Research Article Journal homepage: https://so05.tci-thaijo.org/index.php/MFUconnexion

CONNEXION
Journal of Humanities and Social Sciences

Vol. 13 No. 1, Article ID: 267918. doi: 10.14456/connexion.2024.3

Received: September 16, 2023
Revised: April 25, 2024
Accepted: April 26, 2024
Published: May 27, 2024

Economic Valuation of Canals and Tributaries' Water Quality Improvement in Bangkok

Muhammadmunit Phimpraphan[1*], Udomsak Seenprachawong[1]

[1] School of Development Economics, National Institute of Development Administration (NIDA)

[*] Corresponding author e-mail: munit@hotmail.com

Abstract

This study aimed to analyze and estimate willingness to pay (WTP) and its determinants for the waterway quality improvement by using the samples in five districts of the Bangkok area and also to approximate the economic value of such a program. It is also meant to gauge individuals' WTP for two scales of area development with three waterway improvement levels divided into six scenarios. Scenarios I, II, and III represent levels 1 (slightly), 2 (significantly), and 3 (completely) of improvement for only the nearest canal. Scenarios IV, V, and VI represent levels 1, 2, and 3 of improvement for all canals in the Bangkok area. The Contingent Valuation Method (CVM) has been deployed to value the proposed scenarios. The data set used in the econometric analysis consists of 626 responses for Single-Bounded Dichotomous Choice (SBDC) and Double-Bounded Dichotomous Choice (DBDC) elicitation formats. As a result, the individuals' socioeconomic characteristics, which significantly affect the WTP, comprise awareness of the waterways' quality problems, education, and age. The WTP values in scenarios I to VI, estimated with the SBDC model, are approximately 71.05, 71.51, 121.31, 73.43, 125.45, and 198.05 baht per month per household. However, such values, estimated with the DBDC model, are approximately 75.91, 96.93, 145.39, 111.78, 153.54, and 198.29 baht per month per household. The DBDC model gave a smaller variance of estimated WTP and complied more with the scope test. The total economic value of the improvement program estimated from the individuals' WTP is approximately 1,093.11 Million baht annually.

Keywords: Contingent Valuation Method (CVM), Single-Bounded Dichotomous Choice (SBDC), Double-Bounded Dichotomous Choice (DBDC), Willingness to pay, Waterway quality

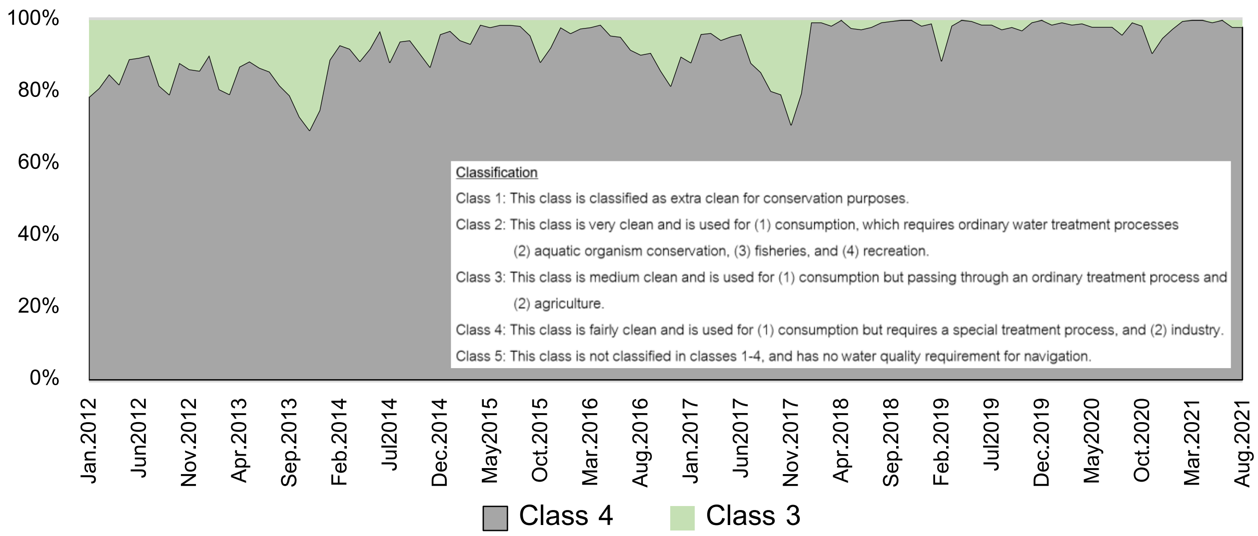
Introduction

According to the World Bank (2020), 80% of global wastewater streams were once released into the ecosystem without being treated or reused. The volume of generated wastewater and its pollution load is increasing globally because of a growing population, urbanization, and economic activities. In developing countries, several cities have been releasing massive volumes of wastewater directly into the surface water without any appropriate treatment.

Bangkok, the largest city in Thailand with a population of over 5.49 million (in the year 2022), is dealing with extreme water pollution from untreated wastewater released into waterways. The Bangkok Metropolitan Administration (BMA), subdivided into 50 administrative districts, has prepared the master plan for wastewater management in all areas up to 2040, including the development of 27 wastewater treatment plants (WWTPs) in 27 zones (Japan International Cooperation Agency (JICA), 2011, pp. iii-iv).

There are many canals and their tributaries (sub-canals) in Bangkok. The data from the Drainage and Sewerage Department (DSD), BMA (2021), reveals that 1,161 canals and 521 tributaries are located in the Bangkok area with a total length of 2,604 km. The changes in water quality in any waterway will unavoidably affect economic activities and people's lives. Okadera et al. (2020, pp. 73-74) studied water quality in the Bangkok area in 2015 and found that the water quality of some waterways has not been treated satisfactorily.

According to the DSD, BMA (2021), the statistical data of the canals' water quality in the Bangkok area, which has been monthly measured from January 2012 to August 2021, is presented in Figure 1. The water quality from 257–318 measuring stations revealed that there was no class 1 or class 2 water quality from any measuring stations. That meant there were no canals that could be used for consumption. The figure shows that the water quality in all canals could reach only class 3 and class 4. Besides, the portion of water quality in class 3 tended to decrease continuously. For instance, in the first quarter of 2021, all measuring stations reported the water quality of class 4.



Source Raw data from Drainage and Sewerage Department, BMA (2021), analyzed by the author

Figure 1 Water quality monitoring of waterways in Bangkok (2012-2021)

According to sanitary engineering, implementing wastewater treatment covering all the Bangkok areas can solve the problems. In economics, the questions always asked are how much the value of such an improvement program is and whether investing in it is worthwhile. In economic theory, the value of goods commences with the individual utility that the consumer receives from the goods. The willingness to pay (WTP) can derive utility representing welfare. In the case of environmental improvement, WTP will reflect the individual utility received from the change in a particular environment. This value is necessary for the program's cost-benefit analysis (CBA).

The JICA (2011, p. 44) described that at least four studies have investigated WTP for WWTP in the Bangkok area, which the WTPs are estimated in the range of 39.2-100.8 baht/month-house. Other studies consist of Tapvong and Kruavan (1999), and Boontanon (2014). The results show that the average wastewater treatment fee ranges between 101.45-168.90 baht/month-house (Tapvong & Kruavan, 1999, p. 17) and 39-197 baht/month-house (Boontanon, 2014, p. 18). However, all studies, except those of Tapvong and Kruavan (1999), have focused on WTP for WWTP fees. The results, therefore, may not be reliable enough to represent the WTP for water quality improvement for the canals in the entire Bangkok area due to different scenarios.

Objectives

1. To estimate the households' WTP and its determinants for the canal water quality improvement in the Bangkok area.

2. To analyze the households' WTP representing the value of water quality improvement of either the whole waterway or only a canal near their houses.

3. To estimate the economic value of canal water quality improvement.

Materials and Methodology

1. Conceptual Foundation of Willingness to Pay

The term willingness to pay (WTP) is commonly used in economic analyses. It refers to the maximum value an individual would provide to pay for something to receive benefits or avoid losses (Freeman et al., 1993, p. 8). The challenging issue is measuring and aggregating individual utilities into a social utility (Vanberg, 2018, pp. 31-36).

The fundamental concept to capture WTP for WWTP in this study follows the measure of welfare improvement by using Hicksian welfare surplus measures after a change in goods or services, which is classified into compensating surplus (*CS*) and equivalent surplus (*ES*) as described in Freeman et al. (1993, pp. 66-68), Boyle et al. (1996, p. 383), and Choe et al. (1996, p. 528). Compensating surplus (*CS*) is the change in income that will make individual utility remain the same as the initial position. Equivalent surplus (*ES*) is the change in income that will leave the individual in a new level of utility regardless of a change in goods or services. The *CS* and *ES* measures are derived as below.

$$u(q_1, M - CS, S) = u(q_0, M, S), \quad (1)$$

$$u(q_1, M, S) = u(q_0, M + ES, S), \quad (2)$$

where *u* is the indirect utility function, *q* is goods or services, *M* is income, and *S* is the vector of individual characteristics. The 0,1 subscripts are denoted as before and after providing the goods or services. The vector of prices (*P*) is assumed to be constant. *CS* and *ES* are interpreted as the individual's willingness to pay (WTP) or willingness to accept (WTA), depending on the direction of change in the goods or services (Bateman & Turner, 1993, pp. 124-125; Freeman et al., 1993, pp. 55-57). Since water quality improvement provides the infrastructure for positive change and the study aims to measure individuals' WTP for such service provision, the *CS* is appropriate.

According to Whittington et al. (1990, p. 294), the WTP valuation can be applied with two basic approaches: direct and indirect. The first approach was named as the contingent valuation method (CVM) because the interviewer asked questions about a hypothetical market.

2. Econometric Model

In the binary choice model, an individual can face this question: "Would you be willing to pay *$T* for a certain good?". The possible answer can be either "*yes*" or "*no*". Following Freeman et al. (1993, pp. 390-394), Seenprachawong (2001, pp. 15-16), and Habb and McConnell (2003, pp. 24-26), the individual will respond "*yes*" if

$$u(q_1, M - T, S) > u(q_0, M, S), \quad (3)$$

where u is the indirect utility function, q is the goods or services, M is income, S is the vector of individual characteristics, and the 0,1 subscripts are denoted as before and after the provision of the goods. The maximum value of T, equivalent to compensating surplus or willingness to pay (WTP) for q_1, is defined implicitly by

$$u(q_1, M-T, S) = u(q_0, M, S)\,. \tag{4}$$

The random utility theory implies that the individual utility of choice consists of two parts: deterministic and random components. An individual will decide by selecting an alternative to maximize their utility gained, which is expressed by this equation:

$$u_{in} = \upsilon_{in} + \varepsilon_{in}\,, \tag{5}$$

where u is the individual utility of choice, υ is the determinant component, ε is the random component, and subscripts i and n are denoted as the alternative of choice and individual, respectively. Let $\upsilon(.)$ be denoted as the observable element of utility. The probability of a "*yes*" response will be expressed by

$$\Pr(y) = \Pr[\upsilon(q_1, M-T, S) + \varepsilon_1 > \upsilon(q_0, M, S) + \varepsilon_0]\,, \tag{6}$$

where ε_i is denoted as the unobserved random element of utility. In the econometric model, the probability of a "*yes*" response estimation depends on the distribution of ε_i. Suppose that the indirect utility function of an individual for a "*yes*" response is $u_{yes} = \upsilon_{yes} + \varepsilon_{yes}$, and that for a "*no*" response is $u_{no} = \upsilon_{no} + \varepsilon_{no}$, the equation (6) can then be rewritten as:

$$\Pr(y) = \Pr[\upsilon_{yes} + \varepsilon_{yes} > \upsilon_{no} + \varepsilon_{no}]\,, \tag{7}$$

$$\Pr(y) = \Pr[\varepsilon_{no} - \varepsilon_{yes} < \upsilon_{yes} - \upsilon_{no}]\,. \tag{8}$$

If the terms (ε_{yes}, ε_{no}) are independent and have a normal distribution form, the probability of a "*yes*" response is therefore given by

$$\Pr(y) = \frac{1}{\sigma\sqrt{2\pi}} \int_{\varepsilon=-\infty}^{\upsilon_{yes}-\upsilon_{no}} e^{-\frac{1}{2}u^2}\, du\,. \tag{9}$$

This equation can be written in symbolic terms as below.

$$\Pr(y) = \Phi\left[\frac{\beta'}{\sigma}(X_{yes} - X_{no})\right]. \tag{10}$$

In case the terms (ε_{yes}, ε_{no}) are independent and have a logistic distribution form, the probability of a "*yes*" response is then given by

$$\Pr(y) = \frac{1}{1+e^{-(\upsilon_{yes}-\upsilon_{no})}} . \quad (11)$$

Suppose that the individual indirect utility function is linear, the subscript 0 is denoted as the status quo, and the subscript 1 is denoted as the status after a change. Hence, υ_1 and υ_0 can then be expressed by these equations.

$$\upsilon_1 = \alpha_1 S + \beta_1 (M - T) + \varepsilon_1 , \quad (12)$$

$$\upsilon_0 = \alpha_0 S + \beta_0 M + \varepsilon_0 , \quad (13)$$

where α is the vector of parameters and β is the marginal utility of income. To estimate willingness to pay (T) for q_1, it is simply done by setting υ_1 = υ_0, and the equations turn out as below.

$$\alpha_1 S + \beta_1 (M - T) + \varepsilon_1 = \alpha_0 S + \beta_0 M + \varepsilon_0 , \quad (14)$$

$$\beta_1 T + \varepsilon_1 = (\alpha_1 - \alpha_0) S + (\beta_1 - \beta_0) M + \varepsilon_0 . \quad (15)$$

Assuming that the marginal utility of income is constant, β_0 therefore equals β_1 which becomes this equation.

$$\beta T + \varepsilon_1 = \alpha S + \varepsilon_0 . \quad (16)$$

The mean of estimated willingness to pay (T) is therefore given by

$$T = \frac{\alpha S}{\beta} . \quad (17)$$

Now, the equation (7) and (8) can be expressed as below.

$\Pr(y) = \Pr[\alpha S - \beta T + \varepsilon > 0]$, where $\varepsilon = \varepsilon_0 - \varepsilon_1$. (18)

Since β is the marginal utility of income, its value should be positive theoretically. Equation (18) implies that the higher the value of β or T, the lower the probability of a “yes” response. The coefficients α and β will be estimated using maximum likelihood estimation (MLE).

3. Literature Reviews

The variable used in the CVM model should be supported either by relevant theories or by solid evidence from empirical research. In this study, the author surveyed and analyzed the studies of the WTP for the WWTPs and the WTP for water quality improvement in many countries for pre-selecting the significant variables affecting the individual WTP. The results of 10 case studies based on WTP determinants on target areas in eight countries referred to Whittington et al. (1990) - Haiti, Tapvong and Kruavan (1999) - Thailand, Fujita et al. (2005) - Peru, Genius et al. (2005)

- Greece, Birol and Das (2010) - India, Trang et al. (2018) - Vietnam, Chopra and Das (2019) - India, Le and Aramaki (2019) - Vietnam, Makwinja et al. (2019) - Malawi, and Deh-Haghi et al. (2020) - Iran. In this regard, all studies used the CVM method for the WTP estimation. The commonly used independent variables, considered from appearance in more than half of studies, consist of education, age, gender, income, awareness, and household size.

4. Scenarios Design

Most of the canal's water in the Bangkok area has been classified as class 4, which makes it hard to be used for general consumption. An improvement in reaching class 1 or class 2 seems impossible. Therefore, the hypothetical market in this study was to improve the whole canal's water quality to meet the class 3 standard, which could be suitable to use for general consumption with an appropriate pretreatment. The study prepared two other water quality levels between class 4 and class 3, which enabled an analysis of the marginal benefit of improvement. The scenarios were presented through relevant video clips, photos, and other media types to ensure the respondents were on the same page.

According to the constructed situation, BMA would invest in the central wastewater treatment plant (CWTP)'s initial costs and expenses for each zone. The collection system would collect all households' effluent and treat it before releasing it into the canals, as presented in Figure 2. Without contamination of discharged wastewater, the water quality in the waterways would rehabilitate itself. The water quality after rehabilitation would reach level 3, which could still be used for general purposes with an appropriate pretreatment and could improve the scenery of the waterways. The payment for the program would be collected by incorporating the surcharge into the household's water bill. The water quality improvement is categorized into six scenarios as follows.

Scenario I: Only the nearest canal is slightly improved, the water quality is still at level 4, named 1 star (★).

Scenario II: Only the nearest canal is significantly improved, the water quality almost reaches level 3, named 2 stars (★★).

Scenario III: Only the nearest canal is completely improved to reach the water quality at level 3, named 3 stars (★★★).

Scenario IV: All canals in Bangkok are slightly improved, the water quality is still at level 4, named 1 star (★).

Scenario V: All canals in Bangkok are significantly improved, the water quality almost reaches level 3, named 2 stars (★★).

Scenario VI: All canals in Bangkok are completely improved to reach the water quality at level 3, named 3 stars (★★★).

The scenarios have been proposed with the condition that the decision to enact water quality improvement would be based on the survey results rather than being done automatically. This condition helps eliminate the solid free-rider incentive, as recommended by Bateman and Turner (1993, p. 148). Five wastewater-related experts and five household heads were selected to participate in the focus group. They all contributed fruitful recommendations for crafting the scenarios and updating the questionnaire. Their advice covered the act of identifying the waterway quality at each level, ways to communicate such context to individuals, advice on the central wastewater treatment plant (WWTP) concept, and also the starting bid prices in dichotomous choices both single-bounded (SBDC) and double-bounded (DBDC) questions.

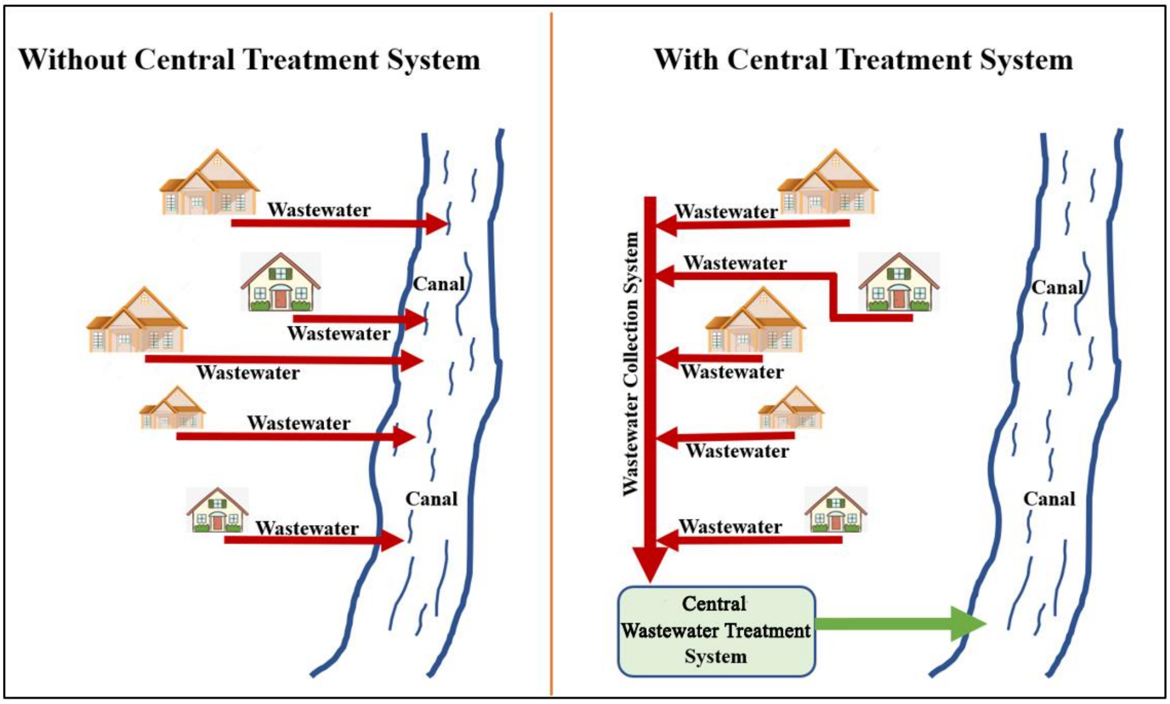


Figure 2 Scenario for the water quality improvement

5. Elicitation Format and Payment Vehicle

The study utilized both SBDC and DBDC formats for the WTP elicitation using relevant techniques recommended by Arrow et al. (1993, p. 52) and Seenprachawong (2006, p. 9). The WTP question format was "Would you pay X baht every month through the water bill increase, to improve the canal's water quality as you see in the video clips?". The varied amount of X was randomly assigned across the sample. After that, a follow-up bid price would be asked. If the respondent said "*yes*", the next question would be "And would you pay 2X baht?". If they said "*no*", the follow-up question would be "And would you pay X/2 baht?".

The answer for SBDC was taken from the first response, which consists of "*yes*" and "*no*" (Y, N), while the answer for DBDC was taken from both the first and the second responses, consisting of YY, YN, NY, and NN, as shown in Figure 3. The starting bid price used in the primary survey consisted of 50, 100, 200, 300, and 400 baht, and was targeted for all respondents in random. This study also applied the cheap talk script to remind the respondents to think about the value they would state if their income became reduced.

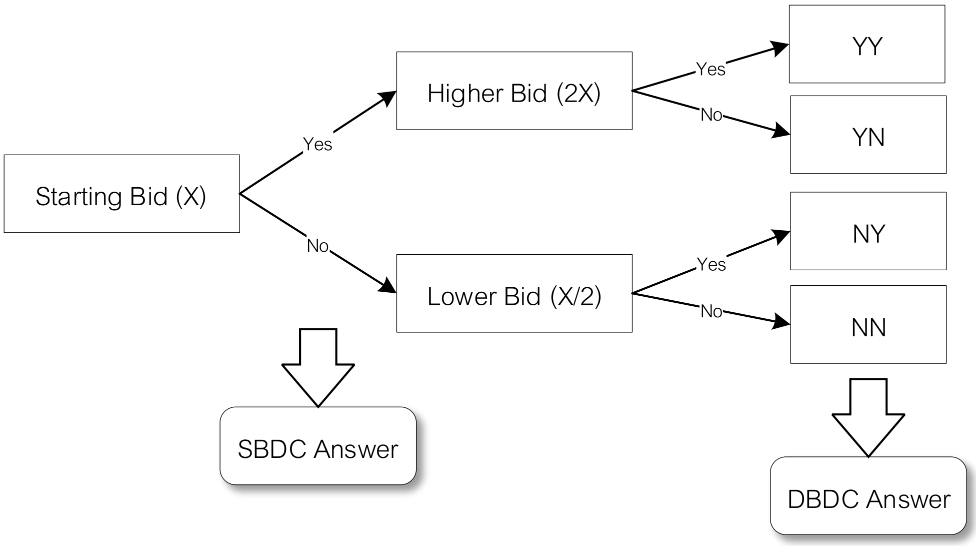


Figure 3 Elicitation steps in dichotomous choice format

6. Beneficiaries' Profile and Samples

The study was conducted in five districts, namely Don Mueang, Chatuchak, Khlong Toei, Prawet, and Lat Krabang, which were considered high-priority areas in the BMA's master plan for CWTP. There were 459,389 households in such study area, as presented in Table 1. The survey used the systematic sampling method, where every household in each administrative district had an equal chance of being selected. The plan was to interview 500 samples; however, the survey ended up interviewing 626 respondents, slightly more than the original plan.

Table 1 Population in the study area in 2019 and the number of samples

District	Population	Number of Households	Number of Samples	
			Planned	Actual
Don Mueang	170,021	77,220	84	127
Chatuchak	156,605	121,352	132	144
Khlong Toei	101,244	74,741	81	117
Prawet	180,769	89,608	98	120
Lat Krabang	177,769	96,468	105	118
Total	786,408	459,389	500	626

Source Population and household from the Department of Provincial Administration, Ministry of Interior (2019)

Study Results

1. Variables and Data Editing

The 206 respondents who came up with zero WTPs during the survey and were considered the protest responses were excluded from the model. The primary reason was that the canals' water quality improvement was not their responsibility, with about 93 respondents (45.15%). Sixty-six respondents (32.04%) claimed they had already paid enough tax to the government. Forty-seven respondents (22.82%) mentioned that BMA should bear all the program's costs. Finally, all protest responses were removed from the data set.

The variables used in the CVM models are described in Table 2. BID, BIDHI, BIDLO, YY, YN, NY, and NN are specific to the DBDC elicitation format. Some multiple-choice variables, such as knowledge/awareness of wastewater problems, occupation, and marital status, were transformed into binary data (0,1) to suit econometric model analysis.

Table 2 Variables used in the CVM models

Variable	Name	Definition
SBDC Vote (Yes, No)	SB	1 = if the respondent says yes for the first bid; 0 = otherwise
DBDC Vote (Yes, No)	YY	1 = if the respondent says yes for both the first and the second bids; 0 = otherwise
	YN	1 = if the respondent says yes for the first bid and says no for the second one; 0 = otherwise
	NY	1 = if the respondent says no for the first bid and says yes for the second one; 0 = otherwise
	NN	1 = if the respondent says no for both the first and the second bids; 0 = otherwise
Initial bid price	BID	Starting bid for WTP elicitation (baht/month/household)
Higher bid price	BIDHI	Higher bid for WTP elicitation (baht/month/household)
Lower bid price	BIDLO	Lower bid for WTP elicitation (baht/month/household)
Income	INC	Total monthly income of a household (baht)
Gender	GND	1 = if the respondent's gender is male; 0 = otherwise
Knowledge/awareness of wastewater problems	KNW	1 = if the respondent is concerned about the water quality of canals; 0 = otherwise
Education	EDU	The respondent's education level (year)
Age	AGE	The respondent's age (years old)
Occupation	OCC	Type of the respondent's occupation
Marital status	MARS	1 = if the respondent is married; 0 = otherwise
Water bill	WB	Last water bill received by a household (baht)
Distance	DST	The distance from a house to the nearest canal (meters)

The descriptive statistical data in Table 3 reveals that the households' monthly income averaged about 35,830 baht. More than half of the total respondents (62.14%) were male. Only 58% of the respondents were aware of the wastewater problems. The respondents' education level averaged about 12.76 years. The average age of the respondents was about 47.81 years old. About 34% of them were firm owners. Less than half of those (40.74%) have married status. Finally, the respondents' houses were located 228 meters on average away from the nearest canal.

Table 3 Descriptive statistics of respondents (*n* = 626)

Variable	Mean	Std. Dev.	Minimum	Maximum
INC (1,000 Baht)	35.83	12.34	15	105
GND	0.62	0.49	0	1
KNW	0.57	0.49	0	1
EDU	12.76	3.26	6	20
AGE	47.81	10.70	25	68
OCC	0.34	0.47	0	1
MARS	0.41	0.49	0	1
WB (100 Baht)	3.18	2.04	0.5	25
DST (10 meters)	22.83	25.41	0.5	70

2. Determinants of WTP

Table 5 shows the estimated coefficients of all variables in the SBDC model in scenario VI, using MLE with normal and logistic distribution forms. The results from both distribution forms indicated similarly that KNW, EDU, and AGE affected the probability of individuals saying "yes" significantly. In contrast, GND, OCC, MARS, WB, and DST did not considerably affect the acceptance probability. All significant variables, i.e., KNW, EDU, and AGE, have coefficients with P-values less than 0.01, which means that the confidence interval is higher than 99%. However, as the DBDC model has yielded a significant coefficient of DST in some scenarios (see Table 5), it is an inconclusive variable for the determinant of WTP thereof.

Table 4 Coefficients and statistics of all variables using SBDC model (in scenario VI)

Variable	Normal Distribution				Logistic Distribution			
	Coefficient	Std. Dev.	Z	*P*-value	Coefficient	Std. Dev.	Z	*P*-value
Constant	-1.358***	0.477	-2.83	0.005	-2.305***	0.806	-2.86	0.004
BID	-0.067***	0.006	-11.82	0.000	-0.113***	0.010	-11.11	0.000
GND	-0.145	0.123	-1.18	0.240	-0.264	0.212	-1.25	0.212
KNW	0.465***	0.123	3.80	0.000	0.813***	0.210	3.87	0.000
EDU	0.109***	0.022	4.97	0.000	0.183***	0.038	4.89	0.000
AGE	0.022***	0.006	3.74	0.000	0.038***	0.010	3.74	0.000
OCC	0.066	0.131	0.50	0.614	0.133	0.224	0.59	0.553
MARS	0.056	0.123	0.45	0.652	0.130	0.211	0.62	0.538
WB	-0.027	0.032	-0.86	0.391	-0.050	0.053	-0.94	0.350
DST	0.004	0.002	1.62	0.105	0.006	0.004	1.62	0.105
Log likelihood function -304.61777					Log likelihood function -305.15486			

Note ***, **, * => Significance at 1%, 5%, 10% level

3. Estimating WTP

The estimated WTP values were selected from the normal distribution models due to higher log-likelihood function values. The socioeconomic characteristics put in the model comprise KNW, EDU, AGE, and DST. Table 5 summarizes the WTP estimations using SBDC and DBDC models. As a result, with the SBDC model, the estimated values of WTP for the scenarios I, II, and III, are approximately 71.05, 71.51, and 121.31 baht per month per household, respectively. Meanwhile, the estimated values of WTP for the scenarios IV, V, and VI, are around 73.43, 125.45, and 198.05 baht per month per household, respectively. In contrast, having deployed the DBDC model, the estimated values of WTP for scenarios I, II, and III, are approximately 75.91, 96.93, and 145.39 baht per month per household, respectively. At the same time, the estimated values of WTP for scenarios IV, V, and VI, are about 111.78, 153.54, and 198.29 baht per month per household, respectively. In comparing the same level of water quality improvement, one-star, two-star, and three-star levels, the values of WTP for the improvement at only the nearest canal, from the SBDC model, take the portion of 96.76%, 57.00%, and 61.25% of the whole canals' improvement, respectively. The counterparts from the DBDC model are 67.91%, 63.13%, and 73.32%, respectively.

Table 5 WTP estimation using SBDC and DBDC with a normal distribution model

Model / Variable	Improve only the nearest canal			Improve the whole canals in Bangkok		
	Scenario I (★)	Scenario II (★★)	Scenario III (★★★)	Scenario IV (★)	Scenario V (★★)	Scenario VI (★★★)
SBDC model						
Constant	-1.341***	-1.533***	-0.651	-1.612***	-0.994**	-1.397***
BID	-0.076***	-0.067***	-0.074***	-0.065***	-0.060***	-0.066***
KNW	0.175	0.192	0.241*	0.208*	0.241**	0.446***
EDU	0.069***	0.078***	0.065***	0.082***	0.076***	0.108***
AGE	0.019***	0.019***	0.012**	0.019***	0.013**	0.022***
Log likelihood	-271.58	-288.98	-300.28	-294.51	-328.35	-307.06
Estimated WTP	71.05	71.51	121.31	73.43	125.45	198.05
DBDC model						
Constant	-1.074**	-1.208***	-1.282***	-1.083***	-1.160***	-1.481***
BID	-0.099***	-0.096***	-0.073***	-0.093***	-0.072***	-0.063***
KNW	0.140	0.215**	0.286***	0.348***	0.304***	0.402***
EDU	0.079***	0.090***	0.092***	0.084***	0.090***	0.111***
AGE	0.014***	0.017***	0.020***	0.016***	0.018***	0.021***
DST	0.004**	0.003	0.002	0.004**	0.003*	0.004**
Log likelihood	644.76	713.72	819.16	765.74	814.66	737.09
Estimated WTP	75.91	96.93	145.39	111.78	153.54	198.29

Note ***, **, * => Significance at 1%, 5%, 10% level

4. Aggregation of Economic Value

The aggregation of total economic value that commenced from the households' WTP for waterway quality improvement in the study area could be estimated straightforwardly by multiplying the households' WTP value by the household number. Table 6 shows the program's economic value aggregation in each area classified by scenarios, estimated with SBDC and DBDC models. The total economic value is estimated at 90.98 million baht per month, or 1,091.78 million baht annually, according to the SBDC model, and 91.09 million baht per month, or 1,093.11 million baht annually, according to the DBDC model.

According to the results, it could be inferred that the individual's valuation of the canals' water quality improvement consisted of two dimensions. The first dimension was to value the benefit of better water quality only near their homes, and the second was to value such benefit for the whole area. The value of the first dimension took a portion more than half of the whole.

Table 6 Economic value of waterway quality improvement

Model	Household[1/]	Economic Value (Million baht per month)					
		Scenario I (★)	Scenario II (★★)	Scenario III (★★★)	Scenario IV (★)	Scenario V (★★)	Scenario VI (★★★)
SBDC	459,389	32.640	32.851	55.729	33.733	57.630	90.982
DBDC		34.872	44.529	66.791	51.351	70.535	91.092

Note [1/] From the Department of Provincial Administration, Ministry of Interior (2019)

5. Assessing the Validity of the CVM

Since the CVM estimates the value of goods or services in the constructed market, many scholars recommended that such methods' results be assessed for validity and reliability. This study applied some approaches, as suggested by Habb and McConnell (2003, p. 128), to support the validity and reliability of the estimated WTP.

All 626 respondents, with an average monthly income of about 35,827 baht, were divided into the under-mean and the over-mean income groups, with 316 and 310 samples, respectively. The estimated WTP values, which are visually different between the two groups, are presented in Table 7. The WTP of the over-mean group, compared to the under-mean group, is more than double in all scenarios. This result could be concluded that the WTP was positively related to individual income, which showed that the result contained theoretical validity. The higher improvement levels yielded more WTP in all models. This evidence confirmed that the estimated WTP conformed to the scope test condition.

Table 7 Estimated WTP of under-mean and over-mean income groups

Scenario	Under-Mean Income Group	Over-Mean Income Group
Scenario I	31.38	127.22
Scenario II	36.83	134.98
Scenario III	88.40	166.48
Scenario IV	41.01	139.79
Scenario V	82.95	186.55
Scenario VI	128.85	262.56

Table 8 shows the corresponding scenarios' mean WTP and 95% confidence interval. The estimation from DBDC yielded slightly higher mean WTP with smaller variance, resulting in a relatively narrower confidence interval in corresponding scenarios. Therefore, the DBDC complies more with the scope test and corroborates the higher efficiency than the SBDC model.

Table 8 The mean WTP and 95% C.I. from SBDC and DBDC models

Scenario	SBDC		DBDC	
	Mean WTP	95% C.I.	Mean WTP	95% C.I.
Scenario I	71.05	50.93 – 91.17	75.91	62.88 – 88.93
Scenario II	71.51	48.94 – 94.08	96.93	84.43 – 109.44
Scenario III	121.31	104.52 – 138.10	145.39	129.76 – 161.02
Scenario IV	73.43	50.35 – 96.50	111.78	98.90 – 124.66
Scenario V	125.45	105.28 – 145.62	153.54	138.50 – 168.58
Scenario VI	198.05	180.19 – 215.90	198.29	182.28 – 214.29

Conclusion and Recommendations

1. Conclusion

The study explored fruitful information for planning and implementing waterway quality improvement programs and benefited scholars interested in further studies. All data used in the models was collected by using an interview survey, which applied multimedia and video clips to present the scenarios instead of verbal communication to ensure that the respondents would perceive the proposed scenarios in the same direction. The study applied many practices, such as suitable conditions, bid price selection, and a cheap talk script, to reduce biases in the CVM.

The proposed scenarios have been divided into two dimensions: the WTP for improving only the nearest canal, which consists of scenarios I, II, and III, and that for improving the whole canals in the Bangkok area, which consists of scenarios IV, V, and VI. Each dimension comprises three levels of improvement: one-star, two-star, and three-star, respectively. The WTP elicitation format is a dichotomous choice: single-bounded and double-bounded questions. The data set used in the econometric model comprises 626 responses. The following findings are the main issues considered based on the study results.

The socioeconomic characteristics that affected the WTP significantly in both SBDC and DBDC models include knowledge/awareness of wastewater problems (KNW), education (EDU), and age (AGE). The estimated WTP values generated from SBDC and DBDC models differed slightly; however, the DBDC estimator gave a smaller variance. As a result, the WTP values from the DBDC model, scenarios I to VI, are approximately 75.91, 96.93, 145.39, 111.78, 153.54, and 198.29 baht per month per household, respectively. The results have been analyzed by examining the variation of WTP of the under-mean and over-mean income groups and using the scope test to ensure their validity.

The total economic value can be estimated by multiplying the household number in the service area by the mean WTP. Such value is, for instance, 198.28 baht per month in the case of scenario VI. This economic value might be used in the CBA of any wastewater treatment projects in the Bangkok area.

2. Discussion

In this study, multimedia was used to present scenarios in the CVM survey instead of verbal communication. This helped ensure that all respondents received the information on the same page and reduced the bias caused by human error. The study estimated that the households' WTP for different scenarios ranged from 71.05 to 198.05 baht per month per household using the SBDC model, and 75.59 to 198.28 baht per month per household using the DBDC model. The service fee to be implemented in the corresponding program could be set within these ranges to reflect the households' WTP.

The econometric results of the WTP determinants analysis showed that respondents' socioeconomic characteristics, which affected their WTP, consist of knowledge/awareness of the wastewater problems, education, and age. All of these factors positively influenced the respondent's WTP. Validity assessment of the CVM revealed different WTPs among households in the under-mean income group and over-mean income group. These findings can be used to set the service fee discriminately depending on the household's socioeconomic characteristics.

The study results revealed that the household's WTP comprised two dimensions: the first was WTP for improving water quality only in the nearest canal, and the second was WTP for improving water quality in all canals in the Bangkok area. The WTP in the first dimension took up more than half of the second dimension.

One limitation of this study was the inability to estimate the costs of the waterways' water quality improvement program, which requires engineering design. Therefore, cost-benefit analysis (CBA) was unavailable. By using the estimated WTPs from this study, the BMA should conduct the engineering design and the CBA of the waterways' water quality improvement to estimate the program's economic return.

3. Recommendations

The lesson learned from this study motivates the author to focus primarily on the data collection and management issues. As a result of a significant portion of the protest responses, future studies of projects of the same type should emphasize the preparation of data collection. The researchers must be aware of the perception of the individuals and the usage of the free charge for wastewater management.

The estimated WTP values in this study could be applied in planning and developing any wastewater management projects in the Bangkok area based on the benefit transfer approach and setting the service fee for wastewater treatment. The econometric results from the DBDC models yielded a narrower range of WTP values, which helps make the application more manageable and feasible. Setting an appropriate service fee should match the right improvement level of the corresponding program and might be discriminated rates depending on the household's characteristics.

Most of the waterways in the Bangkok area are deteriorated and will worsen unless the improvement program is implemented. Currently, the BMA can implement the wastewater treatment system only in eight service areas, which is still far from the total target of 27 service areas. According to the WTP analyzed in this study, the marginal economic benefit from initiating the improvement program is significant even though the program helps elevate the water quality level only to a certain extent. Therefore, the BMA should undergo CBA and expedite the projects in the master plan covering all areas as soon as possible. In addition, the budget constraints may be eliminated by using available approaches, such as public-private partnership (PPP), which is faring satisfactorily in Thailand.

References

Arrow, K., Solow, R., Portney, P., Leamer, . . . Schuman, H. (1993) *Report of the NOAA panel on contingent valuation*, Available: https://edisciplinas.usp.br/pluginfile.php/4473366/mod_folder/intro/Arow_WTP.pdf [15 November 2021]

Bateman, I. J., & Turner, R. K. (1993) 'Valuation of the environment, methods and techniques: The contingent valuation method', in. R. K. Turner (ed.), *Sustainable environmental economics and management: Principle and practice*, pp. 120-191, Belhaven Press.

Birol, E., & Das, S. (2010) Estimating the value of improved wastewater treatment: The case of river Ganga, India, *Journal of Environmental Management*, Vol. 91, No. 11, pp. 2163-2171. https://doi.org/10.1016/j.jenvman.2010.05.008

Boontanon, S. K. (2014) *Wastewater management in Bangkok, Paper presented at the WEPA Sessions in 11th International Symposium on Southeast Asian Water Environment (SEAWE11)*, Mahidol University.

Boyle, K. J., Johnson, F. R., McCollum, D. W., Desvousges, W. H., Dunford, R. W., & Hudson, S. P. (1996) Valuing public goods: Discrete versus continuous contingent-valuation responses, *Land Economics*, vol. 72, no. 3, pp. 381-396. https://doi.org/10.2307/3147204

Choe, K., Whittington, D., & Lauria, D. T. (1996) The economic benefits of surface water quality improvements in developing countries: A case study of Davao, Philippines, *Land Economics*, vol. 72, no. 4, pp. 519-537. https://doi.org/10.2307/3146913

Chopra, V., & Das, S. (2019) Estimating willingness to pay for wastewater treatment in New Delhi: Contingent valuation approach, *Ecology, Economy and Society–the INSEE Journal*, vol. 2, no. 2, pp. 75-108. https://doi.org/10.37773/ees.v2i2.78

Deh-Haghi, Z., Bagheri, A., Fotourehchi, Z., & Damalas, C. A. (2020) Farmers' acceptance and willingness to pay for using treated wastewater in crop irrigation: A survey in western Iran, *Agricultural Water Management*, vol. 239. https://doi.org/10.1016/j.agwat.2020.106262

Department of Provincial Administration, Ministry of Interior. (2019) *Population, area, density, number of houses classified by subdistrict in Bangkok 2019 (จำนวนประชากร พื้นที่ ความหนาแน่น จำนวนบ้าน จำแนกตามแขวงในเขตกรุงเทพมหานคร 2562)*, Available: https://webportal.bangkok.go.th/upload/user/00000130/BMA_STATSITICS%202562/2.Stat_Soc_62/Soc_Pop_05_62.xlsx [11 August 2021] (in Thai)

Drainage and Sewerage Department, Bangkok Metropolitan Administration. (2021) *Water quality data for 8 large plants, water quality data for 15 small plants (ข้อมูลคุณภาพน้ำ 8 โรงใหญ่ ข้อมูลคุณภาพน้ำโรงเล็ก 15 แห่ง)*, Available: https://drive.google.com/drive/folders/0B2T8BVW9hMcuZkE3VmtxU1BZNk0?resourcekey=0-dTGjGkpY6YduyclYS5qgPQ [26 October 2021] (in Thai)

Freeman III, A. M., Herriges, J. A., & L. Kling, C. (1993) *The measurement of environmental and resource values: Theory and methods*, Resources for the Future.

Fujita, Y., Fujii, A., Furukawa, S., & Ogawa, T. (2005) Estimation of willingness-to-pay (WTP) for water and sanitation services through contingent valuation method (CVM) - A case study in Iquitos city, The Republic of Peru, *JBICI Review*, no. 10, pp. 59-87.

Genius, M., Manioudaki, M., Mokas, E., Pantagakis, E., Tampakakis, D., & Tsagarakis, K. P. (2005) Estimation of willingness to pay for wastewater treatment, *Water Supply*, vol. 5, no. 6, pp. 105-113. https://doi.org/10.2166/ws.2005.0055

Habb, T. C., & McConnell, K. E. (2003) *Valuing environmental and natural resources: The econometrics of non-market valuation*, Edward Elgar Publishing.

Japan International Cooperation Agency (JICA). (2011) *Preparatory survey for Bangkok wastewater treatment project in Thailand*, Available: https://openjicareport.jica.go.jp/pdf/12034567.pdf [23 November 2021]

Le, T. T. P., & Aramaki, T. (2019) Factors affecting households' willingness to pay for improved wastewater services in Ho Chi Minh City, Vietnam, *Journal of Water and Environment Technology*, vol. 17, no. 3, pp. 163-173. https://doi.org/10.2965/jwet.18-067

Makwinja, R., Kosamu, I. B. M., & Kaonga, C. C. (2019) Determinants and values of willingness to pay for water quality improvement: Insights from Chia Lagoon, Malawi, *Sustainability*, vol. 11, no. 17. https://doi.org/10.3390/su11174690

Okadera, T., Syutsubo, K., Yoochatchaval, W., Ebie, Y., & Kubota, R. (2020) Water volume - and BOD - based flow analysis for domestic wastewater treatment using wastewater inventories of Bangkok, Thailand, *Journal of Water and Environment Technology*, vol. 18, no. 2, pp. 71-79. https://doi.org/10.2965/jwet.19-064

Seenprachawong, U. (2001) *An economic analysis of coral reefs in the Andaman Sea of Thailand*, Economy and Environment Program for Southeast Asia (EEPSEA). https://blogs.ubc.ca/apfnet04/files/2015/08/SUFES_05_Module-VI_Economic-Analysis-of-Coral-Reefs.pdf

Seenprachawong, U. (2006) *Economic valuation of cultural heritage: A case study of historic temples in Thailand*, Economy and Environment Program for Southeast Asia (EEPSEA).

Tapvong, C., & Kruavan, J. (1999*) Water quality improvements: A contingent valuation study of the Chao Phraya river*, Economy and Environment Program for Southeast Asia (EEPSEA).

Trang, T. T. T., Rañola, R. F., & Song, N. V. (2018) Households' willingness-to-pay for wastewater treatment in traditional agro-food processing villages, Nhue-Day River Basin, Vietnam: Case study in Hanoi city, *Journal of Environmental Protection*, vol. 9, no. 10, pp. 1021-1033. https://doi.org/10.4236/jep.2018.910063

Vanberg, V. J. (2018) *Individual choice and social welfare: Theoretical foundations of political economy*, Albert-Ludwigs-Universität Freiburg, Institut für Allgemeine Wirtschaftsforschung, Abteilung für Wirtschaftspolitik und Ordnungsökonomik. https://www.econstor.eu/bitstream/10419/175379/1/1014349494.pdf

Whittington, D., Briscoe, J., Mu, X., & Barron, W. (1990) Estimating the willingness to pay for water services in developing countries: A case study of the use of contingent valuation surveys in Southern Haiti, *Economic Development and Cultural Change*, vol. 38, no. 2, pp. 293-311. https://doi.org/10.1086/451794

World Bank. (2020, March 19) *Wastewater a resource that can pay dividends for people, the environment, and economies, says World Bank*, Available: https://www.worldbank.org/en/news/press-release/2020/03/19/wastewater-a-resource-that-can-pay-dividends-for-people-the-environment-and-economies-says-world-bank [15 November 2021]