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MEASURING THE VALUE OF POTABLE WATER IN PARTIALLY MONETIZED RURAL ECONOMIES[1]

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ABSTRACT: A pilot study was conducted to test the potential of the Contingent Valuation Methodology (CVM) to reveal the value of non-market goods in a partially monetized subsistence economy. CVM was used to estimate the willingness to pay, in the form of labor, for potable drinking water in a rural river-based community located in the Esmeraldas state of northwest Ecuador. Surveys were administered by personal interviews with families living along the waterways of the Santiago river system who used river water for cooking, drinking, washing, and waste disposal.

The mean willingness to pay represented over 23 percent of real income, or 1.4 days per week for a period of one year. Results of multiple regression analysis identified the history of water-related health problems and the number of working adults in a household as significant determinants of willingness to pay.

Using a non-monetary, rather than a monetary, measure of willingness to pay may provide a more accurate representation of value in a subsistence economy where the use of money is limited. The potential for CVM to measure the benefits of non-market goods in rural developing regions whose economies are only partially monetized is demonstrated.

(KEY TERMS: contingent valuation; willingness to pay; Ecuador; rural water quality.)

INTRODUCTION

In much of the humid tropics, water resources are abundant, especially in the seasonal tropical rain forests of the Amazon basin and its peripheral regions. Communities have formed around the river systems that braid the landscape in order to utilize the transportation and subsistence functions they provide. The history of river-based settlement patterns in South America precedes the colonial era by centuries. Today, subsistence river-based communities continue to be common throughout the humid tropics of South America.

Among the local uses of river systems is the provision of water for drinking and cooking. Since the water carries many naturally occurring parasites as well as pathogens associated with human populations, water drawn from rivers in these regions must be treated by boiling or other means of purification. Despite efforts to purify drinking water, water-borne diseases remain prevalent in the communities. Diseases such as cholera (*Vibrio cholerae*), typhoid (*Salmonella typhi*), and hepatitis are common causes of mortality, and a variety of less lethal diseases cause periodic dysentery and other non-fatal illnesses. Because many subsistence river-based communities are isolated and detached from national infrastructure, public works such as the provision of potable drinking water are uncommon.

A subsistence river-based community in Esmeraldas, Ecuador, was selected to measure the potential benefits of potable water provision. In this region, as in many developing rural economies, the measure of potential economic benefits of potable water provision can serve as a guide for development assistance for subsistence communities that do not generate enough money to implement such a project themselves. Measuring economic benefits in rural communities is generally difficult because many activities are non-monetized; therefore, a methodology for doing so must be devised in order to improve the allocation of development assistance.

The community's geographic and cultural isolation from the more economically developed areas of Ecuador made it an ideal site to test the Contingent Valuation Methodology's potential to be used in regions with limited monetary exchanges. The inhabitants of the selected river are the only users of its

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resources, thus eliminating any additional complications from upstream polluters affecting water quality. The community represents a functionally closed economic and ecological system, thus making analysis free of many exogenous factors.

LITERATURE REVIEW

Contingent Valuation Methodology (CVM) is a survey method used to approximate the benefits accrued to a population by the provision of non-market goods, and is broadly applied in the literature as a means of providing otherwise unattainable information concerning the valuation of environmental amenities including their use value, existence value (Groves and Kahalas, 1976), and option value (Greenley *et al.*, 1981). Valuation of environmental amenities is generally problematic because in most cases their use is not exclusive, with property rights not fully assigned, and they are therefore not traded on any market. Policy makers must rely upon methods of social benefit approximation, such as CVM, to determine the appropriate level of public investment in the provision of such amenities (Small and Rosen, 1981; Randall *et al.*, 1983; Mitchell and Carson, 1989). The theoretical groundwork for CVM is explained in great detail by Cummings *et al.* (1986) and Mitchell and Carson (1989).

CVM requires that members of a given population are surveyed about their willingness to pay (WTP) for the provision of a non-market good, such as environmental quality. Respondents may be asked to value varying levels of provision of the good, and/or their willingness to accept (WTA) payment for a decrease in the provision of the good. Questions regarding WTP are generally accompanied by queries about the respondents' social and economic status.

Detractors of the methodology claim that strategic behavior of respondents and the implausibility of contingent, or hypothetical, markets prevent the collection of useful data (Diamond and Hausman, 1993). Critics state that "some number" is not necessarily better than "no number" in cost-benefit analysis because inaccurate or biased data from CVM clouds economic considerations in policy-making (Diamond and Hausman, 1994). Supporters of CVM state that though the method is not perfect and is subject to biases and distortions, CVM data may provide legitimate "core values" (Randall *et al.*, 1983).

The format of the CVM survey is a topic of tremendous debate. Among the points of debate is the way in which WTP is elicited from the respondent. *Open-ended* questions, providing the respondent no cues for response, have been contrasted with *dichotomous choice* questions that force the respondent to make choices analogous to a market situation (Cummings *et al.*, 1986). Recent evidence shows that the difference between these methods for surveys conducted in the United States is insignificant (Loomis, 1990), but administering *open-ended* questions may be easiest in personal surveys in developing regions as the iterative questioning process required by *dichotomous choice* may make the survey arduous and possibly uncomfortable for a respondent not familiar with formal surveys.

The potential for CVM to determine the aggregate social value of basic amenities such as potable water in developing regions is compelling. The World Bank has used CVM to determine site selection, optimal level of service, and tariff design for community-level water provision projects (Whittington *et al.*, 1989a; Whittington *et al.*, 1989b). Cooper (1981) suggests that measuring WTP in non-monetary terms may incorporate non-monetized rural values into social benefit estimates.

For example, in rural Latin America, women work between 12-18 hours a day (Yudelman, 1994) and spend from two to six hours twice a week collecting firewood to boil water for cooking and drinking (L. Grandia, Coordinator, Yale Women, Environment and Development Coalition, Conservation International, Personal Communication, 1995). In addition to the time invested in firewood collection for water purification, sickness and mortality resulting from poor water quality are rarely quantified in conventional cost-benefit analyses for rural water projects in Latin America.

The costs of water purification in the rural tropics vary greatly with climate, available resources, scale of project, and quality of labor (Schulz and Okun, 1984). In many cases drinking water quality is as much a function of water purification systems as it is of sanitation and waste treatment within the community (Mann and Williamson, 1982). For this reason, it is difficult to project the cost of water quality improvements without considering the specific site of the project and the possibility of an integrated water quality program involving the disposal of sewage and waste as well as purification.

METHODOLOGY

Area of Study

Interviews were administered in villages within the Santiago River system, located in northwest Ecuador (Lat. 1° N, Long. 79°W). The main center of

trade within the region and primary point of contact with national infrastructure is the town of Borbón. Elevation in the area does not exceed 400m above sea level. The climate is tropical, with an average annual temperature of 28°C and an annual rainfall of 2,100 mm. The rainy season runs from December to June.

The residents of the region are of African descent. The first individuals to populate the region arrived in the 16th Century, when 23 black slaves (17 men and six women) escaped from a boat sunk near the port of Esmeraldas (Speiser, 1991; Whitten, 1992). A substantial population of escaped and freed slaves formed around this core group during the succeeding 300 years. In 1895 an area of 500,000 hectares was established as a "Republica de Zambos," governed exclusively by the resident black population. Legally, land rights are communal in the region and usufruct tenure delineates agricultural plots.

Adjacent to the area of study lies the Cayapas-Cotacachi Nature Reserve, famed for its biodiversity and species endemism. The watershed of the area of study originates within the Cayapas-Cotacachi area and is therefore not affected by urban pollution from the Andean highlands. Most residents live directly along the rivers that cut through the lush tropical rain forest dominating the landscape. Water for cooking, drinking, washing, and waste disposal comes directly from the rivers. The water carries a number of water-borne diseases, some of which are naturally occurring pathogens and others which are associated with human waste. Table 1 describes the most commonly occurring water-borne diseases in the region.

Interviews

Interviews with heads of households were conducted in each of eight villages located in series along one river, beginning with the most isolated village that had no upstream inhabitants and continuing with downstream villages with progressively more upstream inhabitants. This river was an ideal location for the survey because of its relative isolation from external market forces and sources of industrial water pollution. In effect, the community was a self-contained economic and ecological system, thereby simplifying the potential causal relationships of water quality and WTP for potable water.

The villages were accessed via river in a dugout canoe equipped with an outboard motor. During the interview process, living accommodations were made in the villages, which provided an opportunity to learn more about the context of water problems. All interviews were conducted in Spanish. The interview was designed to solicit information regarding socio-economic status, attitudes about water, water-related health issues, agricultural practices, and WTP for clean drinking water. The interview format was

TABLE 1. Most Common Waterborne Diseases in Rivers of the Neotropics.

Waterborne Disease	Source	Health Effects
	Bacteria	
Escherichia coli	Human feces	Dysentery
Shigella	Human feces	Affects young, dysentery, possibly fatal
Salmonella typhi (typhoid)	Human feces	Highly contagious, 30 percent mortality
Vibrio cholerae (cholera)	Human feces	Dysentery and vomiting, often fatal
	Parasites	
Entamoeba histolytica	Mammal feces	Chronic dysentery
Schistosomiasis	Snails, mammal feces	Chronic GI problems, pulmonary damage
Balantidium coli-rare	Snails, mammal feces	Chronic dysentery
Isospora belli	Snails, mammal feces	Chronic dysentery
Sparganosis	Snails, mammal feces	Chronic dysentery
Paragonimus ecuadoriensis	Snails, mammal feces	Chronic dysentery
	Protozoa	
Giardia lamblia	Mammal feces	Chronic dysentery
	Virus	
Hepatitis A	Mammal feces	Flu-like condition to fatal liver failure

Source: "Hunter's Tropical Medicine" by G. thomas Strickland (7th Edition), W. B. Saunders Co.

unconventional in that it was administered in conversational form. The guidelines for the conversational interview are presented in Table 2.

TABLE 2. Guidelines for Conversational Interview.

1. Weekly agricultural production and labor time requirements.
2. Weekly revenues from each agricultural product.
3. Management techniques for various agro-forestry products in cultivation.
4. Effects of price variations for salable agricultural products.
5. How is income normally spent.
6. If credit were made available, how would it be used. If used for intensifying land use, or clearing forest for cattle, how does that correspond with conservation ethic.
7. Family size, age distribution of family, number of working adults in household.
8. History of water-related ailments in household.
9. WTP, in days of labor per week for one year, for pure drinking water, as an *open-ended* question.

The conversational interview elicited open-ended answers. Conversation allowed for fuller explanation of the context of hypothetical scenarios and therefore may have reduced *hypothetical bias.* The interview was aided by a local resident who helped clarify questions for some respondents. The presence of a community member was believed to reduce *strategic bias* because respondents may have felt less comfortable giving extreme answers. The conversational elicitation of open-ended responses may have permitted hypothetical and strategic biases to affect the survey responses, but the advantages of assuring the understanding and trust of the survey respondents should not be underestimated in a setting where both surveys and individuals from outside the community are far from commonplace.

WTP was measured in terms of labor time per week for one year that the respondent was willing to contribute to the construction of a water purification system for the village. Labor time was used instead of money as a measure of WTP because currency exchanges in the community were limited by the level of economic development. Respondents were permitted to provide full or fractional days in their response. WTP questions were preceded by a number of questions pertaining to work habits and agricultural production, thus forming a context in which respondents' contributions would be considered, and followed by a summary of their weekly work requirements to assist respondents to further consider and confirm their responses.

RESULTS

Socio-Economic Data

The sample size (n = 50) was small due to the time required to administer personal interviews, but sufficient to establish statistical significance for the variables in question. The average family size among the respondents was 5.56. Heads of household were primarily men, though three of the 50 individuals interviewed were women. The mean number of individuals in a family under 18 years of age was 3.66. Though not documented, infant mortality was believed to be higher than the national average of 37.7 per thousand (CIA, 1995).

Mean annual income in each household was US$ 1,203.77 and came from the cultivation of merchantable crops. Households produced a combination of bananas, cocoa, tagua, and cut timber. In general, revenues from agriculture were unstable. Producers were price takers and demonstrated no mechanism for securing forward price contracts to avoid losses during periods of low prices.

The property regime was one of usufruct quasi-private property, and land parcels could not be sold without consensus of the community. Individuals were not able to receive formal bank credit due to the lack of collateral in private land rights. The lack of credit prevented investment in productive capacity beyond simple farm implements, and in some cases a chainsaw or an outboard motor.

Willingness-to-Pay

The mean WTP for potable water was 1.4 days of labor time, or over 23 percent of the total economic activity in the community (based on six days of work per week). Twenty-eight percent of the respondents gave zero as their WTP value, but most respondents agreed to participate with any final decision of the community regarding an appropriate contribution of their labor time.

In monetary terms, US$ 3.86 was generated per day (based on 312 days of work per year) in merchantable agriculture. This figure does not consider non-monetized labor time devoted to subsistence agriculture, household duties, and firewood collection and therefore represents a small fraction of the total

economic value of a day's labor. The limits of monetization in this economy diminishes the usefulness of monetary measures of WTP.

Table 3 summarizes the significant variables in our survey. In addition to WTP, family size, household income, number of working adults, and number of children in each household, the size of each village and the number of upstream users of each village's water were recorded. Of the 50 households surveyed, 75 percent reported a history of water-related health problems. Regrettably, history of water-related health problems was not treated as a continuous variable, but rather a dummy variable, in the survey.

Factors in Willingness-to-Pay

Multiple regression analysis was performed to determine what factors contributed to WTP. The hypothesis that WTP was a function of water pollution, measured by size of communities in which respondents lived and the number of upstream inhabitants polluting the water, did not prove statistically significant. The hypothesis that household characteristics determined WTP was supported by a regression that included annual income, number of working adults in the household, and a dummy variable for history of water-related health problems in the household. The sample distribution was normalized using a natural log transformation, *ln(x)*, and *ln(x+1)* for variables that included zero values. Table 4 summarizes the critical statistics of the variables specified by the regression in Equation (1).

$$\ln(1+WTP) = CON + INC(\ln(Income)) + ADU(\ln(Adults)) + ILL(\ln(History\ of\ Illness)) + \varepsilon . \quad (1)$$

TABLE 4. Regression Results.
(DF = 46; R^2 = 0.739, Adjusted R^2 = 0.722, F-test = 43.425)

Coefficient	Value	T-Statistic	Probability
CON	+0.537		
INC	–0.094	+2.167	0.0354
ADU	+0.217	+1.826	0.0744
ILL	+1.386	+10.180	0.0001

It was expected that a history of waterborne illness in a family would heighten the awareness of the survey respondent to drinking water quality. Families that needed to take time from other activities to treat ill family members or families that had suffered a tragedy related to waterborne illness would value the provision of potable water more highly than those respondents who had not. The number of working adults in the family was expected to be positively correlated with WTP based on the belief that total available labor hours for activities outside of household subsistence activities would increase with the number of working adults in the household. Monetary income was theorized to represent both wealth and the level of integration of the survey respondent into the monetary economy. From the perspective of wealth, WTP should be positively correlated with income because potable water is not an inferior good. However, integration into the monetary economy could result in unanticipated WTP responses, according to the respondent's judgment of the appropriateness of labor as a means of payment over money.

The regression results supported the hypothesis that the number of working adults and the history of waterborne illness in the respondent's family were positively correlated with WTP. A negative coefficient for household income indicates that integration into the monetary economy may be problematic for this methodology and should be treated with specific care in future studies.

TABLE 3. Summary of Data from Interviews (n = 50).

	Mean	SD of Mean	ln (mean)	SD of ln (mean)
WTP (days)	1.40	1.229	0.742	0.536
Family Size	5.56	3.529	1.441	0.830
Working Adults	1.90	0.707	0.581	0.354
Children	3.66	3.198	1.235	0.858
Annual Income ($US)	1203.77	941.492	6.727	0.936
Families in Community	60.48	66.711	3.697	0.903
Upstream Villages	2.76	2.495	1.115	0.664

Note: In the cases of variables *Children* and *WTP*, zero was a potential value. As ln(0) is undefined, the function ln(1+x) was used to normalize the data.

DISCUSSION

The data indicate that WTP for water quality among rural river-based communities in Esmeraldas, Ecuador, is substantial. Individuals were willing to contribute over 23 percent of their overall work time to the construction of a water purification system for the village. In other words, potable water was highly valued by the respondents of the survey.

Despite the high value placed on potable water, several impediments prevent the acquisition of a water purification system. First, access to the appropriate technology is limited by the relative isolation of the communities in this region. Second, despite the value of potable water relative to our approximation of real income, actual monetary income is extremely low, only US$ 3.86 per day. Third, credit is not available to the communities in this region due to the absence of property rights and, hence, collateral.

Two constructive conclusions may be drawn from this data. First, if the communities in this region were provided with access to the appropriate technologies and credit, the community might construct a water purification system. In essence, the CVM reveals that though potable water is highly valued, it might not be provided due to external constraints. Second, the CVM results demonstrate the welfare potential for public investment in this area without reliance on monetary benefits assessment.

The breakdown of labor within a household is not considered in this study; therefore, differences in the value of clean water among family members, especially women who collect the majority of firewood for boiling water and care for those afflicted with waterborne disease, are not examined. Interviewing only heads of household opens the possibility of a gender-role bias and deserves closer attention in future studies. In many developing regions, women's labor comprises a substantial portion of the total household work time but is rarely valued on the same terms as the labor of men.

Though the sample size in this study was small due to the constraints imposed by administering personal interviews, it served its role for a pilot study. CVM proved an effective methodology for evaluating the social benefit of increased provision of potable water in a partially monetized rural developing economy. This capability makes it a potential tool for overcoming the impasse confronted by conventional economic analysis in regions where monetary transactions are not representative of overall economic activity. Development assistance and innovative rural credit programs could refine this methodology to direct programs to those communities where potential benefits are greatest.

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