Economic Value of Groundwater Protection in the Mekong Delta

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Abstract: Groundwater in the Mekong Delta is facing severe levels of pollution and it is apparent that new measures are needed to ensure its protection. Applying the contingent valuation method, the mean willingness to pay estimated by the Probit model was 141,730 VND (US$8.86)/household/year. Groundwater could be an inferior good in the Delta with the negative income effect found in the demand for clean groundwater. There were eight statistically significant variables – both exogenous and endogenous – related to the WTP response while there were only four statistically significantly exogenous variables affecting the maximum offer price a respondent voted for in the OLS model. Respondent's gender and groundwater-related health risk consideration were factors sensitively affecting the WTP values. Household income had a positive effect on the probability of demand for groundwater protection.

Key words: Contingent valuation, willingness to pay, groundwater pollution, Probit model, sensitivity analysis, scenario analysis.

1. INTRODUCTION

1.1 Background

The Mekong Delta (MD) is facing problematic levels of pollution of its groundwater resource. The pollution sources include contamination by agriculture activities, surface pollutants by incompetent drilling wells, natural phenomenon such as arsenic pollution, and salinity due to over-extraction. Firstly, in the modern input-based agriculture economy, water resources are seriously degraded. Along with rivers and canals, groundwater aquifer is being polluted. The contamination by agriculture production is a consequence of overusing pesticides, fertilizers, and other chemical materials. Viet (1998) showed that agro-bio chemicals were found in the groundwater sampled. Quyen (2005) reported that pollutants as Cl^-, SO_4^-, NO_3^-, NO_2^-, NH_4^+, PO_4^{3-}, etc., were found in many places in the MD and its concentrations were higher than the Vietnam standards for drinking water. These pollutants infiltrate into groundwater through incompetent tubewells that are found in many places in the MD. It is said that in the MD more than 15 percent of private-dug wells cannot be used because of improperly drilling (VNN 2003). The fact that well drilling is not performed by experienced technicians results in a large number of wells being rendered unusable, Consequently, these wells are discarded and can be polluted. Secondly, the fact that arsenic pollution in groundwater has just been observed at many places in the MD raises more concern about the health risks for its residents. Long An, Dong Thap, An Giang, and Kien Giang are provinces having a very high possibility of arsenic pollution in groundwater (Youth 2006). It is said that arsenic is a culprit for skin cancer to humans. Preventing the source of pollution and using other alternative water sources has become the main priority in combating this issue. Finally, salinity of groundwater caused by over-extracting is another source of groundwater pollution in the MD. The variance of the water table between the rain season and the dry season tends to increase year to year. At some places people cannot use groundwater for domestic use because of the salinity although they may have been able to do so easily in the past. Managing groundwater production is considered as a measure to protect this invaluable natural resource.

Groundwater needs to be protected. Policies implemented should be based on responses of the consumers who are directly affected by the quality of groundwater. Households' perception on groundwater-related issues decides their behavior to the potential markets through the price or the willingness-to-pay (WTP) to prevent the pollution that they are affected by. The potential or contingent markets for public goods like groundwater are policies proposed to prevent the pollution. Economically, WTP estimate is to measure the monetary amount that the household is willing to pay to avoid the loss (problems associated with/from) from pollution. In other words, an economic valuation of groundwater protection measures the social welfare to be maintained if the pollution problem can be avoided.

In this study, a contingent valuation method (CVM) is used to estimate household preferences for protected groundwater. A contingent market contains several elements which are required to elicit theoretically valid measures of WTP during a household survey (Mitchell and Carson 1989). A respondent is introduced to a hypothesized market presenting a proposed groundwater protection program (GPP) and a WTP value is then asked for contribution into the GPP fund.

1.2 Objective of the Study

The main objective of the study is to measure the economic value of groundwater protection in the MRD region. The specific objectives are:

1. to estimate household's WTP for the groundwater protection;
2. to evaluate potential factors affecting a household's WTP; and
3. to propose the agenda to action for groundwater management.

The paper is presented in five sections. The first section is to introduce a background on the groundwater pollution situation and describe the objective of the study. The next section presents the methodology applied to conduct the study. The modeling helps to understand how a CVM survey is prepared and implemented to measure the household preferences in terms of WTP value. A detailed sampling strategy and questionnaire design are also presented in this section. To ensure that the WTP estimate in the study is relevant for a public good such as groundwater, a CVM literature relating to groundwater is reviewed in the third section. The fourth section presents the results of the study in which household's knowledge and perception about groundwater and pollution-related issues, determinants of WTP response, and WTP values are described in detail. Finally, the fifth section presents a conclusion and recommendation for policies proposed.

2. METHODOLOGY

2.1 Conceptual Framework

To value environmental goods like improved groundwater quality, the CVM is used in this study. The household WTP, including use and non-use or passive values, is estimated based on the hypothesized market. The CVM is aimed to elicit the WTP in monetary value. In general, the CVM survey consists of three parts.

The first part is the section that describes the environmental goods and a hypothesized market scenario for the respondent. It represents household's knowledge and perception about groundwater resources, groundwater protection service, the baseline level of the provision including a subjective probability of future contamination, and the method of payment for the respondent. The second part consists of questions that elicit the WTP for the service. The valuation process is designed to eliminate or at least minimize the bias on the WTP answers. The third part includes questions related to the household's demographic such as age, sex, income and so on. The information in this section is used in regression equations to estimate a valuation function for the groundwater protection service.

2.2 The Theoretical Model

This study applies the utility difference framework favored by many analysts (e.g., Hanemann 1984, 1996; Sun et al 1992, McFadden et al. 1993) to estimate the WTP for groundwater protection. Suppose that an individual derives a Hicksian private good (X) and a public good groundwater (W). The maximization problem is presented as follow:

$$U = U(X, W) \quad (1)$$
$$\text{s.t} \quad P_x X + P_w W = Y$$

where U(X, W): utility function with respect to private goods quantity (X) and public good quantity groundwater (W)
P_x, P_w: price of private goods and public good groundwater, respectively.
Y: household income

Solving Model (1) will yield the indirect utility function V(.):

$$V = V(P_x, P_w, Y) \quad (2)$$

Assume that CVM survey presents a household maximum WTP to maintain a provision of groundwater at the present level (Q^0) from a future worse level (Q^1) if groundwater is not protected from pollution. The model of household's WTP for protecting groundwater quality is presented as follow:

$$V(Y, P_x, P_L|S) = V(Y - WTP, P_x, P_H|S) \text{ [1]} \quad (3)$$

Where S: household characteristics
P_L: current low price of groundwater

[1] Q^0 and Q^1 are eliminated assuming that the groundwater quantity is the same under with or without the GPP. In this case only price of groundwater is changed. That is why we denote P_H and P_L for P_w

P_H: higher price of groundwater if it is contaminated in the future.

Model (3) shows that the WTP is the decrease in income which makes an individual indifferent between protecting or not protecting groundwater quality. WTP is also explained as the compensating variation measure of a change in welfare. It is a measure of the total economic value that a household pays to protect groundwater from pollution. Protecting groundwater quality brings some benefits for the groundwater users. These benefits include use values such as avoiding health risks, reducing higher water costs due to treatment or other water purchases as well as non-use or passive values. Thus, when a person indicates a WTP to purchase groundwater quality by protecting groundwater from pollution, he or she is purchasing a set of environmental services.

Follows Sun et al. (1992), the effects of supply and demand uncertainties are introduced into the Model (3). Let δ be a person's subjective estimation of contamination probability without the GPP. With the GPP, δ is assumed to be zero. Let γ be a person's subjective estimation of future demand. As a result, a model for economic valuation of groundwater quality protection incorporated into subjective estimation of groundwater supply and demand is represents as follow:

$$\gamma V(Y - WTP, P_x, P_L|S) + (1-\gamma)V(Y - WTP, P_x|S)^{2} = \delta V(Y, P_x, P_H|S) + (1-\delta)V(Y, P_x, P_L|S) \quad (4)$$

The dichotomous choice or yes/no question approach is used to estimate the WTP (Edwards 1988, Schultz et al. 1989, Sun et al. 1992, Caudill 1992, Caudill et al. 1992, Poe 1993, Poe et al. 1992 1993, Clemons et al. 1995, Whittington et al. 2002, Nam et al. 2005). In addition, Carson, Groves and Machina (1999), cited by Nam (2005), argue that "the close-ended format is incentive compatible when a survey is perceived by respondents as a potential source of influence on policy decision-making." Because of this argument, the two types of elicit question are used to estimate WTP and then be compared each other in order to evaluate the efficiencies of the estimates. For the yes/no question, a respondent is asked whether or not he or she would be willing to pay an offer price of X VND in order to have groundwater quality assured by the GPP. Theoretically, the respondent will accept the price if his utility does not decline under the Program, i.e.,

$$\gamma V(Y - X, P_x, P_L|S) + (1-\gamma)V(Y - X, P_x|S) + e_1 \geq \delta V(Y, P_x, P_H|S) + (1-\delta)V(Y, P_x, P_L|S) + e_0 \quad (5)$$

Where e_1 and e_0 are random variables with zero means.

[2] the absence of PL in $V(Y - WTP, Q^0, P_x\ S)$ shows that groundwater is not consumed.

From the Model (5) the probability of a "yes" response to the WTP question is written as follow:

$$Pr(Yes) = Pr\{\gamma V(Y - X, P_x, P_L|S) + (1-\gamma)V(Y - X, P_x|S) + e_1 \geq \delta V(Y, P_x, P_H|S) + (1-\delta)V(Y, P_x, P_L|S) + e_0\} \quad (6)$$

If ŋ is defined as $ŋ = e_1 - e_0$, then

$$dV = [\gamma V(Y - X, P_x, P_L|S) + (1-\gamma)V(Y - X, P_x|S)] - [\delta V(Y, P_x, P_H|S) + (1-\delta)V(Y, P_x, P_L|S)] \quad (7)$$

In a reduced form, the Model (7) can be described as a function:

$$dV = K(\gamma, \delta, X, Y, P_H, P_L, S) \quad (8)$$ [3]

If Fŋ(.) is the cumulative distribution function for the random variable ŋ, then Pr = Fŋ(dV). Thus, the dichotomous choice approach can be interpreted as the outcome of the utility-maximizing choice (Hanemann). In the study, the probit model with assumption that Fŋ(.) is the standard normal cumulative distribution function of the standard logistic variate is used as follow:

$$Pr(Yes) = [1 + \exp(-dV)]^{-1} \quad (9)$$

Or

$$Pr(Yes) = [1 + \exp(-K(\gamma, \delta, X, Y, P_H, P_L, S)]^{-1} \quad (10)$$

Using the linear utility model for the probit model in (10), the WTP is calculated as follow:

$$X = (-\Sigma^{n}_{j=1}\alpha_j Z_j)/\beta \quad (11)$$

Where X: option price or the WTP

β: the option price coefficient

Z_j: means of other independent variables described in Equation (10)

α_j: the estimated coefficients associated with Z_j

2.2.1 Study Location

The study was conducted in Soc Trang province. It has an area of 3,223 km^2 and a population of approximately 1,213,400. It is bordered to the north west by Hau

[3] As the utility difference in the Model (7) is solved, P_X drops out of the equation.

Giang Province and Can Tho City, the south west by Bac Lieu Province, the north east by Tra Vinh Province, the north by Vinh Long Province, and the south east by South Chinese Sea. The major ethnic groups includes Kinh, Khmer, and Chinese. Like other areas in the MD, its agriculture economy is characterized by heavy using of fertilizers, pesticides, and other bio-chemical agents. In recent years it is reported that there is a clear evidence of existing of nitrates and other pollutants from agriculture activities found in samples. Although groundwater is still used for domestic uses within safe contaminant levels, there is a high possibility that the groundwater contamination will accelerate to unsafe levels if groundwater is not protected.

In 2005, 77 percent of the population were living in the rural areas. About 64 percent of the Soc Trang population had access to clean water for domestic use, this included those accessing groundwater. The economic valuation problem for groundwater protection from pollution is defined as the measurement of benefits of protecting currently "safe" groundwater from the potential future contamination.

2.2.2 Research Design

The CVM surveys generate data sets about the responses on household characteristics, attitudes and opinions and WTP responses (Bateman et al. 2002). In this study, CVM survey was used to elicit a household's WTP to eliminate potential future groundwater contamination from pollution. The survey questionnaire contained a hypothetical referendum designed to measure a household's WTP for the GPP which would help protect groundwater from pollution. The CVM survey consisted of three parts. The first part described knowledge and perception of a respondent about environmental issues and groundwater resource as well and a hypothesized market scenario used to elicit household's WTP. In describing hypothesized market, the potential future groundwater contamination by types of pollution such as agricultural chemical and natural pollutants (such as iron and arsen) was discussed. Then the GPP was introduced to invite people to build the fund for preventing or eliminating the pollution or at least maintaining the currently "safe" groundwater quality by installing the treatment equipment to remove the toxic in groundwater. Appendix 1 presents the description of CVM Scenario 1. To test whether respondent's answers to the willingness-to-pay questions were sensitive to the "scope" of the environmental service groundwater protection, a second method of removing toxins from groundwater was described in the questionnaire, This second method used chemical treatment instead of treatment equipment. Thus, a split-sample was used to test the for "scope" or "embedding" effects of the CVM survey (Kahneman et al. 1992, Boyle et al. 1994, Carson et al. 1995). The second part consisted of questions that elicit the WTP for the groundwater protection. The valuation process was designed to minimize the selection bias on the WTP answers. Respondents were asked to vote for the GPP given the amount of income reduction (e.g., offer price). For those who voted for the GPP, in order to get additional information, open-ended question of the maximum WTP was asked. For those who did not vote for the GPP, the follow-up questions were asked to examine the selection sample bias. Moreover, to examine whether the WTP referendum was consistent with the respondent's concern about the GPP, questions on the opinion of voter for the GPP were designed in this section. The third part included questions on the household's demographic such as age, sex, income and so on. The information in this section was treated as exogenous variables and used in regression equations to estimate a valuation function for the groundwater protection service. Additionally, the subjective evaluation of the household on groundwater supply and demand was also asked in this section.

Before designing the questionnaire, the focus group discussion was conducted to get the information sufficient for the CVM situation in the study site. Based on the preliminary questionnaire, a pre-test with a small sample was done. As a result, a CVM questionnaire was completed and ready for the survey.

2.2.3 Sampling Strategy and Survey Procedure

The questionnaire was initially applied in a small pilot survey to give more statistics information for the decision on selecting a suitable sample size[4]. The formal survey was implemented in five districts of Soc Trang Province; they are Thanh Tri, Nga Nam, My Xuyen, My Tu, and Soc Trang Town. The questionnaire was asked by using face-to-face interview technique. Five hundred and ninety eight households were randomly selected by the cluster sampling technique for the first CVM scenario in which groundwater was hypothetically treated by using a water filtering equipment. Cummings (1986) stated that if a person bids zero as a protest to being asked to pay for an environmental good, the bid is not an indicator of his true valuation. Protest bids are inconsistent with an implicit model of contingent valuation behavior. So, these bids are screened out of the sample. Respondents who bid zero were asked to provide a reason. As a result, a sample of five hundred and seventy four households was selected in the study. Additionally, a split sample of eighty eight households was randomly selected with the same sampling technique for the second CVM scenario in which groundwater was hypothetically treated by using a chemical technique. Both samples were divided into eight subgroups. Each of these subgroups received one of eight offer prices assigned for the referendum question. The offer prices were VND 50,000, VND 75,000, VND 100,000, VND 125,000, VND 150,000, VND 175,000, VND 200,000, and VND 250,000 respectively. These offer prices were based on the

[4] Sample size determined to the official survey follows the formula $se_{WTP} = \sigma/n^{1/2}$

focus group discussion and the results of pretest survey. Table 1 details the sample structure and the proportion of respondents who voted for the offer price referendum question.

Table 1: Sample structure and percentage of respondents voting for the offer price

Offer price (VND)	Sample mechanism in offer prices (%)	Scenario 2: chemical use (n = 88) (%)	Scenario 1: use filtering equipment (n = 575)		
			Tubewell user (%)	GSU user (%)	Total (%)
50,000	12.4	80	79	76	78
75,000	12.2	78	88	70	78
100,000	12.9	92	81	84	84
125,000	11.9	36	68	89	75
150,000	12.8	83	73	61	66
175,000	12.7	64	70	78	73
200,000	12.7	64	74	59	70
250,000	12.4	55	67	60	63
Total	100.0	-	-	-	-

3. REVIEW OF LITERATURE

For environmental goods like groundwater protection service, pricing its value differs from private goods. Various methods of economic valuation are developed and applied in the real world. Many studies are implemented in developed countries while few of them are conducted in developing countries. There are basically two approaches to economic valuation, namely, stated preference and revealed preference methods. Among valuation techniques of stated preference method is the Contingent Valuation Method (CVM). This section will make a review of CVM literature related to water resources that is relevant in the study.

In developed countries there are various CVM studies for water-related goods. Edwards (1988) presented WTP estimates for a “regional aquifer management plan” in Cape Cod, Massachusetts. Data was collected with a mail survey (59% response rate). Annual WTP estimates were elicited with dichotomous choice questions. The payment vehicle used was a bond referendum. The WTP estimates were found to be sensitive in the expected directions to income, demand uncertainty and supply uncertainty. Option prices ranged from $581 to $2324 as the change in supply uncertainty from 25% to 100%, assuming demand certainty. At the average supply uncertainty, 80% of the average annual option price was $1858 with demand certainty.

Schultz et al. (1989) estimated WTP, including both direct use and passive use values, for groundwater protection plans in Dover, New Hampshire. The payment vehicle was an increase in property taxes and the WTP question was of dichotomous choice. In the empirical models, WTP varied in the expected direction (expected sign in parentheses) with land use (+), age (-), and household income (+).

Sun et al. (1992) used the CVM technique with dichotomous choice and open-ended questions to estimate option price for groundwater quality protection regarding the effects of subjective demand and supply uncertainty. The payment vehicle used was a reduction in the amount of income a respondent had to spend on other goods and services. Valuation results suggested that the monetary benefits to citizens of protecting groundwater supplies from agricultural chemical contamination were quite large. A regression model revealed that WTP increased with income, concern about health risks, and the subjective probability of future contamination.

McClelland et al. (1992) conducted a CVM study of survey designed using a payment card system in order to estimate valid passive use values for a program to completely clean 40% of the contamination of national groundwater from landfill pollution. The contamination level was described as requiring treatment of water for drinking and cooking. The payment vehicle used was an increase in the water bill. Results showed that WTP varied with income (+), age (-), race (+ for Caucasian), education (+), and other scenario specific variables.

Caudill (1992) and Caudill et al. (1992) estimated groundwater protection benefits in Michigan. Use and passive use values were elicited through a mail survey (67% response rate) with dichotomous choice and open-ended WTP questions. The payment vehicle used was higher taxes. The average annual WTP was $65 which increased with income and education.

Poe (1993) and Poe et al. (1992, 1993) reported findings from a groundwater valuation study in Portage County, Wisconsin. Information about groundwater contamination (i.e. nitrates and baby blue syndrome, nitrates and cancer) was presented in the CVM questionnaire. Using CVM design with a dichotomous choice question and the payment vehicle of a combination of increased taxes, lower profits, higher costs, and higher prices the WTP value was estimated at $290 for the protection program. In this study, the ex-ante study was experiment in a way that all respondents were invited to have their groundwater tested; then along with presentation of the nitrate test results, another survey was conducted where respondents had good information about their health risks.

Jordan et al. (1993) estimated the WTP to protect safe drinking for two types of water consumers, namely, those using municipal sources and private wells. A mail survey obtained payment card WTP data for 180 Georgia residents. The proposed policy was installation and maintenance of equipment to clean water for private well users and cleaning by the local water supply company for uses of other sources. For the private well users, WTP increased with income, high school degree and if the respondent lived on a farm, was female, or Afro-America. For the municipal sources users, WTP increased with income, high school degree, and if the respondents were female, Afro-American, or uncertain about their current water quality.

Powell et al. (1994) and Powell (1991) reported on a CVM study with a payment card WTP data and payment vehicle of water bills (if public water supply) and property taxes (if private water supply). In regression models, WTP increased with income, perceptions about safety risk, experience with drinking water contamination, expenditures on bottled water, private wells as the water sources, and number of perceived contamination sources.

Boyle et al. (1994) used CVM technique to measure the benefits of groundwater protection. The study found that much of the variance in WTP was related to the differences CV scenarios. Based on the conceptual model of groundwater value under uncertainty, WTP varied in the expected direction with the magnitude of the change in probability of contamination for the nitrate (+), the costs of substitute sources of drinking water (-), income (+), whether the policy was simply to contain the contamination (-), whether use values were the focus of the study (-), and a reduction in the drinking water supply relative to seeking other sources of drinking water (+).

Goffe (1995) developed a contingent valuation for two goods: improved water salubrity and preservation of the ecosystem against eutrophication. The WTP values were explained using Tobit models. Whatever the good, the WTP was seen to rise with revenue. People accepted the exercise of contingent valuation and were willing to give important amounts.
Clemons et al. (1995) conducted a CVM study with a dichotomous choice WTP question and the payment vehicle of an increase in the current water and sewer bill used. In this study two contingent markets were used to describe a groundwater protection program that would eliminate the risk of exposure to nitrate and VOC contamination of the water supply. The ordering of presentation of these markets

was randomly varied. The results showed that the only independent variables which help to explain the yes/no responses to the WTP question were number of years as a local resident for the nitrate program, income, and perceived seriousness of contamination for the VOC program, Detailed information about nitrate contamination and the objective risk of contamination did not influence responses.

Krug (1995) estimated the WTP for drinking water quality in western Massachusetts. Respondents were presented with two policy options, namely, a public aquifer protection plan or the installation of a private pollution control device in the tap. Payment card WTP questions and payment vehicle of utility bills (if public water supply) and a price for the pollution control device (if private water sources) were used in the study. The results showed that annual household WTP was $67 and $79 for the public and private water supplies, respectively.

Laughland et al. (1992, 1996) presented open-ended WTP estimates for alternative water source options. Here the payment vehicle used was utility bills. Results showed that annual household WTP averaged $276 for the first choice among the three alternative water sources. In a regression model, they found that WTP increased if the respondents had attended a public meeting about the contamination episode. However, WTP was not statistically related to income, water risk perceptions and other demographic variables.

In the developing world, CVM survey for water-related goods was also implemented in recent years. Whittington et al. (1993) used the CVM technique to estimate the household demand for improved sanitation services in Ghana. The result showed that the demand for water and sanitation is large. Moreover, the social and cultural factors had little effect on the willingness to pay of the people.

Choe et al. (1996) used the CVM technique with a three question form of referendum, follow-up yes/no, and open-ended question to estimate the economic value that the people in Davao of the Philippines placed on improving the water quality of the rivers and sea near their community. Results suggested that water pollution control is not of high priority for the residents and supported the argument that households' willingness to pay for environmental amenities such as improved water quality is low.

Whittington et al. (2002) used the CVM technique with yes/no questions to estimate household's demand for improved water services in Kathmandu, Nepal, where the government considered the possibility of involving the private sector in the operation of municipal water supply services. The results provided the first evidence from South East Asia that household's willingness to pay for improved water services was much higher than their current water bills.

Phuong (2003) used the CVM technique to estimate the loss of value of water resources due to pesticide contamination in the Mekong Delta of Vietnam. Results showed that the economic losses were about US$251 million.
Nam et al. (2005) applied the CVM technique with single-bounded dichotomous choice questions to derive household's WTP for improved water services in Ho Chi Minh City, Vietnam. The payment vehicle was household's monthly water bill. The results showed that the WTP amount for improved water services was higher than the sum of their existing water bills plus coping costs like collecting, pumping, treating, storing or purchasing water.

4. FINDINGS AND DISCUSSIONS

4.1 Profile of Respondents

The sample population had an average age of 42.3 in which 56.7 percent of respondents were greater than 40 years old. Average years going to school were 7.37 in which 35.6 percent, 25.2 percent, 25.6 percent, and 13.6 percent of sample population were at primary, secondary, high school, and higher levels respectively. Forty Nine percent of respondents were male. Forty Eight percent of the respondents were farmers. Seventy Five percent of households in the sample lived in rural areas. Fifty Five percent of respondents in the sample belonged to the Kinh ethnic group; 40.9 percent were of Khmer origin, and 4.1 percent were Chinese. The average number of family members was 5.05. The household income was on average 2,025,038 VND per month.

Households selected in the sample were those who were using groundwater from private tubewells and Groundwater Supply Units (GSUs) managed by the state and private companies at the proportion of 54 percent and 46 percent respectively. In evaluating the subjective probability of supply and demand for the groundwater in the future, forty eight percent of respondents, when asked whether the groundwater in the area would be polluted during the next five years, answered "yes". Within the next five years, 10.6 percent of households planned to move to another place. Moreover, the effect of groundwater pollution to human health was concerned by 88.4 percent of the sample population. Table 2 shows the mean statistics of socio-economic and demographic variables and other variables used in the multivariate analysis. Grouping into classes of households allows taking into account the differences across households under the first CVM scenario.

Table 2: Mean statistics of independent variables in multivariate analysis

Variable	Descriptions of Independent Variable	Scenario 1					Scenario 2	Hypothesized Sign for Co-efficient
		GSU Household	Tubewell Household	Urban Household	Rural Household	All		
	Socio-economic and Demographic							
INCOME	Income [a] (VND/month)	1,863,636 (965,352)	2,066,775 (1,285,135)	2,013,513 (1,237,105)	1,958,629 (1,121,764)	1,972,855 (1,151,909)	2,363,636 (1,598,719)	+
AGE	Respondent's age (number of years)	42.43 (13.549)	42.35 (13.481)	42.84 (12.384)	42.43 (13.883)	42.39 (13.501)	42.70 (12.465)	?
GENR	Respondent's gender dummy [b] (1 for male; otherwise 0)	0.46 (0.500)	0.49 (0.696)	0.45 (0.499)	0.49 (0.648)	0.48 (0.613)	0.55 (0.501)	?
EDUC	Respondent's education (number of years)	7.47 (3.585)	7.22 (3.724)	7.50 (4.016)	7.28 (3.528)	7.34 (3.659)	7.60 (3.716)	+
ETHIC	Respondent's ethnic dummy [b] (1 for majority; otherwise 0)	0.57 (0.496)	0.58 (0.494)	0.70 (0.458)	0.53 (0.500)	0.58 (0.495)	0.38 (0.487)	?
CAREER	Respondent's career dummy [b](1 for farmer; otherwise 0)	0.41 (0.492)	0.52 (0.500)	0.40 (0.491)	0.50 (0.501)	0.47 (0.500)	0.53 (0.502)	-
LOCATN	Respondent's location dummy [b] (1 for rural; otherwise 0)	0.75 (0.433)	0.73 (0.444)	-	-	0.74 (0.439)	0.82 (0.39)	-
FAMSZ	Family size (number of persons)	4.84 (1.923)	5.27 (2.170)	5.07 (2.004)	5.07 (2.093)	5.07 (2.069)	4.93 (1.818)	+

Table 2: Continued.

Variable	Descriptions of Independent Variable	Scenario 1					Scenario 2	Hypothesized Sign for Co-efficient
		GSU Household	Tubewell Household	Urban Household	Rural Household	All		
DEPN	Number of children (number of persons)	0.68 (0.820)	0.88 (1.055)	0.82 (0.966)	0.78 (0.956)	0.79 (0.958)	0.81 (0.993)	+
	Groundwater Situation							
USTYPE	Type of user dummy [b] (1 for private tubewell; otherwise 0)	-	-	0.56 (0.498)	0.53 (0.500)	0.54 (0.499)	0.44 (0.500)	?
DEMAND	Demand probability [c]	0.91 (0.293)	0.86 (0.347)	0.52 (0.501)	0.91 (0.282)	0.88 (0.323)	0.97 (0.183)	+
SUPPLY	Supply probability [d]	0.55 (0.498)	0.52 (0.500)	0.56 (0.498)	0.52 (0.500)	0.53 (0.499)	0.35 (0.480)	-
	Opinions and Attitudes							
POCONN	Respondent's concern about groundwater pollution dummy [b] (1 for having concern; otherwise 0)	0.52 (0.501)	0.53 (0.500)	0.52 (0.501)	0.53 (0.500)	0.53 (0.500)	0.52 (0.502)	+
WQUAL	Respondent's evaluation on groundwater quality. (1 for extremely good, 5 for very bad)	2.98 (0.910)	2.90 (0.915)	2.99 (0.973)	2.92 (0.892)	2.94 (0.913)	3.20 (0.697)	-

Table 2: Continued.

Variable	Descriptions of Independent Variable	Scenario 1					Scenario 2	Hypothesized Sign for Co-efficient
		GSU Household	Tubewell Household	Urban Household	Rural Household	All		
ENVAL	Respondent's evaluation on the environment issue dummy [b] (1 for seriously bad; otherwise 0)	0.17 (0.373)	0.16 (0.369)	0.17 (0.381)	0.16 (0.367)	0.16 (0.370)	0.20 (0.406)	+
HECON	Respondent's concern about health impact of using groundwater. (1 for extremely concerned, 5 for not concerned at all)	2.51 (0.966)	2.25 (0.940)	2.44 (0.940)	2.35 (0.967)	2.37 (0.960)	2.60 (0.891)	-

numbers in parentheses are standard deviations.
[a] income is evaluated at mid-point.
[b] mean estimates of dummy variables should be interpreted as percentage.
[c] estimated subjective probability of clean groundwater demand within 5 years. It is calculated by the formula (1-MOVE), where MOVE is the probability of moving out of the village.
[d] estimated subjective probability of clean groundwater supply in 5 years. It is followed by the assumption of the possibility of groundwater contamination evaluated by the respondent.

4.2 Perception on Environmental and Groundwater Resource Issues

Social and environmental problems are great challenges for the people of the MD. Among 662 respondents interviewed, 30 percent stated that poverty was the biggest challenge for the MD while environmental issues were seen as the most challenging of issues by 17 percent of people asked. Interestingly, environmental issues took much more attention than other social issues such as poor infrastructure, low status of education, and social inequality at the voting rate of 11 percent, 8 percent, and 5 percent, respectively. This shows that in the MD environmental issues have been a raising concern relative to other development issues. Corresponding to this evaluation, 61 percent of respondents said that government funds should be used for reducing poverty; 16 percent supported the use of government funds for environment programs; 11 percent voted for infrastructure improvement; 9 percent voted for education upgrading; and 4 percent voted for inequality alleviating programs. Finally, in evaluating the role of the government for environmental problems, 64 percent of respondents thought that environmental and natural resources management in the MD was under control and was currently not a problematic issue.

In relation to groundwater resources, more than 70 percent of respondents subjectively judged that the quality of groundwater for domestic use was relatively good. Causes for the possibility of groundwater pollution were the improper drilling of tubewells, contamination from livestock production activities, industrial waste discharge, and over-extraction by small scale private tubewells and large scale water-plants. Thirty five percent of respondents had heard or learnt information regarding groundwater pollution around their living area. The information on the pollution issue was collected mainly from media such as radio, television, and local informers. In the study, the perception of groundwater resources by the public was summarized in Table 3. It shows that most of the problems relating to groundwater protection were supported by the households.

4.3 Determinants of Willingness-to-pay Responses of Households

In estimating the WTP, variables affecting the responses of the households play an important role. Despite the difficulties in interpreting the analysis of WTP data of endogenous variables (Bateman et al. 2002), along with exogenous variables they were used to form the WTP model. Endogenous variables are those whose values are determined through choices made by the household. Exogenous variables are those over which the household has no choice, In this study two kinds of variables are jointly used to determine the WTP responses of the household. Socio-economic and demographic variables are defined as exogenous variables and groundwater situation, opinion and attitude variables are defined as endogenous variables. The signs expected for coefficients are also presented in Table 2.

Household income, education status, family size, number of children, and demand probability for clean groundwater were variables expected to have positive signs in the Probit model. Meanwhile, supply probability for clean groundwater variables and respondent's concern about the health impacts of using groundwater were expected to have negative signs. Besides forming the sign hypotheses for quantitative variables, expected signs of dummy variables were also given. Those who live in rural area such as farmers, and respondent's subjective evaluation on current groundwater quality were variables expected to have negative signs. Conversely, respondent's concern about groundwater pollution, and respondent's rating on the environmental issues were variables expected to have positive signs. Finally, coefficients for the variables: respondent's age, gender, ethnicity, and type of groundwater user (i.e., either private tubewell or the GSU) could not form the prior signs.

Table 3: Opinion of the public on groundwater protection

(1: extremely agree, 5: extremely disagree)

Issue	Score
The government should raise more funds to deal with groundwater protection programs in the MD	1.52 (0.855)
There are other environmental concerns more important than groundwater pollution issue	2.83 (1.283)
Groundwater protection/management should be under law.	2.04 (1.150)
It is everyone's duty to ensure that groundwater use is sustainable now and in the future	1.79 (0.930)
People should contribute to protect groundwater from pollution by making cash donations to funds	2.31 (1.168)
The government should repair wells polluted	2.11 (1.263)
Groundwater protection programs should not be a priority concern of the government	3.47 (1.456)

numbers in parenthesis are standard deviations.

4.4 Contingent Valuation Results

The WTP responses of respondents associated with Scenario 1 were used to estimate household's willingness to pay for protecting groundwater from pollution. There were two kinds of WTP estimation depending on what kinds of data was used to elicit the willingness to pay of the respondent. For the dichotomous-choice question with the analysis based on binary data, a Probit model was used. For the open-ended question with the analysis based on continuous data, the WTP mean and median were estimated using survival analysis.

The first approach used the answers from the initial referendum question with only either "yes" or "no" answers to the proposed price. Results of the responses for each proposed price level were already showed in Table 1. It showed that most of people were willing to pay for the GPP within the next five years, The voting rate was very high ranging from 63 percent to 78 percent of the sample population. There was a general trend for all groups of households, as the proposed price increased, that the percentage of respondents supporting the GPP decreased. To model the determinants of WTP responses to the initial referendum question, an individual was assumed to compare his or her current utility level to the utility level that would be obtained under the GPP program described in Scenario 1, and the amount of paying per year within next five years. A Probit model was used to explain the initial votes for and against the program. Table 4 presents the results of the multivariate analyses from OLS and Probit models.

The Probit model results in Table 4 shows that the higher the monthly price offered to the respondents, the less likely they were to vote for the GPP. It was consistent with the behavior of the household followed by rule of demand. All estimators, which were statistically significant, except for household income had the signs as expected. Surprisingly, household income had a negative relationship with the voting for the GPP. This can be explained as follow. If it is not difficult to get clean water from the tubewell or easy to buy from the GSU, it is a normal good. In this context, the relationship between household income and the demand for clean water (by voting for the GPP) is positive. Conversely, if the possibility of accessing clean water is at the edge of the risk, for instance, due to contamination, it could be an inferior good. In this case, as the prediction of demand theory, the demand for clean water decreases as household income increases. The result also means that clean water is a necessary good for people in the MD. The results from the Probit model show that household income, respondent's gender, and education status were exogenous variables, which are statistically significant determinants of household response to the referendum question. The lower the household income, the more likely the respondent was to support the GPP. The marginal effect of 100,000 VND decrease in monthly household income on the probability of accepting the suggested price was small at 2.0 percent. The marginal effect of a year increase in education on a respondent's accepting the suggested price was 4.3 percent. The probability of accepting the suggested price by a male head was higher than a female head, by about 1.6 percent.

Table 4: Multivariate analysis of household's willingness to pay for groundwater protection

Variable	PROBIT Model	OLS Model
Dependent Variable [a]	VOTE	FINALBID
Independent Variable		
Constant	1.3660 (0.000)	-55,437 (0.223)
Initial price (VND/month)	-.00000295 (0.007)	0.5751 (0.000)
Income [b] (VND/month)	-0.00000003 (0.096)	0.0089 (0.069)
Respondent's age (number of years)	-0.0038 (0.507)	966.63 (0.044)
Respondent's gender dummy [c] (1 for male; otherwise 0)	0.4889 (0.001)	8,215 (0.350)
Respondent's education (number of years)	0.0236 (0.084)	4,358 (0.017)
Respondent's ethnic dummy [c] (1 for majority; otherwise 0)	-.03156 (0.826)	8,977 (0.472)
Respondent's career dummy [c] (1 for farmer; otherwise 0)	-0.0169 (0.907)	-23,551 (0.059)
Respondent's location dummy [c] (1 for rural; otherwise 0)	-0.2470 (0.100)	16,582 (0.101)
Family size (number of persons)	-0.0026 (0.945)	-3,984 (0.213)
Number of children (number of persons)	-0.0484 (0.554)	-5,476 (0.418)
Type of user dummy [c] (1 for private tubewell; otherwise 0)	0.0511 (0.714)	25,048 (0.030)
Demand probability [d]	0.2409 (0.088)	9,913 (0.560)

Table 4: Continued.

Variable	PROBIT Model	OLS Model
Supply probability [e]	-0.0909 (0.535)	-3,014 (0.807)
Respondent's concern about groundwater pollution dummy [c] (1 for having concern; otherwise 0)	0.1178 (0.092)	9,393 (0.414)
Respondent's evaluation on groundwater quality. (1 for extremely good, 5 for very bad)	0.0233 (0.771)	952.90 (0.884)
Respondent's evaluation on the environment issue dummy [c] (1 for seriously bad; otherwise 0)	0.2409 (0.100)	1,878 (0.906)
Respondent's concern about health impact of using groundwater. (1 for extremely concerned, 5 for not concerned at all)	-0.3906 (0.000)	-3,847 (0.585)
Log(L)	-226	-
χ^2	58.08	-
N	505	399
(Pseudo) R-squared value	0.1137	0.1806

numbers in parentheses are p-values.

[a] VOTE is yes/no variable for voting the initial price; FINALBID is the highest/maximum price that a respondent votes in open-ended question.

[b] income is evaluated at mid-point.

[c] mean estimates of dummy variables should be interpreted as percentage.

[d] estimated subjective probability of clean groundwater demand within 5 years. It is calculated by the formula (1-MOVE), where MOVE is the probability of moving out of the village.

[e] estimated subjective probability of clean groundwater supply in 5 years. It is followed by the assumption of the possibility of groundwater contamination evaluated by the respondent.

Besides exogenous variables being determinants of the WTP response in the Probit model, four endogenous variables were positively related to – and statistically significant determinants of – household responses to the referendum questions, Namely; subjective demand, respondent's concern about groundwater pollution, respondent's evaluation on the environment issue, and respondent's concern about health impacts of using groundwater. As the possibility of demand increase (proxy variable of not moving out the area within next five years) goes up one percent, the probability of accepting the suggested price increases 7.9 percent. The probability of accepting the suggested price as a respondent giving care to the pollution of groundwater was higher than those who did not care at 7.3 percent. Similarly, the probability of accepting the suggested price as a respondent evaluating the environment state currently very bad was higher than those who evaluating the environment state currently good at 15.1 percent. Finally, the marginal effect of a one point increase in concern about the health impact of using groundwater on a respondent's accepting the suggested price was about 4.4 percent increase.

Results in the OLS model showed that the initially proposed price positively affects the maximum price that a respondent was willing to pay for the program. The marginal effect of a 10,000 VND increase in the initial price on the maximum price was 5,751 VND. Results also showed that only exogenous variables presenting social-economic and demographic characteristics of households affect the maximum price that a respondent votes for the GPP. These statistically significant variables are household income, respondent's age, respondent's education status, and respondent's career. As monthly household income increases 100,000 VND, the maximum price a respondent is willing to pay was very small at 890 VND. As respondent's age increases one year, the maximum price he or she can pay was approximately 1,000 VND. As respondent's number of years at school increases by one year, the maximum price he or she can pay was 4,360 VND. This shows that education status plays an important role in perception of groundwater pollution problems a respondent faced. So, he or she was willing to pay more for the GPP. Finally, a respondent who is a farmer would pay less for the GPP compared to those who are not farmers, at 23,550 VND.

A separate set of multivariate analysis was also conducted to test whether CVM scenario affects household's WTP response. Results are presented in Table 5. All signs of coefficients for statistically significant variables are consistent with Table 4. This split-sample experiment designed to test for "scope" or "embedding" effects showed that respondent's answers were not sensitive to variations in the commodity described in the hypothesized markets. The coefficient for the dummy variable SCENARIO2 indicated that the scope effect did not happen in the Probit model. In other words, household's WTP response was not dependent on the commodity described in the hypothesized markets. One possible explanation of this result is that a single referendum question simply provides less information on a respondent's values than other referendum question formats; so, the Probit model cannot as readily discriminate between those who received the two scenarios (Hanemann, Loomis, and Kanninen 1991, cited by Choe et al. 1996). However, in the OLS model, the result showed that respondents were sensitive to the scope of the commodity described in the scenarios. Those who were offered the option of utilizing a chemical filtering system paid 27,591 VND less than those who were introduced to a regular filtering system. The highest amount of money paid by the former was less than 23.2 percent of the amount paid by the latter.

Table 5: Multivariate models testing the significance of the scope of CV scenarios

Variable	PROBIT Model	OLS Model
Dependent Variable	VOTE	FINALBID
Independent Variable		
Constant	1.1778 (0.000)	-40,438 (0.331)
Initial price (VND/month)	-0.000003 (0.003)	0.5660 (0.000)
Income [a] (VND/month)	0.00000002 (0.106)	0.0094 (0.021)
Respondent's age (number of years)	-0.0071 (0.104)	884.30 (0.051)
Respondent's gender dummy [b] (1 for male; otherwise 0)	0.4533 (0.001)	7,983 (0.324)
Respondent's education (number of years)	0.0173 (0.083)	3,564 (0.027)
Respondent's ethnic dummy [b] (1 for majority; otherwise 0)	-0.0491 (0.712)	6,728 (0.549)
Respondent's career dummy [b] (1 for farmer; otherwise 0)	0.0634 (0.633)	-20,907 (0.063)
Respondent's location dummy [b] (1 for rural; otherwise 0)	-0.1917 (0.104)	10,474 (0.183)
Family size (number of persons)	0.0040 (0.909)	-4,282 (0.107)
Number of children (number of persons)	-0.0722 (0.322)	-135.53 (0.982)
Type of user dummy [b] (1 for private tubewell; otherwise 0)	0.0617 (0.626)	22,226 (0.030)
Demand probability [c]	0.1560 (0.068)	12,586 (0.434)
Supply probability [d]	-0.0883 (0.518)	-5,982 (0.594)

Table 5: Continued.

Variable	PROBIT Model	OLS Model
Respondent's concern about groundwater pollution dummy [b] (1 for having concern; otherwise 0)	0.1467 (0.096)	7,843 (0.448)
Respondent's evaluation on groundwater quality. (1 for extremely good, 5 for very bad)	0.0198 (0.793)	76.87 (0.990)
Respondent's evaluation on the environment issue dummy [b] (1 for seriously bad; otherwise 0)	0.0739 (0.122)	4,480 (0.749)
Respondent's concern about health impact of using groundwater. (1 for extremely concerned, 5 for not concerned at all)	-0.3499 (0.000)	-2,926 (0.642)
SCENARIO2	-0.0272 (0.883)	-27,591 (0.080)
Log(L)	-268	-
χ^2	59.41	-
N	582	459
(Pseudo) R-squared value	0.0999	0.1781

numbers in parentheses are p-values.
[a] income is evaluated at mid-point.
[b] mean estimates of dummy variables should be interpreted as percentage.
[c] estimated subjective probability of clean groundwater demand within 5 years. It is calculated by the formula (1-MOVE), where MOVE is the probability of moving out of the village.
[d] estimated subjective probability of clean groundwater supply in 5 years. It is followed by the assumption of the possibility of groundwater contamination evaluated by the respondent.

The estimated coefficients of the statistically significant variables in the Probit model presented in Table 5 were used to calculate the Hicksian welfare benefits from the GPP to protect groundwater from pollution. Originating from the theoretical model (10), the econometric model used to estimate the WTP is presented in Equation 12 as follow:

$$\text{Prob(yes)} = \alpha - \beta_1 \text{INITIAL\_PRICE} - \beta_2 \text{INCOME} + \beta_3 \text{GENR} + \beta_4 \text{EDUC} + \beta_5 \text{DEMAND} + \beta_6 \text{POCONN} + \beta_7 \text{ENVAL} - \beta_8 \text{HECON} + \varepsilon \quad (12)$$

The Hicksian welfare benefits recovered from Equation (12) is showed as the following:

$$E[WTP] = (\alpha - \beta_2 INCOME + \beta_3 GENR + \beta_4 EDUC + \beta_5 DEMAND + \beta_6 POCONN + \beta_7 ENVAL - \beta_8 HECON)/\beta_1 \quad (13)$$

Using the mean values of independent variables in Equation (13), the economic benefit of protecting groundwater measured by the mean WTP value was determined at 141,730 VND (US$8.86) per year. At the 95 percent confidence interval, the mean WTP value ranged from 153,667 VND to 140,190 VND (approximately US$9.60-US$8.76)[5]. Those who were private tubewell users were willing to pay about 159,832 VND (US$9.99) per year and those who were GSU user were willing to pay about 117,527 VND (US$7.35) per year. Results showed that the option price that a GSU user was willing to pay for the GPP's fund was less than 26.5 percent of the price that a private tubewell user was willing to pay for.

Estimated WTP values using the information from the open-ended question were calculated by the survival analysis technique. The estimated mean and median for the log-logistic distribution used for policy implications on either efficiency or welfare distribution respectively (Bateman et al. 2002) were presented in Table 6. Since there is no upper bound on this distribution, the estimated WTP value from the left-censored responses increased the estimated mean for the assumed distribution. Result showed that the mean WTP and median WTP values were 122,838 VND per year and 100,000 VND per year, respectively. At the 95 percent confidence interval, the mean WTP and median WTP values ranged from 111, 429 VND to 134,247 VND per year and from 98,136 VND to 101,864 VND per year, respectively. Results also showed that the mean WTP value estimated by the first approach (i.e., single referendum choice question) was relatively higher than the mean WTP value estimated by the second approach (i.e., open-ended question) at the edge of 15.4 percent.

[5] Since the negative effect of household income, the lower bound and upper bound values had an opposite direction.

Table 6: Mean and median WTP values estimated by the survival analysis

Unit: VND

Mean option price	Standard error	95% confidence interval		Median option price	Standard error	95% confidence interval	
		Lower bound	Upper bound			Lower bound	Upper bound
122,838	5,821	111,429	134,247	100,000	951	98,136	101,864

To take into account the uncertainty in estimating the mean WTP value, a sensitivity analysis was done with the base case of 141,730 VND mean WTP estimated by the Probit model. For the continuous variable household income and the interval variables respondent's education level and concern on health risk, values used to estimate new mean WTP values were one standard deviation below and above the mean value. For the dummy variables respondent's gender, location, demand probability, concern on groundwater pollution, and environmental issue evaluation, values used to estimate new mean WTP values were zero and one. Results of sensitivity analysis are presented in Table 7. Results also showed that the mean WTP values were very sensitive to a respondent's gender, concern on health risk as using groundwater, and subjective evaluation on the environmental issue. If the head of household were a male, the WTP was at 62, 181 VND per year. Meanwhile, a female respondent would be willing to pay 227,910 VND per year. The interval difference was at 3.5 times. It can be explained that those who are a female had a perception on clean water issues better than a male. So, women are willing to pay more to enable access to a clean water source for their families. Next, those who took more care of health risks relating to using groundwater would be willing to pay much more for the GPP fund at the bid price of 270,828 VND per year. The difference depending on a respondent's attitude to health impacts was 16.3 times. Finally, a respondent's perception on environmental issues affected the WTP response choice. Those who think that the quality of the environment is extremely bad exercised higher price behavior than those who do not care about it. The offer price the former is willing to pay was 154,797 VND per year while the offer price the latter is willing to pay was 73,136 VND per year.

Regarding the prediction of demand for the groundwater protection, the scenario analysis method is made applying the Probit model for different situations depending on the household's characteristics. Using values of statistically significant variables in Table 5 and taking antilog of the odd ratios, the probabilities of demand for groundwater protection are easily calculated. Table 8 presents the probabilities of demand for groundwater protection associated with a household's characteristics. The probability of demand for groundwater protection, on average, was 63 percent[6]. Generally, if household income increased and the household was living in the urban area, the probability of demand for groundwater protection would be higher. For example, if a certain household's income were higher than double an average household, the household was living in the urban area, and the head of household was male, then probability of demand for groundwater protection was at 81 percent, This is 18 percent higher than the base case's probability. Moreover, the probability of demand for groundwater protection would decrease if a respondent did not have any significant concern about groundwater pollution, made a good evaluation on the environment, and had no concern about the health impact of using groundwater. In this case, the probability was calculated at 33 percent, being about half the base case.

Table 7: Sensitivity analysis of the WTP responses

Variable	Value	Option price VND [a]
Income [a] (VND/month)	798,225[+] 3,251,851[#]	153,676 128,724
Respondent's gender dummy [b] (1 for male; otherwise 0)	0 (min) 1 (max)	62,181 227,910
Respondent's education (number of years)	3.705[+] 11.035[#]	112,651 171,291
Respondent's location dummy [b] (1 for rural; otherwise 0)	0 (min) 1 (max)	203,690 119,961
Demand probability [c]	0 (min) 1 (max)	213,593 131,932
Respondent's concern about groundwater pollution dummy [b] (1 for having concern; otherwise 0)	0 (min) 1 (max)	120,567 160,499
Respondent's evaluation on the environment issue dummy [b] (1 for seriously bad; otherwise 0)	0 (min) 1 (max)	154,797 73,136
Respondent's concern about health impact of using groundwater. (1 for extremely concerned, 5 for not concerned at all)	1.395[+] 3.315[#]	270,828 16,607

[a] the estimated option price uses means of the variables having a mean of 141,730 VND.
[+] indicates that the value is one standard deviation below the mean value.
[#] indicates that the value is one standard deviation above the mean value.

[6] An average probability is calculated based on the mean values of the statistically significant variables in Table 5.

Table 8: Predicted probability of demanding for the groundwater protection

Variable	Predicted probability (%)
Baseline (income of 1,500,000 VND/month; female head with 9 years schooling; located at the rural area; not moving out within 5 years; concern about groundwater pollution; bad evaluation on environment; and extremely concern about health impact of using groundwater)	62.95
Scenario 1 (income of 3,500,000 VND/month; female head with 9 years schooling; located at the rural area; not moving out within 5 years; concern about groundwater pollution; bad evaluation on environment; and extremely concern about health impact of using groundwater)	61.54
Scenario 2 (income of 5,500,000 VND/month; female head with 9 years schooling; located at the rural area; not moving out within 5 years; concern about groundwater pollution; bad evaluation on environment; and extremely concern about health impact of using groundwater)	60.14
Scenario 3 (income of 3,500,000 VND/month; female head with 9 years schooling; located at the urban area; not moving out within 5 years; concern about groundwater pollution; bad evaluation on environment; and extremely concern about health impact of using groundwater)	67.15
Scenario 4 (income of 3,500,000 VND/month; female head with 5 years schooling; located at the urban area; not moving out within 5 years; concern about groundwater pollution; bad evaluation on environment; and extremely concern about health impact of using groundwater)	65.18
Scenario 5 (income of 3,500,000 VND/month; male head with 9 years schooling; located at the urban area; not moving out in next 5 years; concern about groundwater pollution; bad evaluation on environment; and extremely concern about health impact of using groundwater)	80.95
Scenario 6 (income of 3,500,000 VND/month; female head with 9 years schooling; located at the urban area; not moving out within 5 years; not concern about groundwater pollution; good evaluation on environment; and extremely concern about health impact of using groundwater)	69.81
Scenario 7 (income of 3,500,000 VND/month; female head with 9 years schooling; located at the urban area; not moving out within 5 years; not concern about groundwater pollution; good evaluation on environment; and not concern about health impact of using groundwater)	32.74

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Results of the Probit model analysis showed that the economic benefit of protecting groundwater measured by the mean WTP value was 141,730 VND (US$ 8.86) per year. At the 95 percent confidence interval, the mean WTP value ranged from 153,667 VND to 140,190 VND (approximately US$9.60-US$8.76). Those who were private tubewell users were willing to pay 159,832 VND (US$9.99) per year and those who were GSU user were willing to pay 117,527 VND (US$7.35) per year. Results also showed that there was no "scope effect" affecting the WTP response of a respondent. It means that a respondent's WTP was not dependent on the type of commodity described in the contingent market. His or her participation in the GPP program was concerning the pollution for groundwater source possibly affecting the clean water use and not because of type of commodity supplied in the hypothesized market.

Results of survival analysis showed that the mean WTP and median WTP values were 122,838 VND per year and 100,000 VND per year, respectively. At the 95 percent confidence interval, the mean WTP and median WTP values ranged from 111,429 VND to 134,247 VND per year and from 98,136 VND to 101,864 VND per year, respectively. Results also showed that the mean WTP value estimated by Probit model was relatively higher than the mean WTP value estimated by the survival analysis at the edge of 15.4 percent. From the WTP estimations, the GPP fund, which is economically the cost of groundwater polluted, was predicted at 29.4 billion VND to 33.9 billion VND per year (US$1.8 million - US$2.1 million). For a five-year project, the fund would be a range of 147 billion VND to 170 billion VND (US$9.2 million - US$10.6 million)[7].

Results indicated that groundwater would be an inferior good with the evidence of a negative relationship between household income and the demand for groundwater protection. This means that clean water is a necessary good for people in the MD. Besides household income, respondent's gender and education status were statistically significantly exogenous variables affecting the WTP response. Additionally, there were four statistically significantly endogenous variables positively related to household responses to the referendum questions, Namely; subjective demand, respondent's concern about groundwater pollution, respondent's evaluation on environment issues, and respondent's concern about the health impacts of using groundwater. Eight variables were used in the Probit model to estimate the mean WTP.

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[7] Prediction is calculated based on the total population of 1,213,400 people (in 2005) and average family size of 5.07 people in the sample.

Results in the OLS model showed that initially proposed price positively affects the maximum price that a respondent was willing to pay for the GPP program. This indicated that the estimated WTP using survival analysis method could be affected by the starting point chosen to elicit the monetary amount for voting the GPP. Results also showed that only exogenous variables presenting social-economic and demographic characteristics of households affected the maximum price that a respondent votes for the GPP. These statistically significant variables are household income, respondent's age, respondent's education status, and respondent's career.

Regarding the uncertainty in estimating the WTP, the analysis showed that the mean WTP values were very sensitive to the following variables; respondent's gender, concern of health risks of using groundwater, and subjective evaluation on the environmental issue. To predict the possibility of demand for groundwater protection, results of scenario analysis showed that the probability of demand for groundwater protection increases as household income increases. Conversely, the probability of demand for groundwater protection decreases if a respondent has little or no concern about groundwater pollution, made a good evaluation on environment, and is not concerned about the health impacts of using groundwater.

5.2 Recommendation

Although the study was made in order to estimate the economic value of groundwater protection from pollution, it should not be used as the sole basis for evaluating the groundwater protection projects. There are two important limitations of using such economic efficiency criterion, namely, the ethical legitimacy of using households' existing preferences for groundwater projection projects and the distributional effects of not protecting groundwater from pollution. Taking into account the two limitations, the contribution of the study is to provide important, policy-relevant information for evaluating groundwater protection projects and water sanitation investments as well.

This finding suggests that public education programs or social marketing efforts on groundwater pollution status, environmental degradation and protection, and the health effects of environmental issues are likely to have a dramatic effect on willingness to pay for environmental improvement. Perception of the public plays an important role for the acceptance of public investment projects. This study is a pioneer within this field aiming towards public participatory-based projects.

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APPENDIX

Appendix 1: Description of CVM scenario and referendum question format.

At Soc Trang Province, groundwater is a main source of drinking and cooking water for residents in the rural areas during the dry season when river is salinized and polluted. Results from previous studies of wells at Soc Trang Province showed that groundwater wells contain nitrates. Nitrates are chemical substances hazardous to human health if they are taken in large quantities. Most of the wells in the survey in 1999 implemented by Center of Water Resource Evaluation had nitrate levels below hazardous levels.

To cope with the problem of groundwater pollution, the government establishes an action plan so-called the Groundwater Protection Program which mobilizes the fund and uses the money from the fund to buy a equipment to remove the nitrates and other polluters from groundwater at private wells and public wells. Suppose that you are invited to contribute to the fund.

After reading the above statement, the respondents will be asked if they receive their water from their own wells or from a public well. If they check "own well", they are asked to read the following statement:

Suppose that you found that the amount of nitrates in your well water exceeds the safe level. Suppose also that to protect the people from the illness due to using polluted groundwater, a local authority (through a public water supply company) offers to install and maintain new equipment on your well. This equipment will clean your water from nitrates, but the water supply company will charge you for the use of its equipment. If you do not want to pay to the water supply company, the equipment will not be installed and you have to bear the risk of increasing nitrates in your drinking water.

If the respondents receive public water, they will be asked to read the following statement:

Imagine that the amount of nitrates in underground water will increase. This will increase the costs of cleaning water. Imagine that the local water supply company will made sure that your water is safe for drinking but will increase your monthly water bill.

Given this assumption, please evaluate and give YOUR BEST ANSWERS to questions Q.11 to Q.14.

Q. 11 Would you vote to support the Groundwater Protection Program for preventing groundwater pollution from agricultural pesticides, fertilizers, and other polluters, if the program reduces the amount of money you have to spend on other goods and services by ____________VND?

Yes 1	No 1	Do not know 1	Q11

If Do not know, proceed to Q.12; if No, proceed to Q.13, and if Yes, skip to Q.14.

Q.12 Understandably there are various factors that you are considering before you can decide whether to agree or oppose the Groundwater Protection Program. What are the reasons that hinder you from making your decision at that time?

Q12

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....
....
....

Q.13 What are the reasons why you did not vote for the program?

a. I can not afford that amount	1	Q13a
b. I do not think protection of groundwater from pollution is worth doing.	1	Q13b
c. I do not believe that the money that I will pay will actually be used for the Groundwater Protection Program.	1	Q13c
d. I think other environmental issues are more important than pollution of groundwater.	1	Q13d
e. Others (please verify)		

Q.14 What is the HIGHEST amount the program could reduce the amount of money you have to spend on other goods and services BEFORE you would vote against it?

......................................VND	Q14