EVALUATION OF PRICE ELASTICITY FOR DOMESTIC WATER DEMAND USING WILLINGNESS TO PAY; CASE STUDY-MANDALAY

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Abstract - This paper intends to find the price elasticity of domestic water demand for Mandalay using willingness to pay. The study was conducted to 286 sampled households in Mandalay using questionnaire survey. Contingent valuation method is used in questionnaire survey and the value elicitation method is used as a closed ended format questionnaire and open ended follow up questionnaire. The average monthly household's consumption of domestic water was also estimated for the sampled households. Demand curve is constructed by using willingness to pay values versus average monthly water consumption of households. The price elasticity of demand is determined by using arc elasticity method. In this method, value of price elasticity is estimated by mid-point formula. In segment 5, the unit elasticity 1.11 is found and the price values are the upper price 233 MMK/m^3 and the lower price 195MMK/m^3. Factors affecting to the willingness to pay was analysed by using Linear Regression Model. The mean willingness to pay value is 252 MMK/m^3 from linear regression analysis. All the values of price are well above the current water tariff 85 MMK/m^3.

Keywords - Price elasticity, willingness to pay, arc elasticity method, linear regression, contingent valuation method, elicitation method and domestic water demand.

I. INTRODUCTION

In Myanmar, the fresh water systems are mainly used by the agriculture sector and small quantities being used for domestic, industrial and other sector. For domestic use, water is available from municipal water supply, private business supply, and private well and other source such as river water. Myanmar population is about 54.6 million and urban population is increasing from 29% in 2005 to 35.3% in 2017 (Department of Population, Ministry of Immigration and Population). Due to increasing population and urbanization, water demand is increased.

In Myanmar, the water supply and distribution system is carried out by municipal water supply system of government organization. But, the set of water tariffs are very low and do not recover the operating and maintaining cost of the system and the lower water tariff may lead to water over consumption. The more water tariffs are needed to recover the operating and maintaining cost of the system. The fourth Dublin Principle asserts that water has an economic value in all its competing uses and should be recognized as an economic good (International Conference on Water and the Environment in Dublin). Hence, the principle of water pricing is needed and systematic tariff system is also needed to assign in domestic water sector.

Moreover, the volumetric water tariffs that should encourage to the consumers to control their water usage are also needed. Pricing can be used as a water demand management tool and most of the countries all over the world accept it. Here, price elasticity is a relationship between the water demand and water pricing. Therefore, this paper tends to find out the price elasticity of water demand.

II. BACKGROUND OF THE STUDY AREA

The study area, Mandalay has five townships namely Aung Myay Thazan, Chan Aye Thazan, Mahar Aungmyay, Chanmya Thazi and Pyigyi Tagon townships and is shown in Fig.1. The location of the Mandalay city is at Long; E 96˚06' Lat;N 21˚59' and area is 117.22 km^2. The population growth rate is 2.72% from 1983 census to 2014 census. In Mandalay, the water supply system is carried out by Mandalay City Development Committee (MCDC). The main water source for piped water is ground water and does not cover the whole city. The piped water system is distributed to 70% population of four townships and only 7% of population can be supplied in Pyi Gyi Tagon township (Water Supply and Sanitation Department, MCDC).

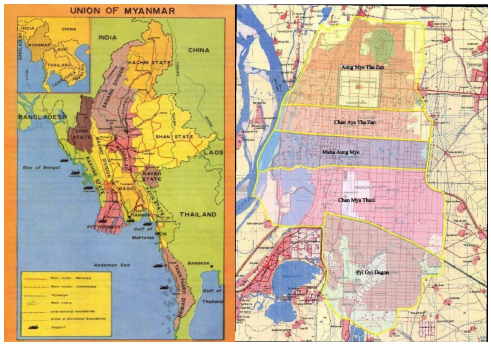


Fig.1. Location Map of Study Area
Source: Mandalay City Development Committee

In the area that is not available piped water system, consumers use private well and the water from water vendor. Moat water is supplied to the areas that can available moat water. As the tariff for piped water and moat water of MCDC is very low, the consumers use more water than the consumers using water from the water vendor.

III. MATERIALS AND METHODS

To approach the water pricing, demand information is essentially needed. But, the reliable demand data is not available for the study area. Therefore, questionnaire survey to the consumers is needed to collect demand side information and including three sections. The first section consists of questions related to socio economic and demographic characteristics of the households such as sex, age, education level, family size and average family income of the respondent. The second section includes questions related with household's water usage practice and present water supply situation. Finally, the third section deals with willingness to pay questions using the dichotomous choice format questions with opened follow up question. The starting bid for the willingness to pay is 200MMK/m^3 and this bid was set up according to the pilot survey and with MCDC proposed tariff plan. Factors affecting to the willingness to pay to pricing is analyzed by Multiple Linear Regression Model. MATLAB Programming is used to construct the water demand curve. Price elasticity is calculated by using the Mid-Point formula.

A. Monthly Consumption of Households

In practice, it is difficult to estimate the volume of water use by household. In general, households do not have a clear idea of how much water they consume per day and even directly asking these households that they do not provide reliable answers. So, the method such as measuring the volume of water storage facilities available in the house and estimation how much of the storage capacity is used on a day-to-day basis. The average consumption of water per month is about 23.28 m^3 for household each which include 5 members of family.

B. Contingent Valuation Method (CVM)

CVM involves asking people directly what they would be willingness to pay (WTP) compensation for change in preferences and the method is called contingent valuation for it is contingent on the hypothetical market. The CVM is preferred for it includes both use and non-use values and survey responses to WTP hypothetical questions go directly to the monetary measures of utility change. The most widely used elicitation formats in CV surveys are (i) Open-ended (ii) Closed-ended (iii) Bidding game and (iv) Payment card method. In this research, both closed-ended and open-ended format is used to achieve the willingness to pay of the consumer.

C. Multiple Linear Regression Analysis

Multiple Linear Regression analysis estimates the coefficients of the linear equation involving multiple independent variables that best predict the value of dependent variable. The linear regression equation is given in (1).

$$Yi = \beta_0 + \beta_1 X_{1i} + \ldots + \beta_k Xki + \varepsilon_i \quad (1)$$

Where, Yi = dependent variable

β_0 = intercept coefficients

β_s = regression coefficients

Xki = independent or explanatory variables

IV. Results And Discussions

Questionnaire survey was conducted in Nov 2016 to 286 sample households in Mandalay. There are two parts of results mean willingness to pay value from linear regression analysis and unit price value from price elasticity method.

D. Description of Independent Variables and Hypothesis

1) The sex of the respondent: it is assumed that women would express more preference for improved water services and would be more willing to pay than men because they use more water for domestic uses. A dummy variable for sex will be specified as 1 for male and 0 for female with a negative expected sign.

2) Age of the respondent: this is a continuous variable and negative relation is expected between age and WTP because of the older people who used to live free water supply and less prices.

3) Education level: It is expected that households with higher educational level are more aware of the benefits of improved water services so the higher education of the respondent has the more willingness to pay and thus positive relation is expected.

4) Family Size: The relation between family size and willingness to pay may be positive or negative.

5) Initial bid: The values of initial bid are set up according to the pilot survey and MCDC proposed tariff plan and these values are distributed to the randomly sample households. The relation between initial bid and WTP is difficult to expect since it is determined by respondent.

6) Average family income: The available literature suggests that there is a positive relationship between income and improved water service. The higher family income has the more willingness to pay.

7) Primary source of water: It is a dummy variable, taking 1 if the household has municipal water supply and 0 otherwise. Since a household with municipal water supply system is expected to be less likely to pay for the improved service than other source. Therefore,

the expected sign of this variable's coefficient is negative.

E. Data Description of Independent Variables

The statistical values for independent variables are presented in Table I.

Variable	Mean	Std.dev	Min	Max
Gender	0.4	0.491	0	1
Age	44.54	11.339	22	71
Education level	3.59	1.258	1	6
Family size	4.68	1.499	1	8
Household income per moth	328097	164370	100000	1000000
Initial bid	199.3	84.186	100	300
Source	0.67	0.471	0	1

Table I. The Statistical Values for Independent Variables

Of the surveyed households, 171 (59 %) were female respondents while 115 (40.2%) were male respondents. The data about the respondent's age shows that the average is about 45 years which range from 22 to 71 years of old.

According to the survey findings, non-schooling is 19 (6.6%), primary education is 58 (20.3%), middle education is 43 (15%), high school education is 81 (28.3%), graduated number is 87(29.4%) and post-graduated number is 1 (0.3%). The average family size is about 5 individuals with a minimum of 1 person in the house to a maximum of 8 household members.

The most difficulty was the query on the level of income the households earns. Most of the respondents were not eager to state their earnings and others don't really know their average monthly income. Therefore, the average monthly expenditure of household was also asked as a cross checking mechanism and the average monthly income of the sample households is 328,000 Myanmar Kyats (MMK) and the income level ranges from a minimum of 100,000 MMK to a maximum of 1,000,000 MMK. From the surveyed households, 67.1% use municipal water and about 32.9 % of the households use other water sources.

The average initial bid amount is 199.33 MMK/m^3 of water which ranges from a minimum of 100 MMK/m^3 to a maximum of 300 MMK/m^3 and these values were set up with reference to the MCDC proposed tariff plan and pilot survey.

F. Determinants Analysis

The parameters estimation of the variables expected to affect willingness to pay are shown in Table III.

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig
		Beta	Std.error	Beta		
1	Constant	134.037	37.93	-	3.59	0.000
	Gender	-3.958	8.38	-0.015	-0.472	0.637
	Age	-1.788	0.45	-0.156	-4.04	0.000
	Education	25.21	4.34	0.244	5.884	0.000
	Family size	-1.05	3.16	-0.012	-0.333	0.739
	Family income	0.20×10^{-3}	0.0003	0.249	6.102	0.000
	Initial bid	0.472	0.09	0.306	5.475	0.000
	Existing water source	-68.082	8.312	-0.25	-8.185	0.000

Table III. Estimated Parameter of Independent Variables

The average initial bid amount is 199.33 MMK/m^3 of water which ranges from a minimum of 100 MMK/m^3 to a maximum of 300 MMK/m^3 and these values were set up with reference to the MCDC proposed tariff plan and pilot survey.

The word "data" is plural, not singular. The subscript for the permeability of vacuum μ_0 is zero, not a lowercase letter "o." The term for residual magnetization is "remanence"; the adjective is "remanent"; do not write "remnance" or "remnant." Use the word "micrometer" i n), "complement" and "compliment," "discreet" and "discrete," "principal" (e.g., "principal investigator") and "principle" (e.g., "principle of measurement"). Do not confuse "imply" and "infer."

Prefixes such as "non," "sub," "micro," "multi," and ""ultra" are not independent words; they should be joined to the words they modify, usually without a hyphen. There is no period after the "et" in the Latin abbreviation "et al." (it is also italicized). The abbreviation "i.e.," means "that is," and the abbreviation "e.g.," means "for example" (these abbreviations are not italicized).

The dependent variable is a continuous variable that individuals respond as maximum willingness to pay to water pricing. A total of 7 explanatory variables were considered in the econometric analysis, out of which five variables were found to significantly influence the individual willingness to pay for water pricing. As expected, the respondent age has a negative sign and implying that one unit increase in age (one year) willingness to pay for water will decrease.

Educational level of the respondent also has positive sign as expected and implying that the higher the education level, the more WTP.
Income of the household is statistically significant and positively related to WTP which implies that the higher the income, the more WTP.
The variable of initial bid is positively related and statistically significant to the dependent variable and this implies that the consumers tend to more pay than the initial bid values.

The primary source of water has a beta value of 68.082 indicating that households whose reported municipal water supply as the primary source of water were found to have 68 kyats less willingness to pay than households who use other water source.
The variables such as respondent sex and family size were not statistically significant predictors of the dependent variable, maximum willingness to pay.

G. Description of Dependent Variable

The dependent variable, willingness to pay value is obtained from the open-ended follow up question and 278 (97.2%) of them give the positive amounts as they are willing to pay to water pricing and the rest 8 (2.8%) were having zero of WTP. These values are summarized in Table II.

Maximum WTP Reported	Number of surveyed Households	Valid Percentage	Cumulative Percentage
0-100	71	24.8	24.8
101-200	69	24.1	48.9
201-300	81	28.3	77.2
301-400	28	9.8	87
401-500	37	12.9	100

Table II. Summary of Maximum Willingness to Pay

H. The Value of Willingness to Pay to Water Pricing

Based on the result of linear regression analysis using SPSS 23.0, obtained an equation of customer willingness to pay is is shown in (2) and the mean willingness to pay value is 252 MMK/m^3.

$$Y= 134.04 - 3.96\ X_1 - 1.79X_2 + 25.12X_3 - 1.05X_4 + 0.2x10^{-3}X_5 + 0.47\ X_6 - 68.08\ X_7 \quad (2)$$

Where, Y= willingness to pay to water pricing (Kyats)
X_1 = gender of respondent
X_2 = age of respondent
X_3= education level
X_4= family size
X_5= average family income (kyats)
X_6= initial bid
X_7= existing water source

I. Price Elasticity of Water Demand

The price elasticity of demand (Ed) provides the connection between consumer behavior and price fluctuations. The price elasticity of demand is a measure that describes the degree of responsiveness of the quantity of water to a given change and is defined in (3).

$$E = -\frac{\text{percentage change in the quantity of water demanded}}{\text{percentage change in the price per unit of water}} \quad (3)$$

Demand is elastic when the elasticity is greater than 1, so that quantity moves proportionately more than the price. Demand is inelastic when the elasticity is less than 1, so that quantity moves the same amount proportionately less than the price. If the elasticity is exactly 1, so that quantity moves the same amount proportionately as price, demand is said to have unit elasticity.

J. Development of Demand Curve

From an economic perspective, the price of water is an important determinant of per capita consumption. Demand is in term that economists use to refer to what people are willing and able to buy. In this research, the water demand curve is developed from WTP information. The willingness to pay value and average monthly consumption of households are tabulated in Table IV.

Mid value for WTP	Number of HHs			Sample HHs willing to pay (Cumulative)		Volume of water use by HHs
	Count	%	Cumulative %	Count	%	
50	71	24.8	24.8	286	100	6658.08
150.5	69	24.1	48.9	215	75.2	5005.2
250.5	81	28.3	77.2	146	51.1	3398/.8
350.5	28	9.8	87	65	22.8	1513.2
450.5	37	12.9	100	37	13	861.36

Table IV. Willingness to pay value and average monthly consumption of household

Along the vertical axis, the mid willingness to pay amount to the water pricing is set up. Along the horizontal axis, the average monthly consumption of sample household is set up by multiplying the number of household's willingness to pay at least the mid value per unit of water with the average monthly consumption of water (23.28m^3).

MATLAB programming is used to construct the demand curve and is shown in Fig.2. The result values of price and quantity of water consumption from MATLAB Programming are tabulated in Table V.

Monthly Consumption of Households Q (m3/month)	Price P (Kyats)
1441.03	383.838
2020.7	346.038
2600.38	308.238
3180.05	270.438
3759.72	232.639
4339.39	194.839
4919.06	157.039
5498.74	119.239
6078.41	81.4394
6658.08	43.6396

Table V. Fitted Values of Price and Quantity

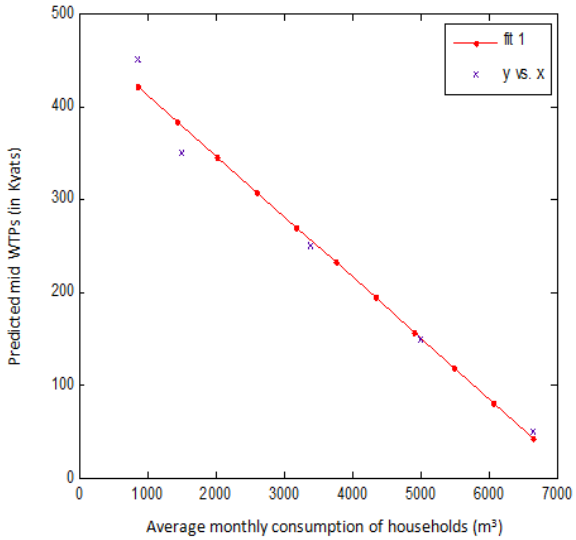


Fig.2 Domestic Water Demand Curve

K. Determination of Price Elasticity

The mid-point elasticity formula is a common method of calculating elasticity, especially the price elasticity of demand, price elasticity of supply, income elasticity of demand and cross elasticity of demand. This formula is most often used at the introductory level of economic instruction and is expressed in (4).

In this study, arc elasticity method is used to compute price elasticity of demand. This formula yields a value that ranges from zero to negative infinity and the price elasticity for water demand is tabulated in Table VI.

$$\text{midpoint elasticity} = E_d = \frac{\Delta Q}{Q_{avg}} x \frac{P_{avg}}{\Delta P}$$

$$(4) \qquad = \frac{(Q_2 - Q_1)}{(P_2 - P_1)} x \frac{(P_2 + P_1)}{(Q_2 + Q_1)}$$

Where, Q_1 = Initial quantity of water demanded

Q_2 = final quantity of water demanded

P_1 = Initial price of water

P_2 = final price of water

Segment No.	Price Elasticity of Demand
1	-5.36
2	-3.23
3	-2.17
4	-1.53
5	-1.11
6	-0.81
7	-0.58
8	-0.41
9	-0.27
10	-0.15

Table VI. Price Elasticity of Domestic Water Demand

For domestic water demand, segment 5 has approximately unit elasticity and the absolute value of price elasticity is 1.11 and the corresponding prices are 233 MMK/m^3 and 195 MMK/m^3.

CONCLUSIONS

In this study, questionnaire survey was conducted to the 286 sample households of Mandalay due to lack of reliable demand information. Contingent Valuation Method is used in questionnaire survey. In questionnaire survey, three sections include such as (i) socio economic and demographic characteristics, (ii) existing water source and water use characteristics and (iii) willingness to pay to water pricing. Factors affecting to the willingness to pay are analysed by Linear Regression Model. In the regression analysis, the independent variables such as age, education level, household income, initial bid and primary water source were found to have a statistically significant impact on willingness to pay. The other variables such as gender of the respondent and family size did not have statistically significant effects on willingness to pay to water pricing. The mean willingness to pay value from regression analysis is 252 MMK/m^3. WTP values and households monthly water consumption data were put in water demand curve. The demand curve is drawn by MATLAB Programming to obtain the values of two points on the segment. Arc elasticity takes the average of two points on the segment. In this method, mid-point formula is used to determine price elasticity which is more accurate measure of percentage changes. The upper price and the lower price of unit elastic value are 233 MMK/m^3 and 195 MMK/m^3 respectively. Based on this study, it is concluded that the water pricings for domestic water in Mandalay is more than the current water tariff and the perception of water pricing of the consumers in Mandalay is in better condition.

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