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Consumers' perception of piped water supply and their willingness to pay for improved water supply: evidence from an Eastern Indian state

Tapasi Mohanty [a] and Himanshu Sekhar Rout [b,*]

[a] School of Management, IMS Unison University, Makkawala Greens Mussoorie, Diversion Road, Dehradun, Uttarakhand 248009, India
[b] Department of Analytical and Applied Economics & RUSA Centre of Excellence in Public Policy and Governance, Utkal University, Vani Vihar, Bhubaneswar, Odisha 751 004, India
*Corresponding author. E-mail: hsrout@utkaluniversity.ac.in

TM, 0000-0002-3118-8398; HSR, 0000-0001-8445-340X

ABSTRACT

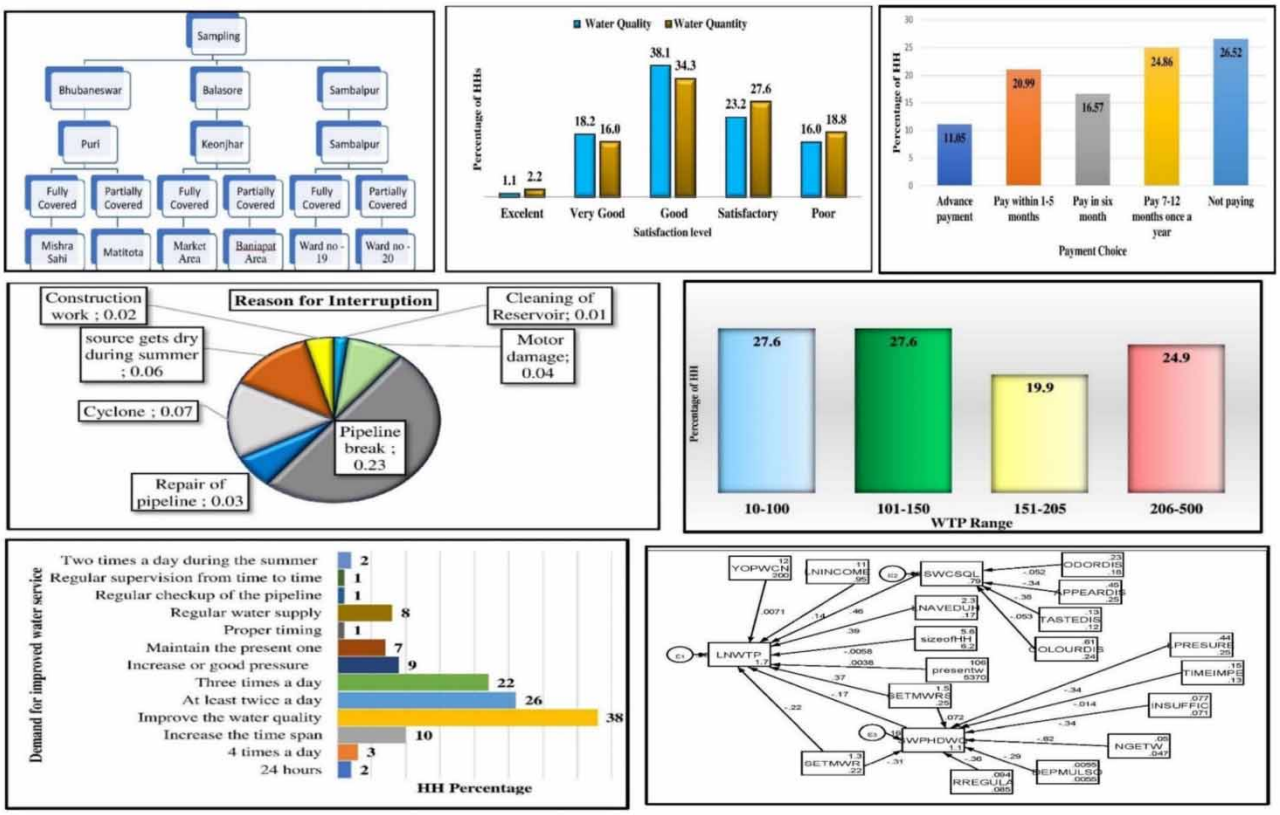
The objectives of the study are to analyse the perception of consumers on piped water supply, the consumers' willingness to pay for improved water supply, and the factors that affect it. The sample unit is the consumer household of the public health divisions. The sample size is 181. A multistage random sampling procedure was adopted to choose the sample household. Descriptive statistics and structural equation models are used to analyse the data. This study found that consumer satisfaction is influenced by water supply quantity, pressure, timing, and visual aspects. The main factors causing interruptions include pipeline breakage, cyclone impact, summer water depletion, construction work, motor damage, and reservoir cleaning. Households are not well-informed about advance payment, its benefits, and the proper procedure for obtaining a receipt. Household income, education, satisfaction with water quality, the period of the service association, supply water price, and sufficiency of water during summer directly affect consumers' willingness to pay. Discontent with appearance and taste affects quality dissatisfaction and indirectly willingness to pay.

Key words: consumers' perceptions, sustainability, urban water utilities, water quality and quantity, water tariff, willingness to pay

HIGHLIGHTS

- 83.7% of households stated that they were facing an interruption of the water service. The main factors causing interruptions include pipeline breakage, cyclone impact, summer water depletion, construction work, motor damage, and reservoir cleaning.
- Household income, education, satisfaction with water quality, supply water price, and sufficiency of water during summer directly affect consumers' willingness to pay.

GRAPHICAL ABSTRACT



INTRODUCTION

The financial sustainability of the water supply is a challenge without enough contribution from consumers. Water utilities (WUs) often struggle to generate sufficient user revenue to cover their operation and maintenance (O&M) costs fully. The reason behind this issue can be understood through an analysis of factors such as the level of water service provided to consumers, water tariffs, production, and associated costs. This study examines the issue by assessing the consumer perception of water service.

With the growing urbanisation, there is a greater demand for household (HH) water services. The people in urban slums are especially more likely to use unprotected sources and are therefore vulnerable to waterborne diseases and public health issues. Access to potable water is a basic necessity of every HH. A well-supported service model is essential for providing safe and affordable water (Ray & Smith 2021).

Drinking water service in India falls under the purview of local government. The Public Health and Engineering Division (PHED) in the urban segment is responsible for water supply to their respective urban local bodies (ULBs). The objective of the PHED is to provide safe and affordable water to its citizens in a sustainable manner. However, several challenges hinder the achievement of their purpose, including high non-revenue water (NRW), unauthorised connections, inefficiencies in the collection, high energy costs, and inconsistent services (Water Aid India 2005; Sastry 2006; Anand 2010; Tiwari & Gulati 2011; Raj 2013; Vishwakarma *et al*. 2016).

It has been found that WUs are facing a substantial number of defaulters, and arrears are more than their current revenue (Mohanty & Rout 2020). Upon examining the situation, the question arises as to why the HHs make irregular payments and often become defaulters.

The HHs as a consumer behaves differently for the water service they receive as compared to any other goods and services. In developing countries, there is a belief that it should be free. Even having significant demand the HH's willingness to pay (WTP) does not reveal its scarcity value. The consumers' payment behaviour is always been influenced by satisfaction with the service. The perceived value will always be there to indicate whether to pay more or less or not.

This gives us a curiosity to understand does the water service fulfils consumer satisfaction. What is the basic problem the HHs face with their pipe water supply? Does their perceived value have an impact on their WTP; these are some of the questions that will give a clear insight into the consumers' perception of water supply.

The objectives of the study are to analyse the consumers' perception of piped water supply, the consumers' WTP for improved water supply, and the factors that affect it.

This piece of research tries to understand consumers' perceived value for pipe water supply and how this perceived value influences WTP for improved water supply. It will help the WU manager to improve the service design and gain consumer satisfaction

The consumer's overall evaluation of utility is based on the trade-off between what they relinquish and what they obtain is the perceived value (Zeithaml 1988; Chang & Dibb 2012; Aulia *et al*. 2016). Value is subjective and has both cognitive and emotional components. Perceived value is based on the buyer's experience with the goods (Sánchez-Fernández & Iniesta-Bonillo 2007). Perceived value is a key metric in the purchase decision process; it spans three sub-dimensions: product value (the necessity of the product's function and the necessity of the enjoyment of using the product), societal value (consumer's attribute value to society), and individual worth (an individual's sense of self-satisfaction) (Aulia *et al*. 2016). The satisfaction response is influenced by value, which is in turn influenced by quality in direct and indirect ways (Morar 2013).

Services have a distinct valuation system than physical products. It takes into account the customer's prior experiences with the service and the organisation itself, as well as any aesthetic aspects of the service. Value, as perceived by the customer, is much harder to quantify than the value of a physical good (Chang & Dibb 2012).

The WUs are service industries that aim to provide potable water to their customers with adequate quantity, desirable quality, and affordable prices so that they can maintain sustainability. The customer payment for the service will now be determined by these attributes.

The HH attitudes towards water contamination, health consciousness (Pattanayak *et al.* 2006), perception about the quality of the existing water supply (Whittington *et al.* 1991; Wendimu & Bekele 2011), emphasis on safe drinking water, information about sources and risk perceptions (Sattar *et al*. 2007; Tanellari *et al*. 2015), motivational variable (Calkins *et al.* 2002), the quantity of water and pressures (Raje *et al*. 2002) has a significant influence on consumers' WTP. The WTP increases as the individual is more concerned about the possibility of water shortage (Elnagheeb & Jordan 1997). Respondents are willing to spend for improved water quality, supply reliability, tap water pressure, and water filtration systems (Ahsan *et al.* 2021).

The consumer always has a demand for reliable water supply (Shamir & Howard 1981; Griffin & Mjelde 2000; De Oca *et al.* 2003; Mmopelwa *et al*. 2005; Wendimu & Bekele 2011). The HH strategy to compensate for unreliable water supply has indirect costs in terms of storing water, travelling distances to search and fetch water, and establishing water storage tanks. The HHs are more concerned about water supply reliability as compared to improved quality (Griffin & Mjelde 2000). An uninterrupted water supply makes the HHs stress-free for collecting water and storing it and benefits, especially for women in terms of free time that they get (Mitra 2008). The maximum WTP for the consumer decreases with the increase in the number of interruptions per year (Hensher *et al.* 2005). HH WTP increases when both service reliability and water quality are improved (Vasquez *et al.* 2021).

Distance and time have a positive impact on the WTP for tap water connections (Whittington *et al.* 1991; Calkins *et al.* 2002; Minten *et al.* 2002; Mehrara *et al.* 2009). Distance from the water point and WTP are inversely related, the nearer the distance higher the WTP. The variation in WTP for water at different distances can be explained in terms of social externalities obtained by reduced time taken, energy expended, ill-health, and general opportunity costs involved in collecting water nearer and far away from home (Shisanya 2005).

The connection charge is a significant variable and holds inverse relation with WTP (Pattanayak *et al.* 2006; Adepoju & Omonona 2009; Wang *et al.* 2010; Wendimu & Bekele 2011).

The dissatisfaction with the current water situation leads to a higher WTP (Minten *et al.* 2002; Fujita *et al.* 2005).

Income of the HHs, education, size of the HHs, and age of the respondent are the most significant factors influencing the WTP for improved water supply (Minten *et al.* 2002; Roy *et al.* 2004; Mehrara *et al.* 2009; Wang *et al.* 2010; Wendimu & Bekele 2011). The education of the HHs (Whittington *et al.* 1991), and the respondent's education level are significant variables that explain WTP (Wendimu & Bekele 2011).

'An analysis of the factors determining HHs WTP for enhanced water supply services indicates that age, gender, education, income, HHs history of water-related illnesses, sanitation facility, monthly water tariffs, water connection charges, time spent fetching water round trip, walking distances to the water source, perceived water quality, adequacy of supply from main source, water source reliability, existing sources for domestic water supply and respondents' attitudes towards water management were statistically significant and acted as determinants to WTP for upgraded water supply services in Nzoia River Basin. Other factors such as marital status, HH size, HH composition, HHs receiving remittance, occupation, HHs location, keeping livestock, kitchen gardening, land tenure security, respondent's years of stay in the area, customer services from the WU and in-HHs treatment of water were statistically insignificant. The HH's WTP for enhanced water supply services is not dependent on any set of factors but rather on their joint effects and on specific cultural settings' (Odwori 2020).

If government agencies increase public supply to satisfy the impoverished, human welfare can improve. By improving public supply to a satisfactory level, government agencies can create a tariff policy based on HHs WTP, which would improve accountability and social welfare of low-income HHs because willing HHs could benefit greatly from the improved supply (Venkatachalam 2015).

The literature reveals that the WTP of a consumer is influenced by the perception of the service they are receiving, the demographic characteristics of the HHs, and the price paid for it.

The review explains that there are factors grouped as HH perceived value, demographic features, and water tariff are the factors that are affecting the WTP of the HHs. The perceived value of the consumer is subjective and contextual. This study tries to understand the perceived value of piped water supply among urban HH consumers. The focus of the study is to find out whether the HH has a demand for improved water supply. How do different factors directly and indirectly have a joint effect on the consumers' WTP? In this context the objectives of the study are to analyse the consumers' perception of piped water supply, the consumers' WTP for improved water supply, and the factors that affect it.

METHODOLOGY

Data

The sample unit is urban consumer HHs, of the Public Health Division (PHD) and the sample size is 181. A multistage stratified random sampling procedure was used to choose the sample HHs. The sampling method is given in Figure 1.

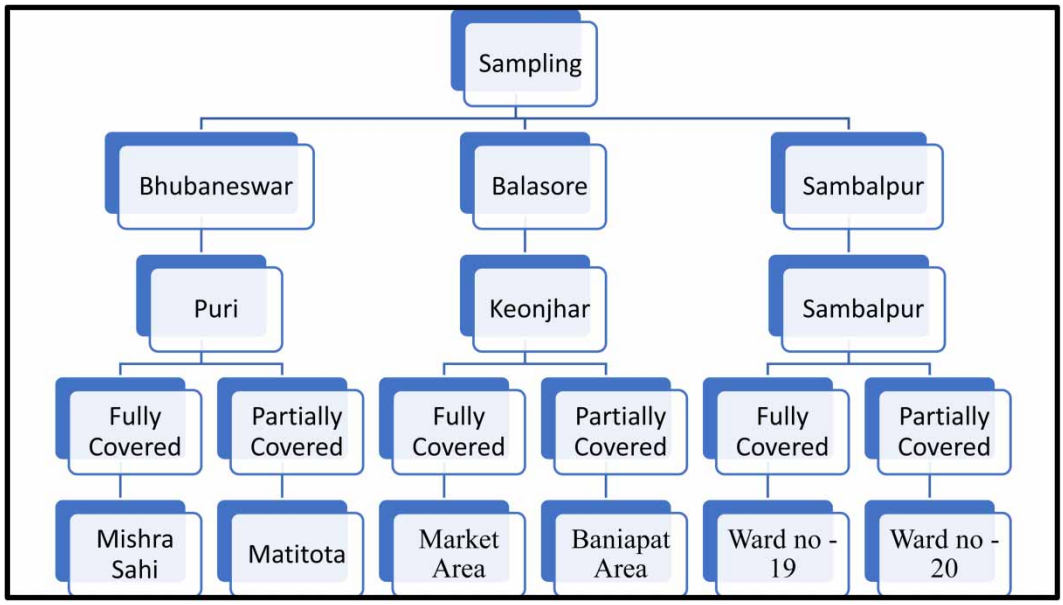


Figure 1 | Sampling. *Source*: Compiled by authors.

A total of 112 ULBs of Odisha consist of 19 PHDs that are under the control of six circles. A random sampling without replacement method was administered to choose three circles, three PHD, and three ULBs, respectively.

The ULB consists of three distinct areas that are classified as fully covered, partially covered, and uncovered. These categorisations are made based on the extent of pipeline coverage within each area. The study focused on areas with pipe water connections, specifically those under full and partial coverage. The uncovered area, where there is no access to piped water connections, was excluded from the study. One fully covered and one partially covered areas were randomly selected from the list. The consumer list for the sampled area was obtained from the respective PHD offices. For the survey, 30 HHs were randomly selected in each area. In Keonjhar, an HH was identified where the connection was linked to the father's name. Two brothers residing in the same HH were utilising the same connection and paying separately. Consequently, these two brothers were treated as distinct HHs in our analysis. The survey included a sample of 181 urban HHs from three ULBs, namely Keonjhar (61 HHs), Puri (60 HHs), and Sambalpur (60 HHs).

Variables

The description about variables used in this study are described in Table 1.

METHODS

Descriptive statistics is used to analyse the data. Structural equation modelling (SEM) is used to identify the direct, indirect, and total effects of factors affecting WTP for improved water supply.

The simultaneous equations used in the study are:

$$\text{WTP} = f(\text{YOPWCN}, \text{SWPHDWQ}, \text{SWCSQL}, \text{LNAVEDU}, \text{LNINCOME}, \text{SETMWR}, \text{SETMWRS}, \text{SIZE OF HHs}, \text{PRESENTW})$$

$$\text{SWPHDWQ} = f(\text{SETMWR}, \text{SETMWRS}, \text{IRREGULA}, \text{DEPMULSO}, \text{NGETW}, \text{INSUFFIC}, \text{TIMEIMPE}, \text{LPRESURE})$$

$$\text{SWCSQL} = f(\text{TASTEDIS}, \text{COLOURDIS}, \text{ODORDIS}, \text{APPEARDIS})$$

RESULT AND DISCUSSION

The consumers' perception of piped water supply

Water usages

Different indoor water sources used by urban HH are wells, tube wells, bore wells, and pipe water connections. 97% of HHs utilise indoor water sources to fulfil their entire household water need. A total of 48.8% of HHs use pipe water for their entire HH work, 74.6% for drinking, 70.2% for cooking, and 65% for both.

Urban HHs rely on various outdoor water sources which include community tube wells and ponds, wells, and tube wells of neighbours. The HHs use outdoor water sources for drinking, cooking, bathing, and washing, as well as all other uses as per their requirement. Only 2.8% of HH use stand pumps for their drinking purpose. The HHs also rely on outdoor water sources for their entire HH requirement when faced with intermittent pipe water supply.

This study explains that while consumers rely on PHD water as their primary water source, they also utilise multiple sources for their diverse water needs.

Consumer perception of water quality and quantity

Satisfaction and dissatisfaction with both the water quality and quantity and their reasons as stated by HH are presented in Table 2.

Table 2 shows that a total of 57.30 and 55.06% of HHs are satisfied with water quantity and quality, respectively. Adequate pressure and sufficiency of supply water, are the two common reasons for HH's satisfaction with water quantity. The other reasons for HHs' contentment for quantity include the perfect timing of the water supply, a supply quantity that is reasonable for the HHs, and the absence of any alternative water source. Clearwater is the most common reason for quality satisfaction among the urban HHs. Directly drinkable, with no problem related to taste counted as the highest reason for quality satisfaction.

Low pressure is considered to be the most prevalent cause of quantity dissatisfaction among urban HHs. Other reasons for quantity dissatisfaction are inconvenient supply timing, irregularity of supply, insufficiency, not having

Table 1 | Description of variables

Variables	Description of variables	Abbreviations used	Description
	The period of the service association with PHD	YOPWCN	
	Average year of schooling of HH	LNAVEDU	
	Amount of total income of HH	LNINCOME	
	Number of people residing in an HH	SIZE OF HHs	
	Per month water charge that the HH is paying	PRESENTW	
Water usage	HHs water sources		
	HHs water usages		
Consumer perception of water quality	PHD water quality satisfaction	SWCSQL	Yes-1 No-0
	Dissatisfaction with taste	TASTEDIS	Yes-1 No-0
	Dissatisfaction with colour	COLOURDIS	Yes-1 No-0
	Dissatisfaction with odour	ORDORDIS	Yes-1 No-0
	Dissatisfaction with appearance	APPEARDIS	Yes-1 No-0
	Satisfaction and dissatisfaction with the pipe water and their reason		
	Rating of satisfaction		1. Excellent 2. Very Good, 3. Good, 4. Satisfactory 5. Poor
Consumer perception of water quantity	PHD water quantity satisfaction	SWPHDWQ	Yes-1 No-0
	Sufficiency of water throughout the year	SETMWR	Yes-1 No-0
	Sufficiency of water during summer	SETMWRS	Yes-1 No-0
	Satisfaction and dissatisfaction with the pipe water and their reason		
	Rating of satisfaction		
			1. Excellent 2. Very Good, 3. Good, 4. Satisfactory 5. Poor
Water service satisfaction	Satisfied with the water service		Yes-1 No-0
	Breakdown of water supply		Yes-1 No-0
	Irregularity in supply	IRREGULA	Yes-1 No-0
	Dependent upon multiple sources for the family water requirement	DEPMULSO	Yes-1 No-0
	Not setting water for long	NGETW	Yes-1 No-0
	Insufficient quantity as compared to their requirement	INSUFFIC	Yes-1 No-0
	Unsuitable timing	TIMEIMPE	Yes-1 No-0
	Low pressure	LPRESURE	Yes-1 No-0
	Number of days facing interrupted water supply		
	Reason for supply interruption		
	Complain to the authority		
	Response to the complaint		

(*Continued.*)

Table 1 | Continued

Variables	Description of variables	Abbreviations used	Description
HHs demand	Improved water service		
	Amount willingness to pay for improved water supply	WTP	
	HHs payment behaviour		

Source: Compiled by author.

Table 2 | HHs satisfaction with water quantity and quality (in percentage)

		Satisfaction with water quantity		
		Yes	No	Total
Satisfaction with water quality	Yes	42.69	12.35	55.06
	No	14.60	42.69	44.94
		57.30	42.70	100
Quantity				
Satisfaction reasons	HHs	Dissatisfaction reasons		HHs
Good pressure with sufficient quantity	27	Low pressure		44
The timing is perfect, sufficient for our family	6	Supply timing is not convenient		15
Sufficient for our family,	19	Not sufficient for our family		8
As there is no alternative	10	We have not received water for a long		5
Good quantity	2	We have to depend on multiple sources		1
Regular water supply	3	Irregular supply		8
Manageable for us	1	Timing is not proper (no time HHs get water and duration of supply)		1
Comparatively better than before	1	Scarce during summer		6
Quality				
Satisfaction	HHs	Dissatisfaction		HHs
Clearwater	40	Unclear water		17
Directly drinkable	8	Muddy water during the rainy season		33
It is better than our present source	1	Muddy water most of the time		23
No problem related to taste	3	Red colour water		14
No problem related to smell	1	Foul smell sometimes		7
No problem related to colour/appearance	1	Bleaching smell		10
Good for cooking	2	Found muddy clay after storing		4
Manageable quality	1	Iron water		2
Hygienic	1	Acidic taste		4
		Not good for cooking		1
		Dusty water		1

Sources: Compiled by author.

water for a long time, being dependent on multiple sources, and improper timing (in terms of both the frequency and duration of the HHs' access to water). Findings show that 33.1% of HHs have trouble obtaining water all year round, and that number rises to 54.1% in the summer. The difficulty has persisted for 3 months for 19.3% of HHs.

The primary cause of quality discontent among urban HHs is the presence of muddy water, particularly during the rainy season. Common complaints from urban HHs about their water supply quality include muddiness, redness, occasional unpleasant smell, and a bleaching odour or taste. Out of all the HHs surveyed, 61.33% are dissatisfied with the colour, 44.75% with the appearance, 23.20% with the smell, and 13.16% with the taste.

In analysing the dissatisfaction regarding quality and quantity, it is observed that a higher percentage of HHs express dissatisfaction with the quality of water supply compared to the quantity of water supplied.

The overall picture of satisfaction and dissatisfaction of HHs on their pipe water supply quantity reveals that water supply pressure and timing are the main parameters of satisfaction and dissatisfaction. Appearance, taste, and odour are the main parameters of quality satisfaction and dissatisfaction. The satisfaction of HHs is influenced by the improvement in the parameter, while a poor parameter results in consumer dissatisfaction.

The satisfaction rating of the HH with piped water quality and quantity are presented in Figure 2.

Figure 2 shows that the majority of the HHs' satisfaction with quality and quantity was rated as good. A majority of the HHs' satisfaction levels lie within the range of good, satisfactory, and poor.

Perception of water service

A total of 56.7% of urban HHs are dissatisfied with the water service. The HHs are asked whether they have made any complaints to their respective water supply authority regarding their difficulty with the service. 60.8% of the urban HHs stated that they never complained to the PHD about any of the difficulties. The maximum number of HHs in Keonjhar has complained to PHD in comparison to Puri and Sambalpur.

83.7% of HHs conveyed that they were facing an interruption of the service in the last year, and only 16.3% of the HHs conveyed they did not face any interruption in the last year. Figure 3, explains the number of days concerning last year the HH had to face supply interruption. Figure 4 explains the HH's stated reasons for these interruptions.

Figure 3 shows that the majority of the HHs are facing supply interruption between1 and 5 days, more than 1 month and 6–10 days are the subsequent highest period within which the HH face supply interruption. Pipeline breaks and cyclones are major two reasons for supply interruption.

Various factors contributing to the water supply interruption are pipeline breakage, pipeline repairing, cyclone impact, water source depletion during summer, ongoing construction work, motor damage, and reservoir cleaning.

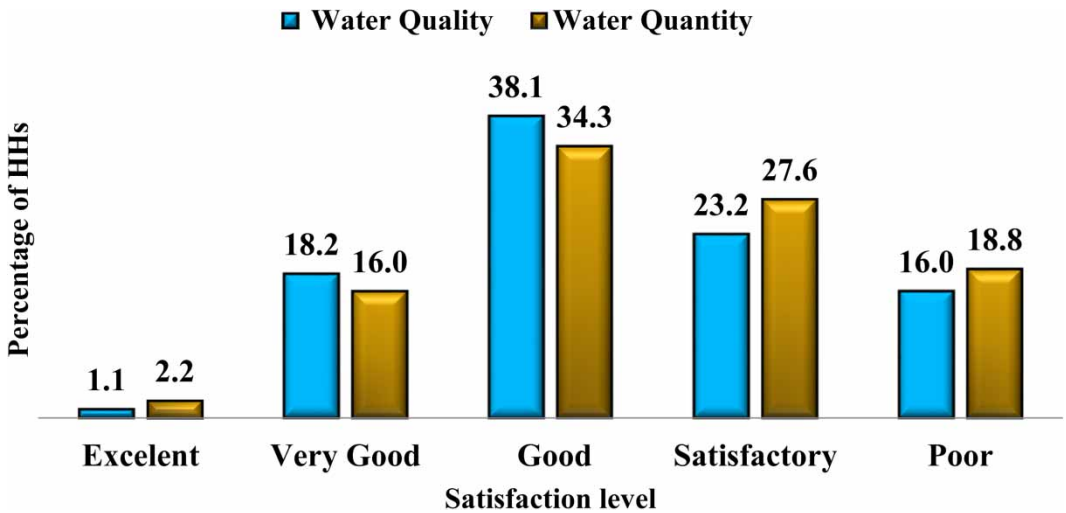


Figure 2 | Water quality and quantity satisfaction (in percentage). *Source*: Compiled by authors.

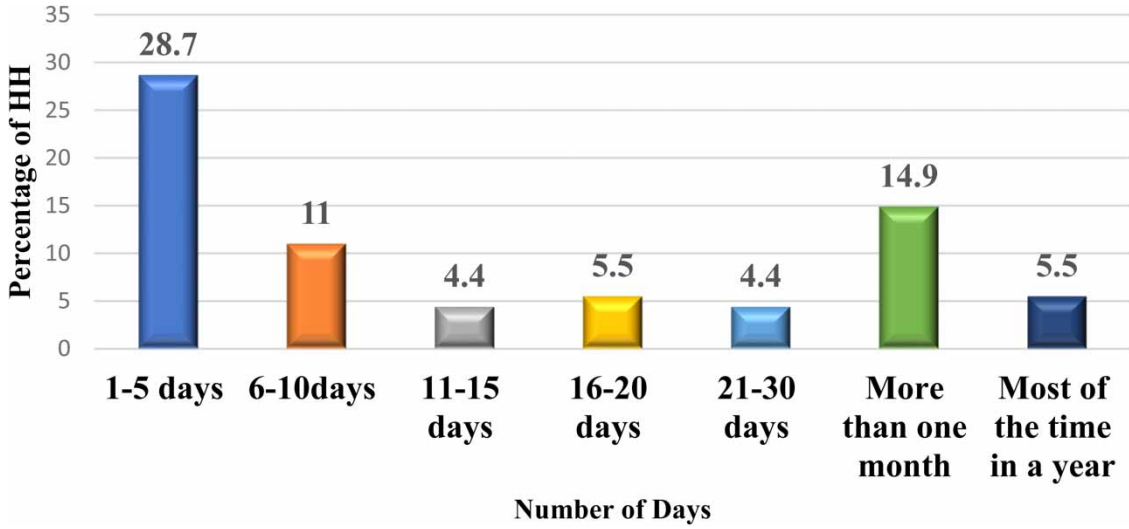


Figure 3 | Number of days the HH faced interrupted water supply in 1 year (in percentage). *Source*: Compiled by authors.

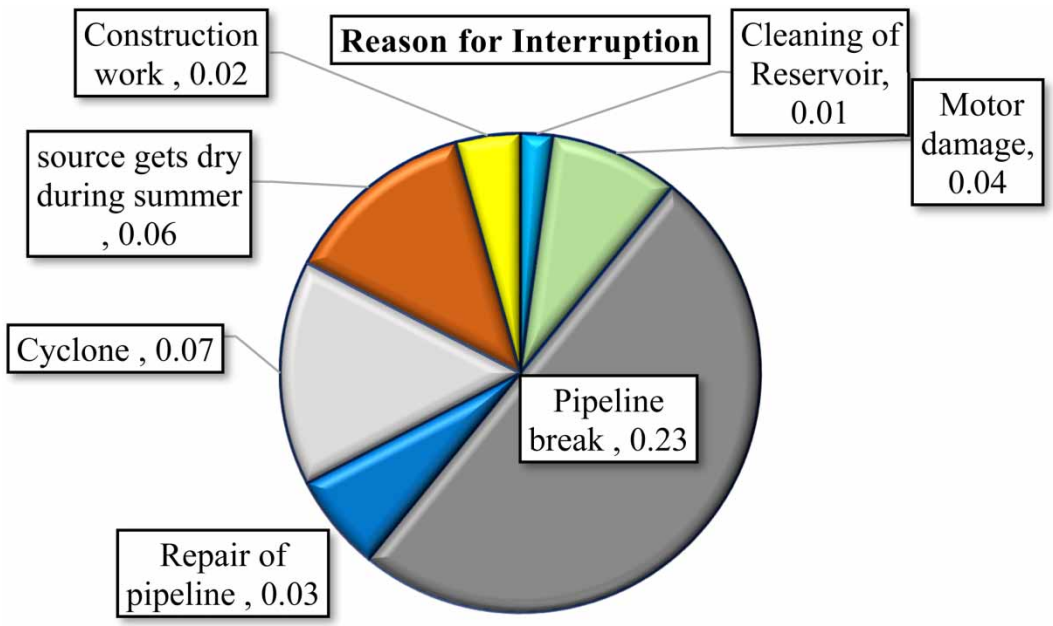


Figure 4 | Reasons stated by the HH for their water supply interruption (in percentage). *Source*: Compiled by authors.

The distribution mains are typically routed along major roadways. The frequent damage to the pipeline can be attributed to the continuous passage of heavy vehicles on the road. The presence of unpaved roads within the residential colony has resulted in the vulnerability of the pipeline to damage. Consequently, the water supply to the HH is impacted. Odisha, a coastal state, is susceptible to cyclones and floods due to its geographical location. The water supply is being impacted due to the ongoing power supply issue during cyclones and floods.

HHs demand improved water service

The HH in the study expressed various preferences regarding improved water supply. Figure 5 illustrates the service preference of the HHs for the improved water supply.

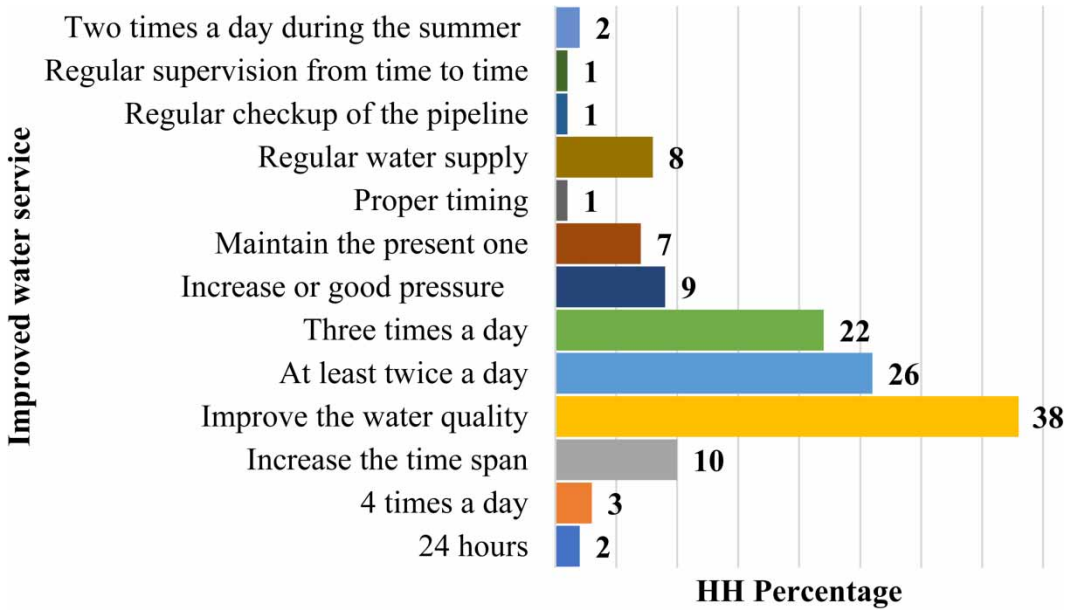


Figure 5 | Responses of the HHs on improved water service (in percentage). *Source*: Compiled by authors.

Figure 5 shows that the most frequently stated water service by urban HHs is improved water quality. The HH preference for improved water supply is linked to improvement in quality, quantity, timing, and maintenance.

HHs payment choice

The average monthly water bill for a household is Rs. 106. The payment amount made by HHs can vary based on several factors. These factors include the economic category of the HHs, the duration of consumer status, the capacity of their reservoirs, and the number of taps directly connected to the pipeline.

The HHs are asked when they pay their water bills and why. Figure 6 displays the selection of payment methods within HHs.

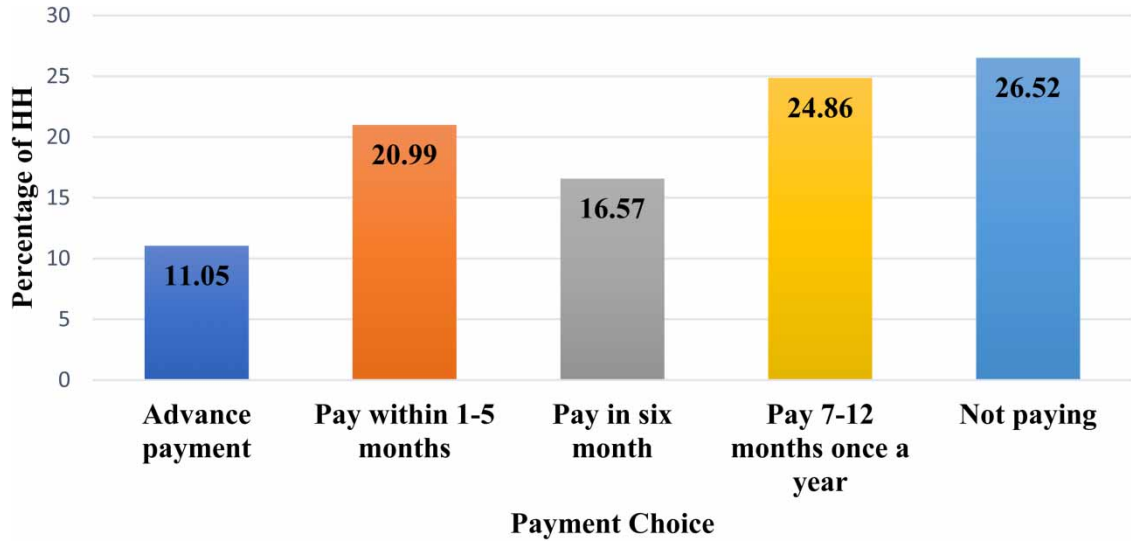


Figure 6 | Responses of the HHs on improved water service (in percentage). *Source*: Compiled by authors.

Figure 6 shows that the largest proportion of HHs (26.52%) are in the 'not paying' group. Pay within 7–12 months, or once a year, is the second-highest payment choice. At the very least, 11.05% of HH make an advance payment. The stated reasons for their respective payment choice are given as follows:

Reasons for payment choice	
Advance payment	Convenience
Pay within 1–5 months	Convenience Low price easy to clear the bill
Pay in 6 months	Convenience The house is far from the office, therefore convenient to pay at a time Poor economic condition PHD person comes once in a year, and we pay at that time All community members are paying in this way We get billed once a year We are not getting water
Pay 7–12 months once a year	Convenience to pay at a time It is convenient to pay such less amount at a time We are not receiving the water bill, therefore we pay at our convenience Convenient to pay at a time but we did not know about advance payment
Not paying	Water quality is not good No one come for the last year to collect the water bill

Convenience to pay is the most frequently mentioned reason given by urban HHs for any type of payment. The HH feels it is convenient for several reasons, including too small amount, better to pay at one time, to far distance between houses and PHD office. The HH chose the period as per their convenience while not receiving the water bill. The payment frequency is also influenced by the poor economic conditions of the HH. When the HH makes an advance payment, they will get a five percent rebate on their payment but if they make a delay, they have to pay a fine. Some of the HHs stated that they were unaware of the advance payment benefit.

There is a lack of awareness among HHs regarding the concept of advance payment and its associated benefits as well as the proper procedure for obtaining a receipt.

Water quality is not good, and no one came for the last year to collect water bills is the stated reason among urban HH for not paying water tariffs.

WTP for improved water supply

The HHs are asked about their WTP for improved pipe water supply (improved quantity, quality, timing, and uninterrupted supply). The mean WTP for it is Rs. 165 while its median is Rs. 150.

Figure 7 illustrates the quantile WTP level of HHs. It shows that the highest percentage of HHs lies within the WTP range of Rs. 10–100 and Rs. 101–150.

One HH belonging to the below poverty line (BPL) category wants to pay less, i.e., Rs. 10 as compared to his present water price of Rs. 50 and it is because of his poor economic condition.

The HH water tariff was not uniform for all HHs. The variation depends on the duration of the service association, the number of tap connections, and the dimensions of the water reservoir. Water rates are subject to a yearly rise of 5% from the previously established rates.

New connections are subject to periodic rate revisions following the order. The prevailing water rates for new connections in Puri, Keonjhar, and Sambalpur were Rs. 115, Rs. 95, and Rs. 135, respectively. The actual monthly water price range of the HHs, as well as the proportion of HHs that fell within that range, are listed as follows.

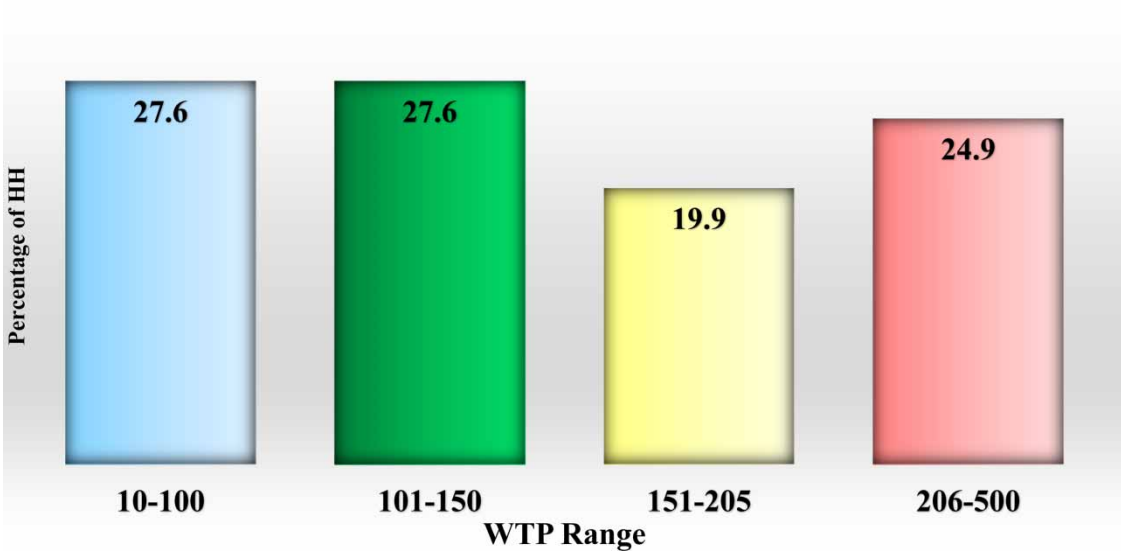


Figure 7 | Average WTP range among HHs (in percentage). *Source*: Compiled by authors.

Price range (Rs.)	HHs percentage
30–100	41.44
101–150	31.49
151–205	14.36
206–250	12.71

This shows that the majority of the HHs' actual monthly water price lies within the range of Rs. 30–100 and Rs. 101–150.

Factors determining WTP

WTP for improved water supply depends on numerous factors directly and indirectly. But how do these factors interact with each other? There can be several factors that have a direct effect on WTP but some of the factors may indirectly affect the WTP. Therefore, to understand the factors affecting the HHs WTP, the SEM is used, which explains that the total effect is a combination of direct and indirect effects.

The direct effect model for factors influencing WTP for improved water supply is

$$\text{LNWTP} = f(\text{SWCSQL, SWPHDWQ, YOPWCN, LNINCOME, LNAVEDUH, size of HHs, presentw, SETMWR, SETMWRS}) \quad (1)$$

Satisfaction with water quality must be determined by the dissatisfaction with the taste, colour, odour, and appearance of the supply water.

$$\text{SWCSQL} = f(\text{TASTEDIS, COLOURDIS, ODORDIS, APPEARDIS}) \quad (2)$$

All these variables indirectly affect the WTP of the HHs through water quality satisfaction.

Satisfaction of water quantity must be determined by the sufficiency of water throughout the year and during the summer, low pressure, an imperfection in supply timing, insufficiency of water for the HHs, the HHs not getting water for long,

dependency on multiple sources, and irregularity of supply.

$$\text{LNWTP} = f(\text{SETMWR, SETMWRS, LPRESURE, TIMEIMPE, INSUFFIC, NGETW, DEPMULSO, IRREGULA}) \quad (3)$$

All these variables indirectly affect the WTP for improved water supply through water quantity satisfaction. The path diagram of our model is presented in Figure 8.

Figure 8 depicts the path diagram for factors affecting WTP. YOPWCN, LNAVEDUH, LNINCOME, SETMWR, and SIZE OF HHs, directly affect LNWTP. The variables like SETMWR, SETMWRS, IRREGULA, DEPMULSO, NGETW, INSUFFIC, TIMEIMPE, and LPRESURE have a direct effect on RATEPHDWTQTY and indirectly affect LNWTP. The variables like TASTEDIS, COLOURDIS, ODOURDIS, and APPEARDIS directly affect RPRWQLT and the LNWTP.

The decomposition of the total effect into direct and indirect effects is presented in Table 3.

From Table 3 SWCSQL, YOPWCN, LNINCOME, LNAVEDUH, presentw, and SETMWRS are significant factors that directly affect consumers' WTP. TASTEDIS and APPEARDIS are the two factors that significantly affect consumers' WTP. All these factors appear to be significant in the total effect. From the literature, we found that education and income were the significant determinants of WTP. This study also confirms the same finding. The present water price is a significant determinant of WTP, which is similar to the findings by Adepoju & Omonona (2009) and Wang *et al.* (2010), which explains current water price is significant. It holds an inverse relation with WTP when the current water price is high. The water price for the BPL HHs is Rs. 50 per month, whereas other HH consumers pay more than Rs. 100 per month. The WTP increases by 0.0038043 with a one percent rise in the present water price. 'Many organizations and governments have suggested different thresholds to classify WSS services as affordable, such as 3–5% by the World Bank, 5% by Asian Development Bank, 2.5% by the United States Environmental Protection Agency, and 3% by OECD' (Fagundes *et al*. 2023). This study found that the contribution of the HHs to WTP is an average of 0.6% of their income. Only one HH who belongs to a BPL economic category is willing to contribute 5% of income for improved water supply. The present water price is very low and affordable because it is less than 2% income of the HHs.

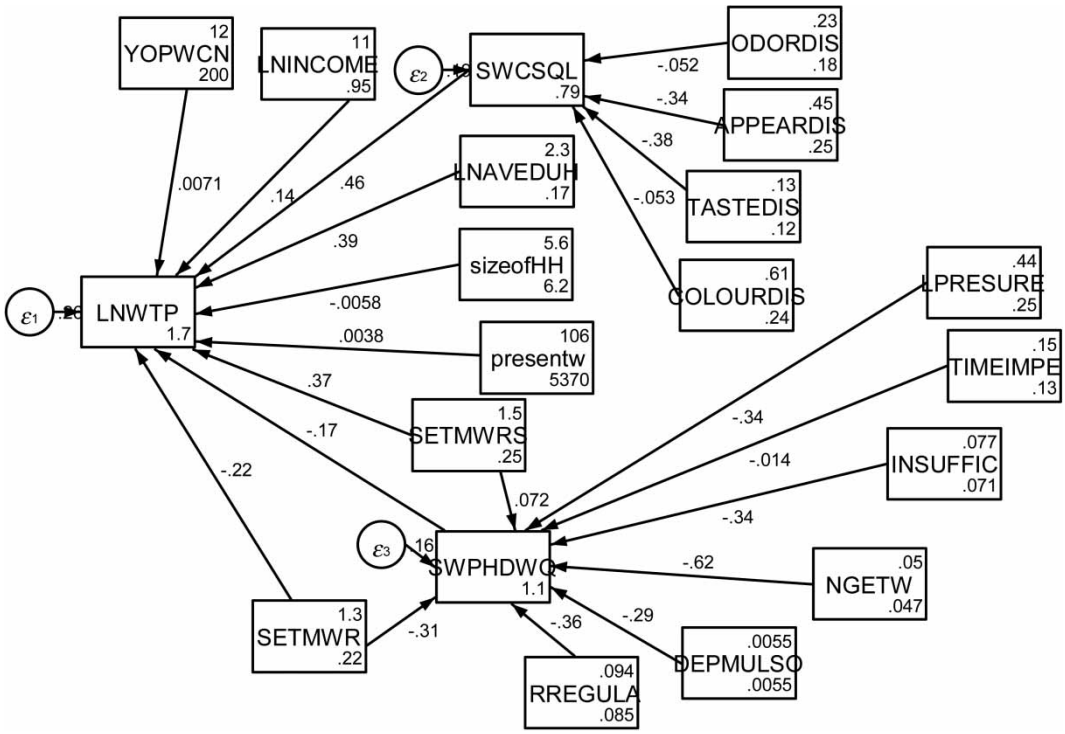


Figure 8 | The path diagram for factors affecting WTP for improved water supply. *Source*: Compiled by authors.

Table 3 | Decomposition of total effect into direct and indirect effects

DEPENDENT	CONSTANT	VAR	
LNWTP	1.658143	0.255566	
SWCSQL	0.7889468	0.187755	
SWPHDWQ	1.111215	0.159253	
LR test of model vs. saturated	152.48*		
INDEPENDENT	**DIRECT**	**INDIRECT**	**TOTAL**
SWCSQL	0.4623068*	0	0.4623068*
SWPHDWQ	−0.1688313	0	−0.1688313
YOPWCN	0.0071062**	0	0.0071062**
LNINCOME	0.1375444*	0	0.1375444*
LNAVEDUH	0.3877218*	0	0.3877218*
Size of HHs	−0.0058467	0	−0.0058467
Present	0.0038043*	0	0.0038043*
SETMWR	−0.2176521	0.052286	−0.1653658
SETMWRS	0.3672762*	−0.01216	0.3551131*
TASTEDIS	0	−0.17788*	−0.1778805*
COLOURDIS	0	−0.02432	−0.0243172
ODOURDIS	0	−0.02423	−0.0242252
APPEARDIS	0	−0.1571*	−0.1571018*
LPRESURE	0	0.05756	0.0575597
TIMEIMPE	0	0.002382	0.0023823
INSUFFIC	0	0.057617	0.0576168
NGETW	0	0.104965	0.104965
DEPMULSO	0	0.049745	0.049745
IRREGULA	0	0.061556	0.0615558
SWCSQL			
TASTEDIS	−0.3847672*	0	−0.3847672*
COLOURDIS	−0.0525997	0	−0.0525997
ODOURDIS	−0.0524008	0	−0.0524008
APPEARDIS	−0.3398216*	0	−0.3398216*
SWPHDWQ			
SETMWR	−0.3096951*	0	−0.3096951*
SETMWRS	0.0720434	0	0.0720434
LPRESURE	−0.3409302*	0	−0.3409302*
TIMEIMPE	−0.0141105	0	−0.0141105
INSUFFIC	−0.3412682*	0	−0.3412682*
NGETW	−0.6217154*	0	−0.6217154*
DEPMULSO	−0.2946432	0	−0.2946432
IRREGULA	−0.3645994*	0	−0.3645994*

Source: Compiled by author. *Significance at one percent level, ** Significance at five percent level.

TASTEDIS and APPEARDIS are the two factors found as significant for SWCSQL with a negative sign. The probability of satisfaction is low with the increase in dissatisfaction with the taste and appearance of the supply water, which states that people put an aesthetic value on the water supply. SWCSQL is a significant factor with a positive sign, which implies that the WTP for improved water supply is high when the HHs are satisfied with water quality. The study by Dietrich (2006)

and Lanz & Provins (2016) explains that the sensory properties of water have been identified as a significant factor that drinking WUs often encounter. These properties, including tastes, odours, and particulates, are frequently noticed by consumers and are the primary cause of complaints received by these utilities. In examining the various aspects of tap water aesthetic quality, it is worth noting that stated preference studies have indicated a greater emphasis on the taste and smell of tap water compared to its appearance. The findings by Sköld *et al.* (2022) suggested that it is significant for water providers to take into account not only health-related indicators when assessing treatment alternatives or monitoring the quality of drinking water but also to consider the visual appeal of the drinking water.

SETMWR, LPRESURE, INSUFFIC, NGETW, and IRREGULA are the significant factors affecting the SWPHDWQ. The HHs are satisfied with the supplied water quantity when they are getting a sufficient amount of water throughout the year. The probability of satisfaction is low when the HHs state the amount of supply water, they are getting sufficient for their family. Because the majority of them stated that during summer they face a little bit of difficulty but they manage with the amount they have with them. The probability of quantity satisfaction is low when the HHs get a supply of water of low pressure, insufficient quantity as compared to their requirement, not getting water for a long time, and irregularity in supply.

The reliability of water supply is significantly impacted by various factors, including the frequent breakdown of borehole engines, outdated equipment and machinery utilised for water reticulation, pipe bursts, and power cut-offs. These issues pose significant challenges to maintaining a consistent and dependable water supply system (Mmopelwa *et al.* 2005).

However, satisfaction with water quantity is found as an insignificant factor affecting WTP for improved water supply. The result shows that when the HHs are satisfied with the supply of water quantity, they want to pay less for improved water supply.

CONCLUSION

The objectives of the study are to analyse the consumers' perception of piped water supply, the consumers' WTP for improved water supply, and the factors that affect it.

The analysis of HHs' satisfaction and dissatisfaction with the quantity of pipe water supply indicates that the primary factors influencing the perception of consumers are quantity, pressure, and timing of water supply. To gain insight into the perception of supply water quality, this study employed the aesthetic value of water as a criterion for judgment. The visual aspect of water predominantly influences the satisfaction of HHs. Clearwater has emerged as a prominent factor contributing to overall customer satisfaction and turbid water contributes to dissatisfaction with supply water quality. This study suggests that the WU needs to improve adequacy, pressure, timing, appearance, taste, and odour to gain consumer satisfaction.

Pipeline breakage and cyclones are two major reasons for supply interruption. Minimising the interruption of the water supply can be achieved through the implementation of preventive measures for the strategic placement of distribution lines and the timely maintenance of the pipeline.

A significant proportion of HHs lack awareness regarding the various service facilities offered by the PHD. Therefore, it is crucial to create awareness among the HHs regarding the provision of water supply and its services.

A significant proportion of HHs express a strong desire for improved water quality followed by improved timing, adequate pressure, and consistent water supply. Additionally, there is a prevailing preference among HHs for the maintenance of the existing water supply infrastructure, including regular inspections of pipelines and diligent supervision to ensure optimal water provision. The average (median) WTP for improved pipe water supply (improved quantity, quality, timing, uninterrupted) is Rs. 150 per month. The average monthly water price is Rs. 106, on average, the HHs WTP an additional amount of Rs. 44 for improved water supply.

Household income, education, current water tariff, and duration of service association are the significant factors found to be directly proportional to the HH's WTP. Satisfaction with supply water quantity is found as insignificant, but sufficiency during summer is found a statistically significant factor affecting WTP. Better service priority for persistent customers, as well as sufficient water during the summer, are crucial for winning customers' trust and, in turn, increasing their WTP.

Sufficiency of water during summer, low pressure, insufficient quantity, not getting water for long, and irregularity of supply are the statistically significant factors affecting the satisfaction with supply water quantity. However, all of these factors have a statistically insignificant relation with WTP. Dissatisfaction with appearance and taste is a significant factor affecting quality dissatisfaction and these are significant factors that have an indirect and joint effect on WTP. Consequently, it is imperative to address these parameters to enhance consumer satisfaction with supply water quality.

DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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