The Economic Value of Basin Protection to Improve the Quality and Reliability of Potable Water Supply: Some Evidence from Ecuador

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Abstract

This study estimates the willingness to pay (WTP) of Loja's households to protect two micro-basins that supply over 40 percent of potable water to the city. Results indicate that households have an average WTP of $5.80 per month, which corresponds to a 25 percent increase in the self-reported monthly water bill, to preserve the basins.

Key words: Contingent valuation, basin protection, Loja, Ecuador

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Loja the capital of Ecuador's Loja Province is located in the southern portion of the country. The city has a population of 119 thousand and is situated 2,100 m. above sea level. It has a mild Andean climate, ranging between 16 and 30°C. As with many other growing cities in developing countries, the demand for water services in Loja is increasing. Between 1996 and 2006, the number of households connected to the Loja public water system more than doubled increasing from almost 11,000 to about 25,000 households. A high percentage of households (about 19%) connected to the water system have access to water for less than six hours per day. Most households in the city consider their water supply to be insufficient (78% of the households) and rate their water quality as poor (70% of households) (Benavides and Arias, 2005; NCI, 2006).

One option being considered to improve the Loja water supply system is to protect the nearby micro-basins of “El Carmen” and “San Simon” that are among the main sources of water to the city. These two micro-basins are part of the “Zamora Huayco” basin which covers an area of 3,113 hectares. Between 1976 and 1998 human activity has cost the basin approximately 25% of the natural forested area. Simultaneous with the reduction in forested area, urban settlement within the basin increased nine-fold (Benavides and Solano, 2005).

This study estimates the willingness to pay (WTP) of Loja’s households to protect the “El Carmen” and “San Simon” micro-basins that supply over 40 percent of potable water used by Loja. This information will provide policy makers with information to help them assess the benefits and costs of plans designed to protect the two micro-basins. This study contributes to the basin protection economic valuation literature because it estimates the economic value that individuals living in an urban area in a developing country place on basin protection when the protection is designed to enhance the water supply for human consumption.

The Water Supply Service in Loja, Ecuador

Loja's water supply and sewer system administration UMAPAL (Unidad Municipal de Agua Potable y Alcantarillado) provides and maintains the city's potable water and wastewater services. Potable water prices are based on the volume of water consumed according to five use categories: residential (84.9 percent of costumers), commercial (11.9 percent), industrial (0.04 percent), government (0.8 percent) and senior citizens (2.3 percent). According to UMAPAL's records, the average price paid by all consumers in Loja is about \$0.18/m^3. Residential households which account for the majority of the consumers pay \$0.13/m^3 and industrial consumers pay about \$0.89/m^3, the highest tariff, or price, among all the user categories. In 2006, UMAPAL provided water services to 24,587 households in Loja (NCI, 2006).

The "El Carmen" micro-basin covers an area of about 1,000 hectares and the "San Simon" basin has an area of about 600 hectares. The two micro-basins have an average altitude of 2,500 m above sea level, a maximum altitude of about 3,400 m above sea level and an average annual precipitation of approximately 1,400 mm. Water from these two micro-basins account for 43 percent of the city's water supply.

The "El Carmen" micro-basin has a population of 82 individuals living in 14 households, and the "San Simon" micro-basin has a population of 210 individuals living in 40 households. Over time, human activities in both basins have adversely affected water quality and increased the risk water can be dependably supplied to Loja. For example, Benavides and Solano (2005) found a variety of coliforms in water samples taken from the "San Simon" creek. The coliform contamination likely was caused by households living in the micro-basins and without access to the city's sewer system and/or result from livestock production activities in the area. There is also the potential of water contamination from agrochemicals that are used in agriculture and livestock production. It is also believed that the basin's water supply has been adversely affected because of the logging of the natural forests in the "Zamora Huayco" basin which has decreased forested land from 1,630 hectares in 1976 to 1,247 in 1998 (Benavides and Solano, 2005). [1]

Literature Review

Several studies have estimated the monetary value of a specified level of change in the water supply service in developed and developing countries. In the United States these studies suggest city residents are willing to pay sizeable sums to avoid even minor restrictions in the supply of water. Griffin and Mjelde (2000) examined customers' preferences for water supply security in seven Texan cities. Respondents were willing to pay, on average, between $25 and $34 (1997 US Dollars) to avoid an occurrence of water restrictions. They also found that respondents were willing to pay, on average, $9.80 per month (or 26 per cent of their bill) to improve future supply security levels. Koss and Khawaja (2001) found that California consumers were willing to pay, on average, between $11 and $17 more per month to avoid restrictions (1993 US dollars), depending on the frequency and severity of the restrictions.

Several Latin-American studies have investigated the value of improved water supply services. In a study conducted in Mexico City, Montes de Oca *et al.* (2003) observed that households were willing to pay more than double the price they currently pay (147 percent

[1] There is still an ongoing international scientific debate regarding the relation between vegetation types (i.e., pastures versus natural forests) and long-term water balance in catchment areas (Andréassian, 2004). However, there is some evidence regarding the flow-stabilization capacity of the Andean ecosystems in high altitudes (Buytaert et al., 2005).

increase) to both avoid water service deterioration and improve the reliability and quality of the service. Casey *et al*. (2005) found that six low-income communities in the eastern area of Manaus, Brazil were willing to pay between R$12 (US$6.10) and R$17 (US$8.70) per month to gain access to water 24 hours per day. Rodriguez (2003) estimated that households in ten communities in Cotacachi, Ecuador were willing to pay approximately 50 percent more than what they currently paid to improve the quality and reliability of their water supply system. In a study of rural communities in Nicaragua, Johnson and Baltodano (2004), found that households were willing to pay 0.61 percent of their monthly income to improve the quantity and quality of their most frequently used water sources including the source of potable water.

There are fewer studies evaluating the economic benefits of watershed protection related to improved potable water services. We only identified two studies that examined the direct relation between basin protection and water service improvements. Eisen-Hecht and Kramer (2002) estimated household willingness to pay to maintain the current water quality level in the Catawba River that runs through North and South Carolina and provides drinking water to several nearby municipalities. They estimated that river basin residents have an annual mean willingness to pay of $139 for a management plan designed to protect the river's water quality. Echavarria et al. (2004; cited by Wunder and Alban, 2008) conducted a survey in 2002 in the town of Pimampiro, in the Northern Province of Ibarra, Ecuador and found that 83% of water users were willing to protect the watershed that delivers water to the town.

Methods

This study used contingent valuation (CV) to estimate household's willingness to pay (WTP) for the protection of the "El Carmen" and "San Simon" micro-basins. The CV method uses surveys to ask individuals their willingness to pay for a specified level of change in an environmental resource (Mitchell and Carson, 1989). CV has been used in several countries to measure the value of household water quality improvements (Whittington, 1998; Rodriguez, 2003). Measuring household willingness to pay for drinking water improvement using the CV method has credibility for two reasons. First, respondents are asked to impute their willingness to pay for a well-defined and well understood good with primarily personal use benefits. Second, it is possible to compare the survey results with actual behavior when the water improvement project is implemented (Goldblatt, 1999).

A person to person household survey of a random sample of Loja's water service consumers was conducted in December, 2005. The survey generated 106 observations, but only 100 were usable because 6 households were not connected to the city's water supply system. In addition to the CV question, the survey collected information on the demographic and socio-economic characteristics of the respondents, perceptions about the water supply services and administration, and the price paid for the service.

The contingent valuation questions were asked using an open-ended elicitation format. This elicitation technique consists in directly asking the survey individual the maximum monetary value the respondent is willing to pay for a specific change in a public good (Venkatachalam, 2004). As is common to other elicitation formats, the open-ended format has strengths and weaknesses. For example, Loomis (1990) notes the answers to open- ended question do not have starting point bias and have the same reliability as dichotomous choice estimates. However, open-ended questions are more difficult to answer than closed-ended ones and can induce to strategic bias in respondents (Hanemann, 1994).

Similar to previous WTP studies on water quality issues (Eisen-Hecht, and Kramer, 2002; Rodriguez, 2003; Johnson and Baltodano, 2004), the WTP question was asked after a statement describing the current situation of the micro-basins and its contribution to Loja's water supply. This statement is designed to reduce the hypothetical bias regarding the knowledge individuals have about watershed protection and the importance of the watershed to the quality of Loja's drinking water supply (see Appendix for the original Spanish version of the survey). Key points included in the statement were: a) the uncertainty regarding the future supply of water to the city given current population growth and the ongoing deforestation and degradation of the micro-basins that provide water to the city; b) the presence of private owners in the micro-basins devoted mainly to agriculture and livestock production and the risk of water contamination resulting from these activities; c) the description of a potential management plan for the area that includes purchasing the land from private owners, reforestation and protection of the area; and d) an explanation regarding the fact that the current cost of water only covers treatment and distribution costs. After this statement the following WTP question was asked (see Appendix for the original Spanish version of the question): *"How much would you be willing to pay in your monthly water bill in order to buy the land of the "El Carmen" and "San Simon" micro-basins to establish a management plan that includes reforestation, protection and maintenance of the area in order to improve the quality and amount of water collected? $ _____________ "*

Regression Analysis

Using a Tobit model we regressed respondents' WTP for the basin conservation and protection plan against a series of explanatory variables listed in table 1 to explore the influence these variables have on household WTP for the resource management plan. The Tobit model was utilized because 15 percent of the surveyed respondents stated they were not willing to pay anything (i.e., their WTP was $0) for the basin protection plan, therefore the household WTP variable is left censored. We hypothesized that household WTP for the basin protection and maintenance may be affected by household socio-economic characteristics, perceptions about the water supply service quality, quantity and price, and perceptions regarding the impact that human activity in the basin watershed is having on water quality.

Because the estimated Tobit model coefficients do not measure marginal effects, the marginal effect of each estimated coefficient were calculated and are reported in table 2 (see Greene, 2003 p. 766 for the marginal formulas). The asymptotic covariance matrix of both the coefficient estimates and the marginal effects was approximated using a non-parametric bootstrapping procedure as outlined by Wooldridge (2002, p.379). A total of 999 replications were used to generate the standard errors.

Results

The average age of the surveyed respondents is 40 years. Fifty two percent of the surveyed individuals were male and 76 percent reported having some college education (individuals with college degrees or at least some college education) and is consistent with the 2001 National Census that reports Loja has one of the highest levels of education attainment in Ecuador. Average household income and household size are $789.80 per month and 4.5 members, respectively.

Survey respondents pay an average of $19.60 per month for water services. Most respondents (65 percent) perceive their water bill cost as normal. However, many individuals believe the water service is poor. Seventy eight percent of respondents stated that the quantity of water supplied is low, 70 percent perceive the water quality as deficient, and 38% view the water supply as unreliable. Even though water is available 7 days a week to all surveyed respondents, 19 percent of the respondents indicated that their access to water is less than 6 hours a day. Respondents believe that poor water quality and intermittent access to water primarily result from poor administrative management and poor system maintenance.

The survey respondents recognize the importance of preserving the basins that serve Loja. In fact, 93 percent of the individuals surveyed believe reforestation of the micro-basins could improve or at least maintain the quantity of water that the two basins now provide. Moreover, 84 percent believe that the best solution to the problems caused by the presence of private owners residing within the watershed is to purchase of their land. Additional compiled survey information is found in Benavides and Arias (2005).

Willingness to Pay Results

The direct responses to the WTP question reveal that average monthly WTP by Loja households is $5.80 to finance a basin protection plan to improve the city's water supply service. In contrast, the estimated median WTP by Loja residents is only $3 per month. The average and median WTP values represent approximately 0.74 and 0.38 percent of monthly income, respectively. These percentage values are consistent with the lower bound estimates of other studies that have estimated household WTP for improvements in drinking water quality which range from 0.25 percent to 3.24 percent of monthly income (Casey *et al*., 2005; Eisen-Hecht and Kramer, 2002; Johnson and Baltodano, 2004; and Whittington *et al*., 1990).

Household's mean and median WTP of $5.80 and $3.00 to improve water supply security corresponds to an increase of 29.5% and 15% in the average household water bill, respectively.

The self-reported average monthly household water bill is $19.60. Our findings differ from previous studies conducted in developing countries where household WTP for improved water supply security more than doubled their current water service payment (Montes de Oca *et al.*, 2003; Rodriguez, 2003; Casey *et al*., 2005; Katuwal and Bohara, 2007). However, our estimated WTP value is very close to the 20% water consumption surcharge that households in the town of Pimampiro in Northern Ecuador currently pay to finance a project for basin conservation, very similar to the project intended for Loja (Wunder and Alban, 2008).

The Tobit model coefficient estimates and the calculated marginal effect values are reported in Table 2. The current monthly amount being paid for water has a positive effect on people's WTP for basin preservation. Each additional dollar paid in the current average monthly water bill increases WTP by $0.15 per month. For example, a household that has a monthly water bill of $20 has a monthly WTP that is $1.5 greater per month than a household with a monthly water bill of $10. This finding contrasts with results reported by Griffin and Mjelde (2000) in a U.S. study which found that households having a higher monthly water bill refused to pay more to avoid water shortages than those with a lower monthly water bill. In another U.S. study, Loomis *et al*. (2000) found that households' with a higher monthly water bill are more likely than those with a smaller water bill to vote against a water conservation project that would increase their water bill.

When the model was re-estimated using the ratio of monthly household WTP to the current household monthly water bill as the dependent variable, it was found that the amount currently paid for the water service has a negative effect on the percentage increase in the monthly water bill that individuals are WTP for basin protection. In other words, despite the fact that in absolute terms households with a higher monthly water bill have a greater WTP for basin protection, in relative terms (when WTP is expressed as a fraction of the current water cost) their WTP is smaller.

Returning to the original model, the marginal effect for income is positive but statistically insignificant. This suggests WTP for the basin preservation is nearly constant across income classes. A positive and significant relationship between income and WTP has been found in other WTP studies for water service improvements (Whittington *et al*., 1990; Griffin and Mjelde, 2000; Montes de Oca *et al.*, 2003). However, prior studies have not identified a statistically significant effect of income on the WTP for water quality improvements (e.g., Johnson and Baltodano, 2004).

The marginal effects for the six dummy variable parameters corresponding to dummy variables included in the regression model to control for individual characteristics are measured relative to an individual without the characteristics. Dummy variable are used to control for (1) the sex of the respondent; (2) respondents who think the current cost (tariff) paid for water is not expensive; (3) households that have access to water for less than 24 hours in a day; (4) households that are not satisfied with current water quality; (5) households that are not satisfied with current water quantity; and (6) households that are not satisfied with current system reliability. Relative to an individual who perceives the current water bill as expensive WTP is $4.70 per month lower than for an individual that views the current bill as reasonable. Male respondents have a $3.80 higher WTP than females. Individuals who have access to water 24 hours per day have a WTP that is $4 higher than those that receive the service less than 24 hours per week.

The gender effect on WTP for water service improvements has not been consistent among prior studies. A study conducted in rural communities in Nicaragua by Johnson and

Baltodano (2004) found that males place a higher value on improving water quality and quantity, contrary to other WTP studies for improved water services in Latin America (Perez-Pineda, 1999**;** Montes de Oca *et al.*, 2003) where females were found to more highly value water service improvements.

Regarding the effect of timely access to water and the perception variables it is unclear which sign these variables should take. Households that have access to water 24 hours per day are likely to be satisfied with the current service and might not have any motivation to pay for service improvements. However, households currently paying for an inadequate service or a service that is perceived as inadequate may be disinclined to pay even more.

Of all the perception variables included in the model, only the variable related to water cost, the water tariffs, was statistically significant. However, only 26 percent of surveyed individuals perceived their water bill as expensive.

We should point out that our results might not be directly comparable to prior studies that examine individually consumer valuation of watershed improvements or water supply enhancements. The focus of the WTP question in this study was on protecting a basin to improve residential water quality and supply conditions. In addition to improving the quality and supply of water to the city Loja, the basin protection plan is likely to improve wildlife and ecological values which are unmeasured in this study.

Aggregate Benefits and Costs

As previously mentioned, in 2006 there were 24,587 households connected to UMAPAL's water system in Loja. Using the estimated average household WTP value of $5.80 per month, the total aggregate value of preserving the two micro-basins is $142 thousand per month or $1.7 million per year. If we assume a 10 percent discount rate and an infinite project life this translates into a capital value of $696 per household, meaning that the Loja residents are implicitly willing to fund a one-time investment of $17 million (to be financed with an additional $5.80 monthly charge over the project lifetime).

The average cost of the land in the “El Carmen” and “San Simon” micro-basins area is between $300 and $700 per hectare (NCI, 2006). Using an average value of $500 per hectare, the total cost of purchasing the land is $800 thousand. The costs of protecting and conserving the basin areas have been estimated at $40,000/year (see NCI, 2006). The capital value of the costs of protection and conservation of the basin area, using the previously mentioned assumptions regarding project life-time and the discount rate, equals $400 thousand. Hence, project benefits exceed the capital value of project cost by more than 14-fold.

Summary and Final Remarks

The objective of this study was to estimate the economic value that people living in an urban area of a developing country place on the protection of two basins when the protection is designed to improve the quality and reliability of the water supply for human consumption of urban residents. The data was collected using a face-to-face survey conducted in December 2005 in Loja, Ecuador. The empirical results indicate that households are WTP an average of $5.80 per month, a 25 percent increase in the monthly water bill, to preserve the basins. The main variables found to affect the WTP are current monthly water cost, the perception about the fairness of the existing water tariff (cost of water), the number of hours that service is available, and the gender of the individual interviewed.

Urban households perceiving the existing water tariffs as too expensive have a significantly lower WTP for the basin preservation program. To help determine the appropriateness of the tariff in Loja, we compared the water tariffs in Loja with the tariffs in other Ecuadorian cities of comparable size and demographic composition. For example, in 2002 the tariff paid by residential consumers in Ambato was \$0.22/m^3 and in Ibarra \$0.16/m^3 (Yepes, 2003). These values are 69% and 23% higher, respectively, than the average tariff of \$0.13/m^3 paid by residential consumers in Loja in 2004 and 2005 (Benavides and Arias, 2005). Hence, and increase awareness of water tariffs in Loja versus other comparable cities in the country could help to gain additional support for the basin protection and conservation projects.

Using the aggregate benefit estimate we evaluated the feasibility of financing a project to preserve the basins. The project comprises purchasing the land and establishing a management plan that includes natural regeneration of the forests and conservation of the basin areas. The total cost of such project assuming an infinite horizon is substantially lower than the aggregate benefits estimated using the WTP survey results. This indicates that Loja households would strongly support a program to preserve the basins that deliver drinking water. The scope of the project could easily be expanded to protect and preserve an additional 1,310 hectares in the two other micro-basins that serve as source of the remaining 66% of water used in Loja (NCI, 2006).

There are also other possibilities regarding the project implementation arrangements. An alternative to the purchase of the micro-basins land areas would be a payment to landowners to protect the environmental services provided by the basins without changing land ownership. Arrangements like this have been successful in other parts of the country (Wunder and Alban, 2008). Both systems should be equivalent in terms of the capital value of the projects but different in terms of cash flows. The consideration of both potential programs by the local government could provide more flexibility for negotiation with the current landowners.

The rapid urbanization in developing countries and the associated demands for new infrastructure services increase the need to invest in new projects, as well as in the operation and maintenance of the current systems (World Bank, 1994; Zerah, 1998). In order to ensure the success and sustainability of these projects, international funding agencies are now stressing the need to obtain resources from domestic consumers (Brookshire and Whittington, 1993). However, local governments are sometimes reluctant to undertake projects that would require increases in utility prices for political reasons or with the intention of helping the poor to have access to the services (Yepes, 1999). This study has shown that households at all income levels strongly support and are willing to pay for a project that has the potential to improve the quality of the water services and protect the environment.

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Table 1. Description of Variables Used in the Regression Model

Variable	Proportion %	Mean	Std. Error	Range
Willingness to pay ($)		5.79	7.72	0-36
Age (years)		39.89	11.73	17-72
Occupation				3 binary variables:
	16			Student
	46			Self-employed
	38			Employed
Gender		0.52	0.50	1 = Male, 0 = Female
Education level		0.76	0.43	1 = College education, 0=Less than college education
Family members		4.50	2.04	1-15
Household income ($ per month)		789.80	648.99	100-4,000
Household expenditures per capita ($ per month)*		126.10	130.58	2.5-992
Water bill ($ per month)		19.61	18.01	3-125
Access to water 24 hours a day water service (hours)		0.80	0.40	1=Yes 0=No
Perception about water tariff		0.26	0.44	1= Expensive,
				0=Normal or cheap
Perception about water quantity		0.22	0.42	0 = no satisfied, 1 = satisfied
Perception about water quality		0.30	0.46	0 = no satisfied, 1 = satisfied
Perception about water service reliability		0.62	0.49	0 = no satisfied, 1 = satisfied
Potential solution to the presence of private landowners in micro-basins		0.84	0.37	0 = Maintain human settlements and educate them about problems 1= Buy land from private owners

*It does not include the expenditure in water services.

Table 2. Tobit Model Regression Results

Variable	Coefficients		Standard Error[a]	Marginal effects		Standard Error
Constant	-2.741		4.107	-2.070		3.180
Age (years)	0.051		0.088	0.038		0.068
Gender (Male=1, Female=0)	3.766	***[b]	1.596	2.844	**	1.256
Income (($100 per month)	0.009		0.194	0.007		0.151
Average monthly water bill ($ per month)	0.157	**	0.090	0.118	**	0.072
Perception about water tariff (1=Expensive, Cheap or Normal=0)	-4.661	**	2.320	-3.520	**	1.822
Availability of service 24 hours/day (1=Yes, 0=No)	3.976	**	1.935	3.003	**	1.510
Perception about quality (1=satisfied, 0=no satisfied)	1.436		1.820	1.084		1.396
Perception about quantity (1=satisfied, 0=no satisfied)	-1.482		2.316	-1.119		1.783
Perception about regularity of service (1=satisfied, 0=no satisfied)	-2.201		2.022	-1.662		1.568
Sigma	7.370	***	0.900			
Log-likelihood function	--297.837					

[a] Standard errors calculated with the asymptotic covariance obtained using bootstrapping

[b] Significance levels of 0.01 and 0.05 are indicated by ***, and ** respectively.