacles for the government in developing water supply projects, among others, is the lack of budgetary needs (Mahesh & Getu, 2018). Although the Ethiopian government frequently subsidies for water supply infrastructure, these funds are frequently insufficient to maintain the required infrastructure, guarantee water delivery and improve the quality of the water supply (MoWIE (Ministry of Water & Irrigation & Energy), 2019). Hence, it is necessary for all development agents involved to work together to mobilize funds and resources to build a water supply that is financially viable for everyone through the cost recovery supply.

Studies have been carried out around the nation to evaluate households' willingness to pay (WTP) for improved water supply in both rural and urban areas using contingent valuation method (CVM), including ones by Bogale and Birhanu (2012), Lema and Beyene (2012), Kebede and Tariku (2016), Tenaw and Assfaw (2022), Eridadi et al. (2021) and Entele and Lee (2019). This suggests that CVM has been widely used in studies assessing household WTP for water supply and water quality enhancements. This method aids in forecasting household behavior in hypothetical improvement scenarios, consistent with economic theory. Again, the Double Bounded Dichotomous Choice (DBDC) elicitation format of the CVM reduces the respondent's burden as helps to make decisions in a way that is similar to everyday market decisions individuals are facing (Freeman, 1993). The DBDC is also considered incentive-compatible and improves the statistical efficiency of the estimated mean and median WTP (Hanemann et al., 1991). Unlike the open-ended and bidding game elicitation format the result from DBDC is not affected by extreme values (outliers) and it results in a reliable response with a lower non-response rate. The DBDC reduces the visual complexity of choices and biased responses arising from uncertainty resulting from the use of the payment card elicitation method.

Previous studies undertaken emphasize urban and semi-urban water supply and hence a limited number of studies (Bogale and Birhanu, 2012; Lema and Beyene 2012) undertaken in rural areas of the country results in a paucity of recent empirical evidence. Specifically, there is no empirical study that has estimated rural households' WTP for improved potable water supply in the study area. In addition, due to factors, such as availability of groundwater, alternative water sources and water supply-related factors,

households located in different places are willing to pay different amount of money for improved water supply. Hence, the WTP differentials across different locations made it difficult to set a common or uniform fee or water tariff structure. The water resource management policy of the Ethiopian government also mandates that site-specific water tariff structures be determined based on local circumstances (MoWEI, 2001), necessitating location-specific estimations.

Hence, a study is needed in the study area to estimate rural households' demand for improved potable water supply and identify the associated factors and provide up-to-date empirical evidence. Such estimation is crucial for formulating an effective pricing strategy and assisting with the project's cost-benefit analysis, both of which are necessary to assure cost recovery and secure the financial sustainability of rural water supply.

2. Literature review

2.1. Economic valuation approaches

The observable price and quantity-based demand estimating methodologies are not workable when commodities and services are not typically traded in the market. Many methods have been developed by economists to quantify the economic value or the intangible welfare impact of non-market goods and services. However, a number several have in common the use of market data and behavior to estimate the economic value of a related non-market welfare impact. There are two frequently used methods for valuing resources economically. These methods are revealed and stated preference approaches.

The observed individual behavioral response to some market good treatments that are connected to the desired non-marketed benefit is what revealed preference techniques are based on. The main benefit of the revealed preference technique is its emphasis on actual options, which avoids potential issues with hypothetical replies. The revealed preference method includes the travel cost and hedonic pricing method (Robert, 2002).

The travel cost method is more suitable for estimating recreational sites than estimating WTP for improved water services. Because households often use a variety of alternative sources to maintain a certain level of water quality and quantity. Measuring the time value of water transport from a particular location may not provide the complete picture (Francesco et al., 2004). The hedonic pricing strategy is based on what people want to acquire, not the actual items but rather the qualities or attributes they include (Blomquist & Worley, 1981). It is mostly employed in property pricing when a property's price is decided by its unique features (Rosen, 1974).

The stated preference approach is based on the technique of direct questioning how people would respond when asked directly about their preferences for goods and services in a hypothetical choice situation (Francesco et al., 2004). The stated preferred methods include choice experiment and CVM. The choice experiment method is rooted in the science of marketing and is an increasingly popular non-market pricing technique used in various economic sectors. A series of experimentally designed choice sets with different attributes are presented to each respondent, and the trade-offs that respondents make when choosing between a given choice set are quantified by using statistical techniques to estimate monetary value (Louviere et al., 2000). This method is useful because the goal is to choose the optimal combination of traits. This method has the major disadvantage of cognitive difficulty associated with multiple choices or complex ratings among packages with many attributes and levels (Adamowicz et al., 1998).

When respondents are directly asked to indicate their WTP contingent on a carefully constructed hypothetical scenario and the details of the proposed intervention, the process is known as CVM (David et al., 2006). By using the CVM, it is possible to estimate the overall economic value of an environmental good or service, taking into account the quality of services that have not yet been received (Cerda et al., 2007). The CVM does not need to connect public products or services with an actual market transaction, in contrast to the travel cost and hedonic pricing methods, which demand an actual market transaction (Francesco et al., 2004). Some scholars have used the CVM to estimate the value of changes in water quality (Alberini & Cooper, 2000; Carson et al., 2001), and they highlighted that this approach has aided in predicting individual behavior in line with economic theory's hypotheses. Most authors encourage

using CVM because of its adaptability in determining the value of a variety of environmental products and services, and the National Oceanic and Atmospheric Administration (NOAA) panel has also recognized its importance.

2.2. Empirical literature review

Several studies have been undertaken to estimate households' demand for improved potable water supply in developing countries including Ethiopia. A study by Dlamini et al. (2016), employed a CVM in semi-urban areas of Swaziland. Rahman et al. (2017) investigated households demand for improved water supply in semi-urban areas of Bangladesh using CVM. The CVM is also employed by Jianjun et al. (2016) to measure the demand for drinking water quality improvements in Songzi China. The results of these studies showed that households' socioeconomic and existing water supply characteristics plays a significant role in determining WTP.

A study by Gossa (2019) and Tenaw and Assfaw (2022) employed the CVM to examine households' WTP for improved urban water supply in Ethiopia. The findings of this study indicate that household income and perceptions of water availability and quality are significant factors. Kebede and Tariku (2016) estimated the demand for improved water supply and its determinants in Jigjiga town, Ethiopia. A similar study was conducted by Eridadi et al. (2021) in Sebeta town, Ethiopia, employing the CVM. The binary logistic model revealed that household socioeconomic and demographic characteristics are the main determinant factors. Entele and Lee (2019) examined the demand for fluoride-safe water service connections in the Rift Valley Region of Ethiopia. The result shows that water quality perceptions, dissatisfaction and number of children less than 5 years of age are found to have a significant influence. Bogale and Birhanu (2012) used a CVM to estimate the demand for improved water service provision and identify its determinants in Eastern Ethiopia. Lema and Beyene (2012) also employed a CVM and found that perception of the existing water supply, socioeconomic and condition of the existing water supply determines WTP.

Generally, the above empirical evidence revealed that the CVM is the appropriate method for estimating households' demand for improved water supply. Although there are studies undertaken in rural areas of the country, studies focus on urban and semi-urban areas which indicates there are is a lack of recent empirical evidence. Furthermore, due to the water resource availability and water supply-related factors, households located in different places are willing to pay different amounts of money for improved water supply. Hence, a location-specific study is needed in the study area to estimate the demand for improved potable water supply and provide recent empirical evidence.

The reviewed empirical literature also shows that the CVM is used with different elicitation formats. A study by Tenaw and Assfaw (2022), Kebede and Tariku (2016), and Eridadi et al. (2021), used a single bounded dichotomous choice format, while a study by Entele and Lee (2019) used an open-ended question format, where both of these elicitation formats have some methodological constraints. The former approach has limitations in terms of producing a statistically accurate estimate of mean WTP (Hanemann et al., 1991). Moreover, extreme values have an impact on the estimates found using the later approach. However, this study employed the DBDC elicitation format to overcome the limitations of the two methods.

3. Materials and methods

3.1. Description of the study area

The study was conducted based on rural households in the Dugda districts of Oromia national regional state, Ethiopia (Figure 1). There are about 29,507 households in the district, of which, 21,202 households (71.85%) are living in rural areas and the remaining 8,305 households (28.15%) are urban dwellers (Dugda Woreda Office of Agriculture [DWOA], 2020). There are about 40 rural water supply sites that are distributed across the rural kebeles[2] in the district. There are four primary types of rural water supply systems in the district: hand-dug wells, dug wells, windmills and hand pump water supply systems. On

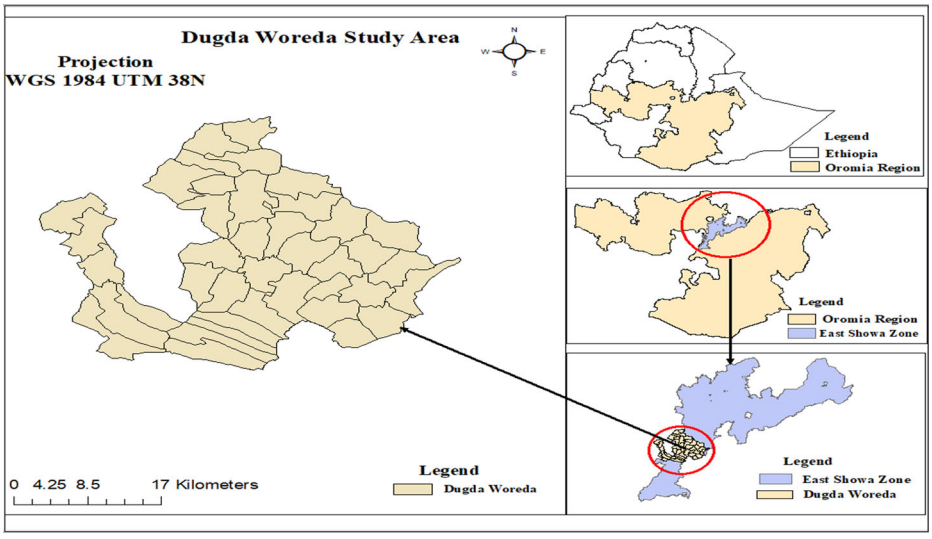

Figure 1. The geographical location of the study area.
Source: Own sketch from GIS.

average, the current rural water supply in the district serves only 47.17% of the total rural population (Dugda Woreda Water Resource & Energy Office [DWWREO]), 2020).

3.2. Sampling procedure and sample size

A two-stage sampling procedure was employed to select sample respondents. In the first stage, rural *kebeles* in the district having a problem with access to water supply were identified and three *kebeles* were randomly selected. In the second stage, individual respondents from these *kebeles* were selected randomly. The probability proportional to sample size technique was used to determine the number of respondents from the three *kebeles*. For its simplicity once, the number of populations is known, the simplified formula given by Yamane (1967) was used to determine the required sample size of 274. Accordingly, the required sample size was calculated as follows:

$$n = \frac{N}{1 + N(e^2)} = \frac{21,202}{1 + 21,202(0.06^2)} = 274 \quad (1)$$

where n = sample size, N = total number of rural households in the district and e = level of precision. The precision level set at 6% is due to the homogeneity of the population in the study in terms of many attributes such as cultural, socioeconomic, institutional and livelihood strategies.

3.3. Elicitation format and survey design

The DBDC format is the one that is recommended by the NOOA panel for its ease of use and resemblance to the day-to-day decision-making of individuals (Arrow et al., 1993). Due to its advantage in estimating a better confidence interval of the mean and median WTP, minimizing non-response and outliers, and controlling biases that arise during the CV study, the DBDC format followed by an open-ended was used in this study. The follow-up open-ended question is used to make a comparison in the mean WTP results obtained from the DBDC and open-ended elicitation format. As recommended by the NOAA guideline, a CV study should have a carefully designed survey questionnaire with a detailed description of the good under consideration (water supply improvement), hypothetical circumstances under which the good is made available to users, conditions for provision, description of a method of payment and questions that elicit WTP/WTA of the respondents for a proposed change and respondents socio-economic and other important issues (Arrow et al., 1993). Hence the CV survey questionnaire in this study is designed to have two main sections. The first section of the questionnaire includes general information which tries to gather information regarding the demographic and socio-economic condition

of the respondents. The second section includes questions regarding respondents' perceptions of the existing water supply, water use pattern, CV scenario and WTP for improved water supply.

Before the survey data collection, enumerators' training and pre-tests were made. Enumerators were given training about the survey with special attention to the CV scenarios and elicitation method to avoid the potential biases that will arise from using CVM studies. A pre-test was made to get further information on the condition of the existing water supply, choose a payment vehicle, determine initial bid values and to further design a sound hypothetical market scenario. A pre-test of the questionnaire was undertaken with a total of 21 randomly selected households in the selected *kebeles*. It is feasible for the researcher to select a small number of respondents, which would facilitate obtaining detailed and reliable information on the current water supply conditions. The payment method of 'cash payment on the spot' was chosen due to its familiarity, as it is widely used by the majority of households in the selected kebeles.

The initial bid values were determined before the data collection using open-ended questions provided for a randomly selected household in the selected *kebeles*. Accordingly, seven households from each of the three *kebeles* were asked their maximum WTP for a 20-L jerrican of improved water supply. The most frequent values were taken as the initial bid to be used in the final survey. The most frequent value reflects what the majority of people would actually be willing to pay and a greater degree of public acceptability than taking an average value, which has been overly influenced by an outlier. Hence, an amount of 0.75ETB was selected as one of the initial bid values with its upper bid value of 1.5 ETB and lower bid value of 0.40 ETB. Again, the second bid amount of 2 ETB was selected as one of the initial bid values with its upper bid value of 4 ETB and lower bid value of 1 ETB. Finally, the amount of 1 ETB was selected as one of the third initial bid values with its upper bid value of 2 ETB and lower bid value of 0.50 ETB. The sets of the upper and lower bid values for each identified initial bid value were made by taking double and half of the initial bid value, respectively except for the lower limit of the initial bid 0.75ETB was rounded to 0.4ETB. These follow-up bid values (upper and lower) are taken as it is advisable to choose bid values that cover a relatively broad portion of the range for WTP (Creel & Loomis, 1997) and used by many previous CV studies. The use of a follow-up bid leads to a better confidence interval for the estimated mean WTP (Hanemann et al., 1991).

Then, the predetermined set of bids was randomly and proportionally assigned to the respondents with the assumption to reduce the starting point bias that would arise in the CV survey. A follow-up question is asked based on the response to the initial bid offered. Hence, a second higher bid value is provided for the respondent if the answer to the first question is 'yes' and a second lower bid value is presented if the answer to the first question is 'no'. After this, the WTP survey question was ended by asking an open-ended follow-up question to state their maximum WTP for improved water supply.

To estimate the mean WTP using a DBDC question starts by simply characterizing a household j's unobserved true WTP as follows:

$$WTP_{ij}^{*} = \mu_i + \varepsilon_{ij} \tag{2}$$

where WTP_{ij} denotes households' *j*th WTP that is unobservable and $i = 1, 2$ represents the respondents' response to the first and second questions (bids offered). μ_1 and μ_2 are the means of the first and second bid responses and ε_{ij} are unobservable random components. Proposing that $\mu_{ij} = X'_{ij}\beta_i$ permits both the means to be reliant upon the characteristics of the respondents (X'_{ij}) and is assumed to depend on individual socioeconomic and demographic characteristics contained in the vector X_i.

In constructing the likelihood function from the DBDC question, there is a probability of observing the four possible responses from each of the two bids offered and the responses are (Yes-Yes, Yes-No, No-Yes and No-No). Accordingly, the four probabilities that household j answers to the initial bid offered, R^1, and again to the follow-up bid offered (R^2), are given by:

$$\begin{aligned}
\Pr(yes, yes) &= \Pr\left(WTP_{1j} > R^1, WTP_{2j} \geq R^2\right) \\
&= \Pr(\mu_1 + \varepsilon_{1j} > R^1, \mu_2 + \varepsilon_{2j} \geq R^2) \\
\Pr(yes, no) &= \Pr\left(WTP_{1j} \geq R^1, WTP_{2j} < R^2\right) \\
&= \Pr(\mu_1 + \varepsilon_{1j} \geq R^1, \mu_2 + \varepsilon_{2j} < R^2)
\end{aligned}$$

$$\begin{aligned}\Pr(no, yes) &= \Pr\left(WTP_{1j} < R^1, WTP_{2j} \geq R^2\right)\\ &= \Pr(\mu_1 + \varepsilon_{1j} < R^1, \mu_2 + \varepsilon_{2j} \geq R^2)\\ \Pr(no, no) &= \Pr\left(WTP_{1j} < R^1, WTP_{2j} < R^2\right)\\ &= \Pr(\mu_1 + \varepsilon_{1j} < R^1, \mu_2 + \varepsilon_{2j} < R^2)\end{aligned} \tag{3}$$

From the above probabilities of the possible responses to the first and second dichotomous choice questions, households' *j*th contribution to the likelihood function can be derived following Haab and McConnel (2003).

$$\begin{aligned}L_i(\mu|R) = Pr\left(\mu_1 + \varepsilon_{1j} \geq R^1, \mu_2 + \varepsilon_{2j} < R^2\right)^{YN} \times Pr\left(\mu_1 + \varepsilon_{1j} > R^1, \mu_2 + \varepsilon_{2j} \geq R^2\right)^{YY}\\ \times Pr\left(\mu_1 + \varepsilon_{1j} < R^1, \mu_2 + \varepsilon_{2j} < R^2\right)^{NN} \times Pr\left(\mu_1 + \varepsilon_{1j} < R^1, \mu_2 + \varepsilon_{2j} \geq R^2\right)^{NY}\end{aligned} \tag{4}$$

where

YY takes the value 1 if the answer to both the initial and second follow-up bid is a Yes-Yes response, 0 otherwise;

NY takes the value 1 if the answer to the first initial bid is No and answers Yes to the second follow-up question, 0 otherwise;

YN takes the value 1 if the answer to the first initial bid is Yes and answers No to the second follow-up question, 0 otherwise;

NN takes the value 1 if the answer to both the first initial bid and second follow-up question is a No-No response, and 0 otherwise.

This type of responsive design is known as the bivariate discrete choice model. The random error term is assumed to be normally distributed with zero mean and a respective variance of $\sigma_1{}^1$ and $\sigma_1{}^2$ WTP_{1j} and WTP_{2j}, and a correlation coefficient of ρ. Then the WTP_{1j} and WTP_{2j} follow a bivariate normal distribution with mean μ_1 and μ_2, variances σ_1 and, σ_2 and a correlation coefficient ρ. Given the design of the dichotomous choice responses to the bids offered, the normally distributed model is referred to as the bivariate probit model. The probabilities of all four possible response sequences are used to derive the likelihood function for the bivariate probit model.

$$\begin{aligned}\Pr\left(\mu_1 + \varepsilon_{1j} > R^1, \mu_2 + \varepsilon_{2j} \geq R^2\right) &= \Phi_{\varepsilon 1\varepsilon 2}\left(-\frac{R^1 - \mu_1}{\sigma_1}, -\frac{R^2 - \mu_2}{\sigma_2}, \rho\right)\\ \Pr\left(\mu_1 + \varepsilon_{1j} \geq R^1, \mu_2 + \varepsilon_{2j} < R^2\right) &= \Phi_{\varepsilon 1\varepsilon 2}\left(-\frac{R^1 - \mu_1}{\sigma_1}, -\frac{R^2 - \mu_2}{\sigma_2}, \rho\right)\\ \Pr\left(\mu_1 + \varepsilon_{1j} < R^1, \mu_2 + \varepsilon_{2j} \geq R^2\right) &= \Phi_{\varepsilon 1\varepsilon 2}\left(-\frac{R^1 - \mu_1}{\sigma_1}, -\frac{R^2 - \mu_2}{\sigma_2}, \rho\right)\\ \Pr\left(\mu_1 + \varepsilon_{1j} < R^1, \mu_2 + \varepsilon_{2j} < R^2\right) &= \Phi_{\varepsilon 1\varepsilon 2}\left(-\frac{R^1 - \mu_1}{\sigma_1}, -\frac{R^2 - \mu_2}{\sigma_2}, \rho\right)\end{aligned} \tag{5}$$

where $\Phi_{\varepsilon 1\varepsilon 2}$ (.) is the standardized bivariate normal cumulative distribution function with zero means, unit variances, and correlation coefficient ρ. Then the resulting likelihood function for a bivariate Probit model is given as follows:

$$L_j(\mu|R) = \Phi_{\varepsilon 1\varepsilon 2}\left(d_{1j}\left(\frac{R^1 - \mu_1}{\sigma_1}\right),\ d_{2j}\left(\frac{R^2 - \mu_2}{\sigma_2}\right),\ d_{1j}d_{2j}\ \rho\right) \tag{6}$$

where $\Phi_{\varepsilon 1\varepsilon 2}$ (.) = the standardized bivariate normal cumulative distribution function.

$$d_{1j} = R_j^1 - 1 \ \textit{and} = R_j^2 - 1$$

σ_1 And σ_2 = standard deviation of errors

ρ = correlation coefficient

The mean WTP from the bivariate Probit model will then be computed following running the regression of the dependent variable which is indicated by the yes/no indicator, on the independent variable consisting of the bid levels. The mean WTP from the bivariate Probit model will be computed depending on the normality assumption of WTP distribution (Haab & McConnell, 2003).

$$\text{Mean WTP} = -\frac{\boldsymbol{\beta}_0}{\boldsymbol{\beta}_1} \tag{7}$$

where β_0 = intercept of the model which is constant (the coefficient for the constant term) and β_1 = slope coefficient (coefficient for the offered bid values).

The bivariate probit model can thus be specified as a latent variable of the structural equation (Greene, 2002).

$$\begin{cases} Y_1^* = & \beta_1 x_1 + \varepsilon_1 \\ Y_2^* = & \beta_2 x_2 + \varepsilon_2 \end{cases} \tag{8}$$
$$E(\varepsilon_1|x_1, x_2) = E(\varepsilon_2|x_1, x_2) = 0$$
$$Var(\varepsilon_1|x_1, x_2) = Var(\varepsilon_2|x_1, x_2) = 1$$
$$Cov(\varepsilon_1, \varepsilon_2|x_1, x_2) = \rho$$

where Y_1^* = *i*th respondent unobserved but true WTP at the time of the first bid offered. $\text{WTP}_1 = 1$, if $Y_1^* >$ initial bid, and 0 otherwise. Y_2^* is the *i*th respondent's implicit underlying point estimate at the time of the second bid offered. x_1 and x_2 are the vectors of explanatory variables. ε_1 and ε_2 are error terms for the first and second equations that are distributed over a $N(0, \sigma^2)$.

4. Results and discussion

4.1. Descriptive results

Respondents were categorized as willing and non-willing based on their response to the initial bid offered to them. Hence, from the total sampled respondents included in the analysis, 193 (70.96%) were willing to pay the initially offered bid price and the remaining 79 (29.04%) respondents were not willing to pay the initially offered bid value.

The description of explanatory variables and summary of descriptive statistics (demographic, socio-economic and existing water supply conditions) were presented in Table 1. Income from agricultural activities, particularly from crop and livestock sales, constituted the primary source of income for rural households in the study. The mean household annual income was 25967.5 Ethiopian Birr (ETB). In addition to income from agricultural activities, households in the study area are participating (50.37%) in off/non-farm income-generating activities to diversify their livelihood. The mean annual off/non-farm income of the households was 4154.08 ETB.

About 58.82% and 33.82% of the respondents perceived the existing water as not safe for drinking and not reliable, respectively. About 51.47% of the respondents responded that the location of the existing water supply point is not convenient in terms of distance and topography. The average time spent collecting water from the existing water supply was 2.26 h (2 h and 15 min) and ranges from 0.17 to

Table 1. Variables description and summary of descriptive statistics (N=272).

Variable	Description	Mean	Std. dev
SEX	Sex of the respondent (1 = Female)	0.448	0.498
AGE	Age of the respondent	38.69	10.48
HHSIZE	Household size (in adult equivalent)	4.89	1.61
EDUCLEVEL	Level of education in years	4.18	3.33
FARM_INC	Household annual farm income	25967.5	11512.6
OFF_INC	Household off/non-farm income	4154.08	6075.4
QUALITY	Perception of existing water quality (1 = Safe)	0.41	0.49
RELIAB	Reliability of existing water supply (1 = Yes)	0.34	0.47
TIME	Time taken to fetch water (in hours)	2.26	1.23
WATERTREAT	Use of water treatment techniques (1 = Yes)	0.10	0.30
EXPEND	Household monthly water expenditure in ETB	64.01	40.97
BID	Initial bid value in ETB	1.25	0.54
NUM_WTRBRN	Number of family members affected by waterborne diseases	0.40	0.69
LOCATION	Convenience of the location of the existing water supply (1 = Yes)	0.48	0.50
Percep_WS_prob	Awareness on existing water supply problem	0.94	0.24
Overall_satsf	Satisfaction on the existing water supply	0.14	0.35
HlthEco_impact	Health and economic impact of using the existing water supply	1.28	0.58

Source: survey result, 2021.

6 h. Women and children (53.68%) take the great burden in collecting water. The majority of the households (90.07%) were not using any kind of water treatment technique.

The average household monthly water expenditure was 64.01 ETB. Households' water expenditure varies as they are using different water supply sources with different prices. The average number of family members affected by the waterborne disease was found to be less than one (0.4) person per household and ranges from 0 to 3 people. Among the total respondents, 30.15% indicated that at least one of their family members had been affected by a waterborne disease in the previous year.

The average household daily water consumption was found to be 51.42 L (equivalent to 2.57 jerrican). Again, the average per capita daily water consumption was found to be 8.54 L with a minimum and maximum of 1.67 and 33.33 L, respectively. The average per capita daily water consumption in the study area was less than the minimum standard set by WHO, which is about a minimum of 20L daily per capita water consumption.

About 94.12% of the respondent are aware of the problem on the existing potable water supply. The overall satisfaction measure indicates that only 14% of the respondents are satisfied with the existing water supply. The result also reveals that 79.04% of the respondent are aware of, 14.34% responded 'no' and 6.62% responded 'not sure' of the health and economic impact from using the existing water supply.

Again, a chi-square and t-test result was also made to show whether there exists a significant association and mean difference among willing and non-willing respondents, respectively.

Table 2 presents the chi-square result of dummy explanatory variables. The findings indicate a notable disparity between willing and non-willing households concerning the dummy explanatory variables at various probability levels. This implies that respondents being female, using water treatment techniques, and dissatisfaction with the quality, reliability and location of the existing water supply would be more likely to pay the initially offered bid.

Table 3 presents the t-test result of continuous explanatory variables. The result revealed that there exists a statistically significant mean difference among willing and non-willing households. The result revealed that households with a higher level of education, annual farm income, off/non-farm income, number of family members affected by waterborne disease, monthly water expenditure, spending much

Table 2. Summary of descriptive statistics for dummy variables.

		Willing ($N = 193$)		Non-willing ($N = 79$)		
Variables		No	Percentage	No	Percentage	χ^2
SEX	Female	104	53.89	18	22.78	21.92***
	Male	89	46.11	61	77.22	
QUALITY	Safe	64	33.16	48	60.76	17.63***
	Not safe	129	66.84	31	39.24	
RELIAB	Yes	59	30.57	33	41.77	3.143*
	No	134	69.43	46	58.23	
WATERTREAT	Yes	24	12.44	3	3.80	4.68**
	No	169	87.56	76	96.20	
LOCATION (Convenient)	Yes	81	41.97	51	64.56	11.45***
	No	112	58.03	28	35.44	

***, ** and *show significant at 1%, 5% and 10% probability levels, respectively.
Source: survey result, 2021.

Table 3. Summary of descriptive statistics for continuous variables.

	Willing ($N = 193$)		Non-willing ($N = 79$)		
Variables	Mean	Std. dev	Mean	Std. dev	*t*-test
AGE	37.99	10.36	40.41	10.64	1.73*
HHSIZE	4.74	1.49	5.23	1.82	2.42**
EDUCLEVEL	4.88	3.28	2.48	2.8	−5.71***
FARM_INC	27940.9	10269.7	21146.46	12950.3	−4.58***
OFF_INC	5198.18	6511.5	1603.3	3818.7	−4.59***
TIME	2.51	1.22	1.65	1.04	−5.46***
EXPEND	67.71	41.37	54.97	38.78	−2.35**
NUM_WTRBRN	0.48	0.47	0.20	0.52	−3.13***

***, ** and *show significant at 1%, 5% and 10% probability levels, respectively.
Source: Survey result, 2021.

Table 4. Distribution of responses to the DBDC question across the bid sets.

	Yes-Yes		Yes-No		No-Yes		No-No		Total	
Set of bids	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
(0.4, **0.75**, 1.5)	64	71.11	22	24.44	4	4.44	0	0	90	100
(0.5, **1**, 2)	39	42.86	35	38.46	17	18.68	0	0	91	100
(1, **2**, 4)	0	0	32	35.16	24	26.37	35	38.46	91	100
Total	103	37.87	89	32.72	45	16.54	35	12.87	272	100

Source: Survey result, 2021.

time in collecting water, smaller household size and younger households would be more likely to pay the initial bid.

4.2. The contingent valuation survey result

The predetermined sets of bids were randomly and proportionally assigned to the respondents and the distribution of responses to the DBDC question across the bid sets was presented in Table 4. The result indicated that 37.87%, 12.87%, 32.72% and 16.54% of the respondents responded Yes-Yes, No-No, Yes-No and No-Yes, respectively. The results revealed that most responses fell under the 'Yes-Yes' and 'Yes-No' response patterns, indicating a strong interest among rural households to pay for improvements in the existing water supply.

After asking respondents the dichotomous choice questions, a follow-up open-ended question was presented to freely state their maximum WTP for a 20-L Jerrican of improved water supply. Hence, the mean WTP for a 20-L Jerrican improved water supply obtained from an open-ended question was found to be 1.37 ETB and ranges from 0.5 to 3 ETB. Again, the majority (69.48%) of the respondents were willing to pay a value between 1 and 2 ETB.

4.3. Econometrics result

Some tests were made as a precondition to check for the existence of some econometrics problems and to look for remedial measures. However, the robust estimator was used as a means to control the potential bias from the problem of heteroskedasticity (Wooldridge, 2018). Again, Mitchell and Carson (1989) and Hanemann et al. (1991) also emphasized the use of robust estimators to control the potential bias of the non-normality and outliers in CV studies. Therefore, this study employed a SUBP robust estimation method, incorporating a total of fourteen explanatory variables (nine continuous and five dummy variables).

Prior to running a bivariate probit model, a decision was made to choose an appropriate estimation method for the data based on the result of the correlation coefficient test against the null hypothesis using a test criterion highlighted by Haab and McConnell (2003). Accordingly, when the correlation coefficient between the two error terms (rho) in the two dependent variable equations is zero, the two WTP equations can be estimated independently. When the value of rho is different from zero and not equal to one and is statistically significant, the two WTP equations can be estimated jointly and hence a bivariate probit model is an appropriate econometric model. If the value of rho is exactly one or if there is a perfect correlation, the interval data probit model is the appropriate model used for estimation of the two WTP equations.

As a result, the correlation coefficient results in this data was found to be 0.48, which is different from zero and statistically significant at a 5% level of significance. The result confirmed that the two WTP equations can be estimated jointly, hence a bivariate probit model was found to be an appropriate econometric model for the DBDC CV data of this study. The t-test was utilized to assess the statistical significance of variables, calculated by dividing the coefficient by its standard error and taking the absolute value. If the calculated *t*-value falls between 1.64 and 1.96, 1.96 and 2.57, or exceeds 2.57, the variable is considered significant at the 10%, 5% and 1% probability levels, respectively.

Table 5 above presents the model summary of factors affecting households' WTP for improved potable water supply. The results indicated that the respondent's sex (SEX) had a positive and significant effect on households' initial bid decision at a 5% probability level. The marginal effect result indicates that being a female will increase the probability of accepting the first bid question by 3%, ceteris

Table 5. Seemingly unrelated bivariate probit regression results.

	WTP1		WTP2		Marginal effect (Joint)	
Variables	Coef	Robust std. Err	Coef	Robust std. Err	dy/dx	Std. Err
SEX	0.559**	0.257	−0.029	0.203	0.030	0.072
AGE	0.024	0.016	0.0004	0.012	0.002	0.004
HHSIZE	−0.270**	0.112	0.019	0.085	−0.013	0.031
EDUCLEVEL	0.054	0.035	0.033	0.036	0.015	0.013
FARM_INC	0.024**	0.012	0.006	0.008	0.004	0.003
OFF_INC	0.052*	0.027	0.042*	0.022	0.018	0.008
QUALITY	−0.278	0.228	−0.431**	0.204	−0.168	0.073
RELIAB	−0.112	0.240	−0.431**	0.195	−0.157	0.070
LOCATION	−0.126	0.221	−0.262	0.185	−0.100	0.068
TIME	0.192*	0.113	0.286***	0.095	0.113	0.036
WATERTREAT	0.997**	0.485	0.717**	0.346	0.296	0.117
NUM_WTRBRN	−0.032	0.200	−0.012	0.133	−0.006	0.049
EXPEND	0.011***	0.003	0.005*	0.002	0.002	0.001
BID1	−1.571***	0.246			−0.116	0.053
BID2			−1.336***	0.200	−0.463	0.081
_cons	1.034	0.662	1.25	0.559		
Number of observations = 272					Wald chi^2 (28) = 206.41	
Log pseudo likelihood = −215.555					Prob > chi^2 = 0.0000	
Rho = 0.48						
Wald test of rho = 0: $chi^2(1)$ = 3.95963						
Prob > chi^2 = 0.0466						
y = Pr (WTP1 = 1, WTP2 = 1) (predict) = 0.47548601						

***, ** and *show significant at 1%, 5% and 10% probability levels, respectively.
Source: survey result, 2021.

paribus. This is because as females bear the greater burden of collecting water and are familiar with water-related activities at home, they are more aware of problems and attach a great value to water supply improvement. A study by Entele and Lee (2019) also confirmed the appositive relationship between sex and WTP. However, the result of this study is in contrast with the findings of Dlamini et al. (2016).

Household size (HHSIZE) had a negative and significant effect on the household's first WTP equation at a 5% probability level. This indicates households with a larger family member are less likely willing to pay the initial bid. It is mainly because of the availability of labor in the household. The result of the marginal effect revealed that by keeping the influence of other variables constant at their mean value, an increase in household size by one adult equivalent will decrease the probability of accepting the initial bid by 1.3%. The result is consistent with the findings of Wana and Sori (2020). However, the result was in contrast with the finding of Kebede and Tariku (2016) as large household sizes have a large labor availability that would help to earn more income in urban areas and hence more willing to pay.

As hypothesized, annual farm income (FARM_INC) had a positive and significant impact on household WTP's decision to accept the first bid at a 5% probability level. The result of this study is in line with the general economic theory of demand which states that income and demand for goods and services are positively associated. The results of the marginal effect revealed that as the annual income of the household increases by one thousand ETB, the probability of accepting the first bid will increase by 0.4%, ceteris paribus. A study by Song et al. (2019) obtained a similar result.

Consistent with prior expectations, off/non-farm income (OFF_INC) had a positive and significant influence on households' decisions for both the first and second bids at a 10% probability level. The marginal effect result indicated that as households' off/non-farm income increases by one thousand ETB, the probability of accepting both the first and follow-up bid will increase by 1.8%, ceteris paribus. This is because households having off/non-farm income have financial freedom in their expenditure and hence help them to pay more. The result is in line with the economic theory of demand.

Perception of the quality (QUALITY) and reliability (RELIAB) of the existing water significantly and negatively affects households' decision to accept the follow-up bid at a 5% probability level. The marginal effect analysis showed that if households perceive the quality of existing water as safe and reliable, the probability of accepting the second bid decreases by 16.8% and 15.7%, respectively, holding all other factors constant. It is because households in the study are experiencing dental and skeleton

fluorosis problems like the decay of teeth and joint pain problems particularly when they get aged. Also, the existing water supply was characterized by poor maintenance and unavailability or too costly to get some spare parts. The result of this study conforms with the findings of Entele and Lee (2019) and Tenaw and Assfaw (2022).

The variable time taken to fetch water (TIME) significantly and positively influences the household's WTP for both the first and follow-up bid at 10% and 1% probability levels, respectively. The marginal effect analysis indicated that a one-hour increase in the average time spent fetching water increases the probability of accepting both the initial and subsequent bids by 11.3%, all else being equal. A study by Dhungana and Baral (2017) also found a positive association between the time taken and WTP. The main reason behind this is that households in the study area are spending a greater waiting time at the water point due to the existence of long queues at the public tap water collection point.

Households who are using water treatment techniques (WATERTREAT) are more likely to be willing to pay both the first and second bids offered as it is significant at a 5% probability level. The result also revealed that households being a user of water treatment techniques will increase the probability to accept both the initial and follow-up bid values by 29.6%, ceteris paribus. Implementing water treatment techniques adds additional time and costs to the process. This study's results align with the findings of Bogale and Birhanu (2012).

Household monthly water expenditure (EXPEND) has a positive and significant influence on the decision to accept both the first and second bids at 1% and 10% probability levels, respectively. Thus, holding the effects of other variables constant at their mean value, a one ETB increase in monthly water expenditure will increase the probability to accept the first and follow-up bids by 0.2%. It is due to households are buying water from private vendors at a higher price including costs associated with transporting water to their homes. This result of the study was consistent with previous studies by Kidu and Ewnetu (2015).

The results showed that the bid value (BID) had a negative and significant impact on households' decisions to accept both the first and second bids at a 1% probability level. This suggests that as the bid value increases by one unit, the probability of accepting and paying the initial bid and second follow-up bid decreases by 11.6% and 46.3%, respectively, all else being constant. The negative relationship between the bid value and the decision to pay is consistent with the economic theory of the law of demand, which states the price and the quantity demanded are inversely related. The result of this study is in line with the findings of Song et al. (2019).

4.4. Estimation of mean WTP and aggregate benefit

After regression of the households' response to the bid offered on the bid values, the mean WTP is then calculated by dividing the constant by the bid coefficient. The mean value is calculated from the first equation as Haab and McConnel (2003) confirmed that the estimated mean WTP from the follow-up bid equation is subject to some noise as a respondent is assumed to take the cue from the first bid while making their decision for the second bid and hence the first bid equation was found to be a better estimation approach.

Table 6 indicates that the estimated mean value for improved water supply from the DBDC elicitation method was 1.80 ETB per 20-L jerrican. In summary, although the mean results from the two elicitation methods are comparable, the result from DBDC elicitation was greater than that of the result from open-ended elicitation. Rural households in the study area currently allocate approximately 3.24% of their average income, and they are willing to allocate up to 7.4% of their average income.

Estimation of the aggregate benefits is a very important part of the CV survey. The aggregate benefit from the improved water supply was calculated by taking the product of the mean WTP, households' average daily water consumption, and the total number of rural households in the study area (Table 7).

Table 6. Seemingly unrelated bivariate probit (mean WTP estimation).

	Coefficient	St. Err	*p* Value
Initial bid (BID1)	−1.215	0.192	0.0000***
Constant	2.198	0.287	0.0000***
Follow-up bid (BID2)	−1.024	0.166	0.0000***
Constant	1.815	0.271	0.0000***
Rho (ρ)	0.600	0.207	
Number of observations		272	
Log-likelihood		−280.2314	
Wald chi^2 (2)		128.68	
Prob > chi^2		0.0000	
LR test of rho = 0: $chi^2(1) = 4.6139$			
Mean WTP = 1.80 ETB			
Prob > $chi^2 = 0.0317$**			
y = Pr (WTP1 = 1, WTP2 = 1) (predict) = 0.4624			

*** significant at a 1% probability level.
Source: survey result, 2021.

Table 7. Aggregation of benefits for improved potable water supply.

	Total number of HHs	HHs average daily water consumption (in 20-L jerrican)	Mean WTP (ETB)	Aggregate benefit
DBDC	21202	2.571	1.80	98118.62
Open-ended	21202	2.571	1.37	74679.17

Source: Survey result, 2021.

Accordingly, as indicated in Table 7, the daily total aggregate benefit of improved potable water supply obtained from the DBDC and open-ended format was 98118.62 ETB and 74679.17 ETB, respectively.

Conclusion

Household socioeconomic, demographic characteristics and the condition of existing water supply play a significant role in determining respondents' WTP for improved potable water supply. Majority of the households are willing to pay towards improved water supply with an amount greater than the existing water tariff. Rural households are willing to pay up 7.4% of their average household income. The mean WTP result from the DBDC elicitation method was greater than the result from open-ended elicitation, showing the former method provides a better estimation of the mean WTP. The result indicates that there is a condition by which the existing tariff structure could be improved as long as it does not exceed the water affordability standard set by the UN, where water spending could be up to 5% of household average income. Users' contributions can significantly enhance the financial sustainability and cost recovery of rural water supply systems. Improving rural water supply has profound implications for enhancing the livelihoods of rural communities by reducing the opportunity cost of time spent on education, employment and income-generating activities. Therefore, there is a critical need to establish cross-sector coordination and strengthen community participation to achieve better and sustainable water supply services.

Notes

1. Jerrican is a portable plastic container used for storing and transporting water with a common size of 20 liters.
2. *Kebele* is the lowest level administrative unit of the government system in Ethiopia and it may contain several villages.

Ethical approval

This study work was approved by the ethical committee of Haramaya University chairman of the Department Graduate Council (DGC), research thematic area leader, and Dean of the Postgraduate Program Directorate (PGPD). Furthermore, informed written consent was obtained from all the respondents during the pretest of the questionnaire.

Author contribution statement

The authors confirm their contribution to the paper as follows: Shimeles Getinet: Study conception and design, data analysis and interpretation of results and draft manuscript preparation.

Abule Mehare and Aemro Tazeze supervised the proposal development and findings of this study, critically revised the article for important intellectual content, and approved the final version for publication. All authors reviewed the results and approved the final version of the manuscript.

Disclosure of interest

The authors declare that they have no known competing interests that could have appeared to influence the result reported in this work.

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Data availability statement

The data that support the findings of this study are available from the corresponding author, Shimeles Getinet upon reasonable request.

References

Adamowicz, W., Peter, B., Williams, M., & Louviere, J. (1998). Stated preference approaches for measuring passive use values: Choice experiment and contingent valuation. *American Journal of Agricultural Economics*, *80*(1), 64–75. https://doi.org/10.2307/3180269

Alberini, A., & Cooper, J. (2000). *Applications of the contingent valuation method in developing countries: A survey*. Economic and Social Development Paper 146, Food and Agriculture Organization of the United Nations.

Andres, L., Borja-Vega, C., Fenwick, C., Jesus Filho, D., & Gomez-Suarez, R. (2018). *Overview and meta-analysis of global water, sanitation, and hygiene (WASH) impact evaluations*. Policy Research Working Paper 8444, Water Global Practice.

Arrow, K., Solow, R., Portney, P., Leamer, E., Radner, R., & Schuman, H. (1993). Report of the NOAA panel on contingent valuation. *Federal Register*, *58*(10), 4601–4614. https://repository.library.noaa.gov/view/noaa/60900

Blomquist, G., & Worley, L. (1981). Hedonic prices, demands for urban amenities, and benefit estimates. *Journal of Urban Economics*, *9*(2), 212–221. https://doi.org/10.1016/0094-1190(81)90041-3

Bogale, A., & Urgessa, B. (2012). Households' willingness to pay for improved rural water service provision: Application of contingent valuation method in eastern Ethiopia. *Journal of Human Ecology*, *38*(2), 145–154. https://doi.org/10.1080/09709274.2012.11906483

Carson, R. T., Flores, N. E., & Meade, N. F. (2001). Contingent valuation: Controversies and evidence. *Environmental and Resource Economics*, *19*(2), 173–210. https://doi.org/10.1023/A:1011128332243

Cerda, A. A., Rojas, J., & Garcia, L. Y. (2007). Willingness to pay for improving the environmental quality in the Great Santiago, Chile. *Lecturas de Economia*, *67*, 143–160. https://doi.org/10.17533/udea.le.n67a2025

Creel, M., & Loomis, J. (1997). Semi-nonparametric distribution free dichotomous choice contingent valuation. *Journal of Environmental Economics and Management*, *32*(3), 341–358. https://doi.org/10.1006/jeem.1997.0972

David, P., Giles, A., & Susana, M. (2006). *Cost-benefit analysis and the environment, recent developments*. Organization for Economic Co-Operation and Development (OECD). ISBN 92-64-01004-1.

Dhungana, A., & Baral, B. (2017). Factors affecting willingness to pay for improved water supply system in rural Tanahu, Nepal. *Janapriya Journal of Interdisciplinary Studies*, *5*, 1–13. https://doi.org/10.3126/jjis.v5i0.17836

Dlamini, N., Edriss, A., Jumbe, C., & Masuku, M. (2016). Households' willingness to pay for improved water services: A case of semi-urban households in the Lubombo and lowveld regions of Swaziland. *Journal of Economics and Sustainable Development*, *7*(3).

DWOA (Dugda Woreda Office of Agriculture). (2020). *Baseline data of agricultural activity and annual socio-economic report, unpublished document*. DWOA.

DWWREO (Dugda Woreda Water Resource and Energy Office). (2020). *Baseline data of Dugda woreda rural water supply access coverage, unpublished document*. DWWREO.

Eludoyin, A. O., & Olanrewaju, O. E. (2021). Water supply and quality in sub-Saharan Africa. *Clean water and sanitation. Encyclopedia of the UN sustainable development goals*. Springer. https://doi.org/10.1007/978-3-319-70061-8_166-1

Entele, R., & Lee, J. (2019). Estimation of household willingness to pay for fluoride-free water connection in the Rift Valley Region of Ethiopia: A model study. *Groundwater for Sustainable Development*, *10*, 100329. https://doi.org/10.1016/j.gsd.2019.100329

Eridadi, H., Yoshihiko, I., Alemayehu, E., & Kiwanuka, M. (2021). Evaluation of willingness to pay toward improving water supply services in Sebeta town, Ethiopia. *Journal of Water, Sanitation and Hygiene for Development*, *11*(2), 282–294. https://doi.org/10.2166/washdev.2021.204

Evan, L., & Christian, G. (2018). *Water and sanitation measurement technologies and practices to inform the sustainable development goals*. IBRD/WB (International Bank for Reconstruction and Development/The World Bank).

FAO (Food and Agriculture Organization). (2018). *AQUASTAT country profile – Ethiopia*. Food and Agriculture Organization of the United Nations (FAO).

Flerence, P. (2019). *Rural water supply in Ethiopia, A political economy analysis*. Report. Overseas Development Institute.

Francesco, D., Irina, K., & Stefano, P. (2004). *The World Bank Group energy working notes. Willingness to pay for water and energy: An introductory guide to contingent valuation and coping cost techniques*. The World Bank.

Freeman, A. M. I. *The Measurement of Environmental and Resource Values: Theory and Methods. Resource for the Future*. Washington D.C. (1993).

Gossa, B. (2019). Examining households' willingness to pay for a reliable and sustainable urban water supply using interval regression analysis: The case of Addis Ababa. *Ethiopian Journal of Economics*, *XXVIII*(1). https://ideas.repec.org/a/ags/eeaeje/343229.html

Greene, W. H. (2002). *Econometric analysis* (5th ed.). Prentice-Hall.

Haab, T. C., & McConnell, K. E. (2003). Valuing environmental and natural resources: The econometrics of non-market valuation. *Journal of Energy Literature*, *9*, 80–80. https://books.google.com.et/books?id=akELpkNetLkC&lpg=PR1&ots=YhPxMHdkGX&lr&pg=PA1#v=onepage&q&f=false

Hanemann, W. M., John, B. L., & Barbara, J. K. (1991). Statistical efficiency of double-bounded dichotomous choice contingent valuation. *American Journal of Agricultural Economics*, *73*(4), 1255–1263. https://doi.org/10.2307/1242453

Jianjun, J., Wenyu, W., Ying, F., & Xiaomin, W. (2016). Measuring the willingness to pay for drinking water quality improvements, results of a contingent valuation survey in Songzi, China. *Journal of Water and Health*, *14*(3), 504–512. https://doi.org/10.2166/wh.2016.247

Kebede, S., & Tariku, L. (2016). Households' willingness to pay for improved water supply: Application of the contingent valuation method; Evidence from Jigjiga Town, Ethiopia. *The Romanian Economic Journal Year*, *XIX*(62). DOI: 10.5897/JDAE2014.0604

Kidu, G., & Ewnetu, Z. (2015). Households' willingness to pay for improved water service in urban areas, a case study from Nebelet town. *Ethiopia: Journal of Development and Agricultural Economics*, *7*(1), 12–19.

Lema, Z., & Beyene, F. (2012). Willingness to pay for improved rural water supply in Goro Gutu District of Eastern Ethiopia: An application of contingent valuation. *Journal of Economics and Sustainable Development*, *3*, 14.

Louviere, J., Hensher, D., & Swait, J. (2000). *Stated choice methods: Analysis and applications*. Cambridge University Press.

Mahesh, K. A., & Getu, T. D. (2018). Assessing the challenges of water supply and consumption systems of Tora town, SNNPR, Ethiopia. Ethiopian Civil Service University, Addis Ababa, Ethiopia. *IJCRT*, *6*(2). https://www.researchgate.net/publication/324727184

Mitchell, R. C., & Carson, R. T. (1989). *Using surveys to value public goods: The contingent valuation method*. Resources for the Future Press.

MoWEI (Ministry of Water, Energy and Irrigation). (2001). *The Ethiopian government water resources management policy*. Policy Document. March, 2001. http://www.uneca.org/groundwater/Ethiopian_water_policy.pdf

MoWIE (Ministry of Water, Irrigation and Energy). (2019). *The federal democratic republic of Ethiopia, second growth and transformation national plan for the water supply and sanitation sub sector (2015/16 – 2019/20)*. MoWIE.

Rahman, M., Alam, K., Karim, R., & Islam, M. (2017). Willingness to pay for improved water supply: A policy implications for future water security. *American Journal of Environmental and Resource Economics*, *2*(4), 116–122. https://doi.org/10.11648/j.ajere.20170204.11

Robert, L. H. (2002, July 28–31). *A comparison of stated and revealed preference methods for fisheries management*. Selected Paper for the American Agricultural Economics Association Annual Meeting, Long Beach, CA.

Rolfe, E. (2019). Access to water and sanitation in Sub-Saharan Africa. Review of sector reforms and investments, key findings to inform future support to sector development. Synthesis Report (Part I). GIZ, Eschborn, January 2019.

Rosen, S. (1974). Hedonic prices and implicit markets: Product differentiation in pure competition. *Journal of Political Economy*, *82*(1), 34–55. https://doi.org/10.1086/260169

Song, N. V., Huyen, V. N., Dung, L., T., P., & Thuy, N. T. (2019). Using double-bounded dichotomous choice to estimate households' WTP for improved water quality in bac Ninh Province of Vietnam. *Journal of Environmental Protection*, *10*(11), 1407–1418. https://doi.org/10.4236/jep.2019.1011083

Tenaw, D., & Assfaw, A. (2022). Households' willingness to pay for improved urban water supply in Dire Dawa city Administration: The role of socioeconomic factors and water supply-related perceptions. *Sustainable Water Resource Management*, *8*, 24. DOI:10.1007/s40899-022-00625-0

Wana, H., & Sori, O. (2020). Determinants of household willingness to pay for improved water supply in Horo Woreda, Oromia National Regional State, Western Ethiopia. *Acta Scientific Agriculture*, *4.3*(2020), 01–09.

WB (The World Bank). (2019). *The world bank report on the world development indicators (WDI)*. https://databank.worldbank.org/data/download/WDI excel.zip.

WHO/UNICEF. (2021). *(World Health Organization/United Nations International Children's Emergency Fund). Progress on household drinking water, sanitation and hygiene 2000–2020*. Five Years into the SDGs.

Wooldridge, J. M. (2018). In M. World (Ed.), Chapter 8: *Introductory econometrics: A modern approach* (7th ed; pp. pp 269-270). South-Western Cengage Learning USA.

WWAP (UNESCO World Water Assessment Program). (2019). *The United Nations world water development report 2019: Leaving no one behind*. UNESCO.

Yamane, T. (1967). *Statistics: An introductory analysis* (2nd ed.). Harper and Row Inc.