ECONOMIC VALUATION OF WATER IN A NATURAL PROTECTED AREA OF AN EMERGING ECONOMY: RECOMMENDATIONS FOR EL VIZCAINO BIOSPHERE RESERVE, MEXICO

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SUMMARY

The El Vizcaino Biosphere Reserve is a natural protected area with limited hydrologic resources because there are no permanent surface streams. Ephemeral streams appear during scarce rains. This has led the inhabitants to use underground aquifers. However, excessive consumption and natural conditions have led to overexploitation of the aquifer and salt intrusion. The main objective is to determine the economic value for improvements in environmental service for providing water using the contingent valuation method (CVM). The results indicate a willingness to pay an additional US$2 per month to what is currently paid by consumers. The low income households appear to be willing to pay about US$1.70 and high income households, US$2.20. The willingness to pay for piped water is US$1.92, while those that remain unconnected, is US$2.52. The additional money collected should be used to improve water conservation, such as restoration of underground aquifers, maintain hydrological services, maintain the distribution system, build an infrastructure for a storage system, build waste water treatment plants, and find alternative water sources. The study offers pertinent quantitative information and recommendations to the decision-makers to improve water management in the reserve. The Presidential Decree of El Vizcaino Biosphere Reserve of 1988 will support attempts to obtain international economic resources for the proper management of the water resource for the inhabitants.

Only a few nations have been concerned about national programs for water conservation. Currently, emerging and developing economies are facing serious problems to provide safe drinking water. Since 1994, Mexico has been adopting models of water management at a regional scale, the drainage basin. In this country, as in many others, the hydrologic basin is the geographical feature used to manage water resources (Dourojeanni, 1994, 2001; Dourojeanni and Jouravlev, 2002; Dourojeanni *et al*., 2002). In Mexico, the National Commission of Water (CONAGUA) is the federal agency directly involved in water management; it deals with water problems and contributes to the management of water resources. For example, there is the Integrated Management Plan of the Aquifer of Maneadero, BC (CNA, 2002a) and the Sustainable Management of Water and Territorial Ordering of the State of Querétaro (CNA, 2003). The latter includes three Natural Protected Areas, the Cerro de las Campanas, El Cimatario, and Sierra la Gorda.

KEYWORDS / Conservation / Contingent Valuation / Natural Protected Area / Water Management / Willingness to Pay /

Received: 12/15/2012. Modified: 04/03/2013. Accepted: 04/11/2013.

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The conceptual framework for the management of water includes several instruments of management, including those based on the market to manage water demand and water supply planning. This can be done through the contingent valuation method (CVM). The environmental imbalances caused by shortages of water, increased demand for water, and deterioration of water quality have motivated the fast growth of the literature based on nonmarket goods appraisal methods, such as the CVM, which focuses on the analysis of politics and research (Hanemann, 1994; McFadden, 1994; Cameron and Englin, 1997; Carson *et al*., 1997).

The CVM has the advantage of measuring use values (municipal, ecological, buffer values, subsidence avoidance and recreation) and nonuse values (existence and bequest) of natural resources such as groundwater (CVGM, 1997). However, only municipal, industrial, and agricultural values are regulated in the market, whereas the long-term value and the nonuse values are not considered. Therefore, this approach to assign value to water has led to excessive consumption of water and problems of saline intrusion into aquifers. The price includes only energy costs to extract water, and distribution and operation costs.

In emerging and developing economies, most literature on economic valuation of water focuses on measuring individual welfare resulting from improvements in water quality (Shultz and Soliz, 2007; Akter, 2008; Vásquez *et al*., 2009; Wang *et al*., 2010), determining the payment for environmental services to protect watersheds (Calderon *et al*., 2006; Kosoy *et al*., 2007; Muñoz-Piña *et al*., 2008; Ortega-Pacheco *et al*., 2009), and estimating the willingness to pay (WTP) for water services (Casey *et al*., 2006; Soto and Bateman, 2006; Kanyoka *et al*., 2008; Akram and Olmstead, 2011). There are numerous studies in economic valuation of groundwater, in industrial nations, that estimate the WTP for environmental asset protection through a given program (Edwards, 1988; Shultz and Lindsay, 1990; Jordan and Elnagheeb, 1993; Lichtenberg and Zimmerman, 1999); however, studies in emerging and developing economies are scarce, especially in natural protected areas with dry climates.

One of the final objectives of this type of studies is to offer quantitative information to decision makers on the financial resources that can be generated, select rational measures directed to water conservation, and promote the integrity of the ecosystem and future development of society. Improvement measures include: decreasing losses from leaks, restoring underground aquifers, maintaining hydrological services, artificially refilling aquifers, constructing an infrastructure to retain water, treating sewage, developing alternative sources, improving the water distribution system, providing high quality water that meets international norms, paying personnel and verifying that consumers do not waste water.

Revenues can also be used to support actions to comply with promoting the rational use of water. Among these are installing, repairing and replacing water meters, establishing vigilance procedure to reducing leaks and unnecessary waste, establishing fines for waste, determining true costs of extraction, maintenance, storage, operation and distribution of drinking water, treating water to meet international norms, avoiding land subsidence related to excessive extraction, and reducing energy consumption for pumping water. The management of water should be economically efficient and environmentally sound.

Efficient collection and consumption eliminates the need to reassign economic resources. It covers basic needs of individuals, avoids denial of water, and reduces the spread of disease and hygiene problems, thus improving the quality of life and development of the communities. Thus, mechanisms for adequate water conservation should be considered. An important approach is to study economic valuation of water to provide decision makers with information to develop policies, implement actions for the responsible use of water, and generate the financial resources that are required.

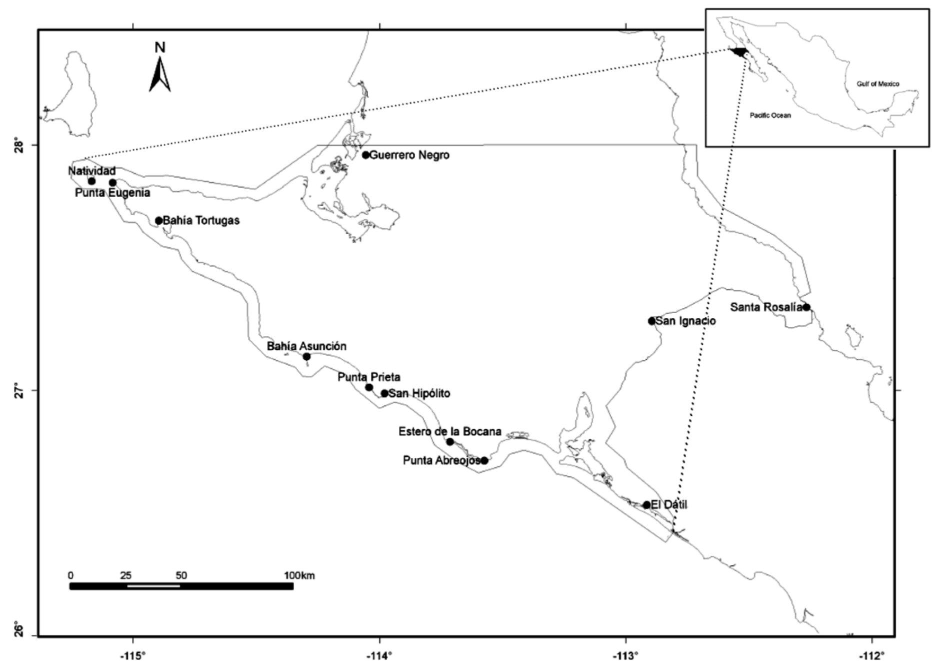

Figure 1. Area of El Vizcaino Biosphere Reserve.

Materials and Methods

Study area

The El Vizcaino Biosphere Reserve is located in the municipality of Mulege, in the northern part of the State of Baja California Sur, Mexico (Figure 1). The Reserve comprises about 2.55×10^6ha, being one of the largest biosphere reserves in Latin America. The establishment of the Reserve allows Mexico to obtain international economic resources for proper management of the available water for the inhabitants of this natural protected area.

The Reserve is a region with scarce rainfall. From 1941 to 2002 this area had an annual average rainfall of ~100mm (CNA, 2004), which is characteristic of the world's driest deserts. The Reserve has limited surface or underground water resources because of the limited rainfall, general weather patterns and topography that reduces potential availability. There are no permanent streams. The absence of surface water and scarce rains led to the exploitation of underground aquifers. Availability of groundwater is directly related to rainfall that infiltrates the underlying aquifers. During heavier rainfall, most of the water evaporates or drains into the sea. The aquifers are overexploited and saline intrusion is widespread (INEGI, 1996; CNA, 2002b).

The main objective of this work is to determine the economic value of improving environmental service of providing water, using the contingent valuation method (CVM). For this the willingness to pay (WTP) was estimated by using a Logit model and then this money used to enhance the mechanisms that permit conservation of water. The study consists of economic valuation in the most representative coastal communities of the Reserve: Guerrero Negro, Isla Natividad, Punta Eugenia, Bahía Tortugas, Bahía Asunción, Punta Prieta, San Hipólito, La Bocana, Punta Abreojos, El Dátil, San Ignacio and Santa Rosalía (Figure 1).

Methodology

The CVM was used to determine the economic value of the environmental service of providing water. By using specific questions in a survey, this technique determines the monetary value of the changes in individual welfare arising from modifications in supplying a natural resource or ecosystem service. *Respondents were* asked how much money they were willing to pay for an environmental benefit. In summary, the CVM measures nonmarket values of environmental goods and services. The market is constructed to propose hypothetical scenarios to interviewees about changes in the quantity or quality of environmental goods and determine their WTP for these goods (Carson, 2000; Carson and Hanemann, 2005). The objective was to estimate the WTP for improvements in environmental service for providing water.

Implementation of the survey must be done carefully because inappropriate design introduces biases. Among these are the vehicle bias (OECD, 1995), design bias (see Boyle *et al*., 1985), operating bias (Cummings *et al*., 1994), information bias (Boyle and Bishop, 1988; Bergstrom *et al*., 1989; Whitehead and Blomquist, 1991), hypothetical bias (Bishop and Heberlein, 1979; Thayer, 1981), starting point bias (Boyle *et al*., 1985) and strategic bias (see Hoehn and Randall, 1987; Milon, 1989; Bergstrom *et al*., 1989; Mitchell and Carson, 1989). The present study was devised to minimize these possible biases. The NOAA Panel (Arrow *et al*., 1993) recommendations were followed for the design and use of the questionnaire. This technique has the advantage of measuring use and nonuse values of natural resources, such as ground water (CVGM, 1997).

Theoretical framework for WTP analysis

One of the ways to assess willingness to pay using the CVM are discrete-continuous choice (DCC) models. These types of models are interpreted by two approaches, the theory of random utility and the theory of latent regression. The first develops the idea that the economic agent maximizes the expected utility by electing a choice. In other words, the objective is to find the most preferred choice over the complementary one.

The DCC models use the random utility maximization (RUM) model because there is limited or scarce knowledge concerning the utility of the alternatives; therefore, it is complicated to predict the behavior of the economic agent. The econometric analysis from the theoretical model of the utility is used to analyze the answers of the surveys of the CVM. Following Hanemann and Kanninen (1998), starting from a good (X) offered to an individual, a change in the quality of an environmental good is proposed to pass from q^0 to q^1 at a cost of C. If the utility function to the individual is U, C>0, W is the income, X is the environmental good, and Z is the socioeconomic characteristic, then

$$U\left(W\text{-}C,q^1,X,Z\right) - U\left(W,q^0,X,Z\right) \geq 0 \quad (1)$$

where U is unobservable. Using V as a deterministic utility function, which is observable and has elements of U more than other components of the indirect utility function, which a stochastic error term. Then the expression remains in the form

$$U\left(W,q,X,Z\right) = V\left(W,q,X,Z\right) + \varepsilon\,(q) \quad (2)$$

The probability to obtain a positive answer, set against a change in the environmental good, is given by

$$\Pr\left(Yes\right) = \Pr\left[V\left(W\text{-}C,q^1,X,Z\right)+\varepsilon_1 > V\left(W,q^0,X,Z\right)+\varepsilon_0\right] \quad (3)$$

Where ε_i is random and collects the unobservable elements of the utility function to the individual. The probability itself is expressed by the form

$$\Pr\left(Yes\right) = \left(1+e^{-\Delta V}\right)^{-1} \quad (4)$$

where $\Delta V = V^1 - V^0$. When the answer of the individual is negative for the proposed environmental change, then the probability is expressed in the form

$$\Pr\left(No\right) = \left(1+e^{\Delta V}\right)^{-1} \quad (5)$$

The WTP for the environmental change q^1 is that which the individual accepts for the alteration in exchange for decreasing his income. This indicates that the individual increase his welfare through improving the environmental good caused for a change in the level of his utility at a cost of decreasing his income, giving rise to what is known as the compensating variation:

$$U\left(W\text{-}WTP,q^1,X,Z\right) = U\left(W,q^0,X,Z\right) \quad (6)$$

and

$$V\left(W\text{-}WTP,q^1,X,Z\right) + \varepsilon_1 - \varepsilon_0 = V\left(W,q^0,X,Z\right) \quad (7)$$

The latter is expressed in terms of the function of observable utility and it is a random variable because of stochastic error. It is a cumulative distribution function (CDF); called F(C)) and the value expected of the WTP is supported in the CDF is in the form

$$E(WTP) = \int_0^\infty \left[1\text{-}F(C)\right] dC \quad (8)$$

Answers can be positive or negative, and the dependent variable will take values of 1 or 0. It is a qualitative variable that represents the odds. Eq. 9 yields these answers, with Y_i being the dependent variable and the term on the right is equivalent to the deterministic utility

$$Y_i = X_i\,\beta + \varepsilon_i \quad (9)$$

where i is 1, 2…N. Eq. (9) refers to a latent variable, which is not observed. If there are two possible results, then the discrete dependent variable takes the value of 1 when the latent variable surpasses a certain level of variation and 0 when it does not reach such a level.

The latent variable is a function of an assembly of explanatory variables:

$$I^* = X_i\,\beta + \varepsilon_i \quad (10)$$

where X is a matrix of size n×k that contains the independent variables k, β is a vector of parameters of size k×1, I denotes the function index, and ε_i is the stochastic disturbance. The term $X_i\,\beta$ determines the value that will take the function index and the regressors generate alternatives, establishing a dichotomist model, where

1- If $I^* > 0$ occurs when $\chi_i\,\beta + \varepsilon_i > 0$, then $I^* = 1$
2- If $I^* < 0$ occurs when $\chi_i\,\beta + \varepsilon_i < 0$, then $I^* = 0$ (11)

The type of model used to make the estimate is going to depend on the assumed distribution form to ε_i. Therefore, the probabilistic model is defined as

$$P_i= Pr= (Y_i=1)= Pr(I^*>0)= Pr(X_i\,\beta + \varepsilon_i > 0)= F(X_i\,\beta) \quad (12)$$

where $F(X_i\,\beta)$ is an associated cumulative distribution function to ε_i that can follow a characteristic normal distribution or a logistic distribution. Similarly, extreme value mass functions can be used. The estimation to obtain the coefficients of regression is through the maximization of the likelihood function

$$L= \prod_{Y_i=0} F(-X\beta) \prod_{Y_i=1} (1-F(-X\beta)) \quad (13)$$

For the present study, we established the supposition that the associated distribution to ε_i follows a logistic distribution with a mean of 0 and a variance $\pi^2\sigma_L^2 / 3$. If normalized by means of σ_L, we have a standard logistic function (Λ) with a mean of 0 and a variance $\pi^2/3$. This way we obtain the Logit model

$$Pr(Yes_i)= \left[1+\exp\left(-\frac{\alpha z_i}{\sigma_L}-\frac{\beta c_i}{\sigma_L}\right)\right]^{-1} \quad (14)$$

Where $Pr(Yes_i)$ represents the acceptance to pay, c_i is the tariff proposed to the individual i, and z_i is a vector that represents the socioeconomic characteristics of individual i.

Taking up again Eqs. 1 and 2, if C > 0, then

$V(W-C,q^1,X,Z)+ \varepsilon_1 > V(W,q^0,X,Z)+ \varepsilon_0$,
$V(W-C,q^1,X,Z) -V(W,q^0,X,Z) > \varepsilon_0 - \varepsilon_1$,
$\Delta V= V(W-C,q^1,X,Z) -V(W,q^0,X,Z)$,
and $\eta= \varepsilon_0 - \varepsilon_1$, then

$$Pr\ (\text{to accept the payment})= Pr(\Delta V>\eta). \quad (15)$$

Considering again Eq. 9, the variation in the utility for the individual for which the observed coefficient is

$$\Delta V= \alpha - \beta C \quad (16)$$

The greater C is, the smaller ΔV will be and the probability to accept will be smaller. The α shows the change of utility caused by the environmental change and represents the marginal utility of the income. If $\Delta V=0$, then the individual would be indifferent to the environmental change.

Description of the survey

There are three types of surveys: face-to-face, telephone, and mail (Mitchell and Carson, 1989). The present field work was a face-to-face survey. The NOAA Panel on Valuation (Arrow *et al.*, 1993) lists advantages of face-to-face compared to mail surveys, including difficulties in controlling the interview process by mail and, often, only a small number of questionnaires are returned because of the wide range of personal interests in the subject. Also, there are problems with random selection. With a small budget, the researcher can use telephone surveys, but there are communities and households that have no telephone. The type of questions for CVM was close-ended with a single dichotomous choice. The NOAA Board on Valuation stated that the disadvantages of open-ended questions are that the subjects tend to exaggerate their answers and the setting is lost. Hanemann (1994) argues that subjects do not know the limit of their WTP and believe that the closed-ended referendum format question is better.

In order to design a questionnaire that would take into account the recommendations outlined above to minimize the possible biases, a pilot study was conducted to know the level knowledge of reserve households about of the environmental service of providing water, more specifically, about knowledge of the hydrological cycle, the current situation of groundwater, its degree of exploitation, and the cause and effect of the intrusion of sea water into the public supply wells within a CV scenario. The results allowed properly designing the questionnaire, the respondent providing clear, updated information about the situation.

The geographical dispersion of the communities, poor communication among them, and time, costs savings and limited budget were important factors that influenced the size of the sample. A random sampling was stratified by differentiated costs, known as cost-optimal allocation. Scheaffer *et al.* (1996) mention the advantages of the use of stratified random sampling: 1) improving precision of estimators of overall population parameters, producing a smaller bound on the error of estimation, particularly this is true if measurements within strata are homogeneous; 2) the technique has the ability to reduce the cost per observation in the survey of the population elements into convenient groupings; 3) estimates of population parameters may be obtained if desired for subgroups of the population. Cochran (1977) and Lohr (2009) argue also that this sampling method can obtain representative estimates of the population and of different strata of the population. These reasons are important to consider when the subject of the survey is related to the geographic area, and therefore the population needs to be split into geographic strata, as in the present case. Disadvantages of its use are that to obtain approximations of the variance for total estimator is more difficult than would be with other sampling techniques (obtained from the pilot study), and cost-optimal allocation will be different from optimal when the costs are different between strata. In this sense, where the strata had high costs, we took small samples to achieve the goal of keeping a minimum sample cost. It may also occur that the information generated is not that needed by the researcher.

According to the General Census of Population and Dwelling (INEGI, 2000), there were 10593 dwellings in the Reserve. The sample consisted of 245 dwellings (2.31%). The questionnaire was divided into three parts: 1) their perception of the safety of the aquifer, 2) domestic water service, and 3) socioeconomic status of the respondents. The format of the question to determine the respondents WTP was: “Would you be willing to pay X dollars to implement measures of water conservation in such a way that an adequate supply and quality of water to your home will be assured?” The proposal CV question was raised in a hypothetical scenario that was implementing a management plan for the conservation of water so that are adequate supply and quality water in households. The program should be implemented to provide safe and clean water that meet national standards, improve delivery of water, restore underground aquifers, maintain hydrological services, create an infrastructure for retention of the water resource, efficiently process wastewater, and develop alternative sources. It was explained to the Reserve households that if the program is not implemented they will face serious water supply problems in the medium and long term.

Importantly, the environmental service is highly vulnerable to the development of any economic activity, due to pollution, overconsumption or the effects of climate change on hydrology, as it can trigger negative impacts on the ecosystem leading to biodiversity loss, on human activities taking place within the Reserve (tourism, agriculture and livestock, fishing) and on drinking water, and produce desertification, impairing the quality of services derived. The payment vehicle proposed was a monthly tariff added to the water consumption bill each month. The minimum and maximum price offered to respondents was based on the pilot survey. In the final survey the

TABLE I
RESPONSE RATES
TO OFFERED PRICES

	WTP	
Price (US$)	Yes (1)	No (0)
0.46	97%	3%
0.92	97%	3%
1.38	91%	9%
1.84	77%	23%
2.30	51%	49%
2.76	40%	60%
3.22	20%	80%

price offered began at US$0.46 and increased in the same amount to reach US$3.22. Whittington (2002) argues that a pretest is useful (with a CV scenario) to help the researcher get the approximate range of prices and provides a basis at the beginning of the study for the development of the survey, but the final instrument should consider the exact valuation questions. The results of the rates affirmative and negative responses to the CV question for each offered price to respondents are shown in Table I. Each increase in the price offered to respondents is equivalent to the cost of a cubic meter of water supplied.

Results and Discussion

Three regressions were estimated and showed a good fit. The variables selected for building the models were based on the test of contrasts of the likelihood ratio statistic, that is, to contrast the overall significance of the estimated Logit regressions. The statistics for the three models were significant at the 99% level, indicating rejection of the null hypothesis that all the estimated coefficients are simultaneously zero. These results suggest that the regressors in the three models jointly determine, with statistic significance, the dichotomous dependent variable. A measure of goodness of fit commonly used in binary choice models in the literature of CMV is the McFadden R^2; in the three models its value falls within the bounds of the empirical results of CVM studies.The variables were also incorporated according to the results obtained by the Bayesian information criteria. The models have a prediction ability of about 80%. The selected variables are shown in Table II.

The results of the Logit CVM model specifications are summarized in Table III. The coefficients had the expected signs and were statistically significant at the 99% level. The coefficients obtained do not have a direct interpretation, but are presented in terms of probability. To interpret them, it is necessary to transform the coefficients in antilogarithms. The main variable, WTP, is negative because it is a function of the demand. There is a smaller probability of those who are willing to pay as a function of the increase in the payment offered, which is in addition to the increase in the current water bill (Table II).

The dwellings that are not connected to the water pipes have a higher likelihood to be willing to pay (64% and 71%) because of their intense desire for piped water. Those without piped water purchase water from vendors that transport it in 10000 liter tank trucks to the dwellings. The block tariff structures for two groups of households are

TABLE II
SUMMARY STATISTICS OF THE VARIABLES USED IN THE REGRESSION ANALYSIS

Variable	Description	Unit	Mean	St. dev.	Minimun	Maximum
Income	Monthly income	US$/month	585	342	49	1982
VIV_17	Dwellings connected to piped water	Binary	1.1	0.3	1	2
ANOSVIVI	Older people are in small communities	Continuous	27.5	16.6	0.25	82
ANP	People that know that their community belongs to an NPA	Binary	1.3	0.5	1	2
VIV_411	Individuals with problems receiving drinking water	Binary	1.3	0.5	1	2
VIV_44A	People give an evaluation of the quality of water service (1-10)	Continuous	7.8	1.9	1	10
VIV_33	People that list water as important for development of daily life (1-10)	Continuous	9.6	0.9	6	10
VIV_34	Number of faucets	Continuous	3	1.8	0	8
Age	Age	Continuous	41.9	15.5	16	93
Work sector*	Work sector	Categorical	4.3	1.4	1	6
Gender	Gender	Binary	1.6	0.5	1	2

TABLE III
LOGIT MODEL RESULTS

Variable	Model 1	P>z values	Exp	Model 2	P>z values	Exp	Model 3	P>z values	Exp
Constant	0.8323	0.001		0.5829	0.001		1.3042	0.001	
WTP quantity	-0.0772	0.001	0.9256						
Dlow income×quantity WTP				-0.0989	0.001	0.9057			
Dhigh income×quantity WTP				-0.0755	0.001	0.9271			
WTP piped water quantity							-0.0791	0.001	0.9239
WTP unconnected piped water							-0.0588	0.001	0.9429
VIV_17	0.498	0.001	1.6454	0.5389	0.001	1.7142		0.001	
ANOSVIVI	-0.0542	0.001	0.9472	-0.0528	0.001	0.9484	-0.0543	0.001	0.9471
ANP	-2.7124	0.001	0.0663	-2.6472	0.001	0.0708	-2.6796	0.001	0.0686
VIV_411	-0.8238	0.001	0.4387	-0.8358	0.001	0.4334	-0.8069	0.001	0.4462
VIV_44A	0.1339	0.001	1.1433	0.1509	0.001	1.1629	0.1417	0.001	1.1522
VIV_33	0.648	0.001	1.9117	0.6274	0.001	1.8728	0.6312	0.001	1.8799
VIV_34	-0.1573	0.001	0.8544	-0.1932	0.001	0.8243	-0.1363	0.001	0.8726
Age	-0.0076	0.001	0.9923	-0.0023	0.001	0.9976	-0.0075	0.001	0.9925
Work Sector	-0.3019	0.001	0.7393	-0.28	0.001	0.7557	-0.2971	0.001	0.7430
Gender	0.6247	0.001	1.8677	0.6687	0.001	1.9517	0.6418	0.001	1.8999
	McFadden R^2 0.27			McFadden R^2 0.29			McFadden R^2 0.28		

the same and the source of water is the groundwater.

Older people in the small communities are less likely to be willing to pay for improvements of the environmental service of providing water, based on their experiences in their locality. They do not trust the water conservation projects. People who understand that their community is part of the desert Reserve are more willing to pay because they have a greater understanding of the importance of conserving water for landscape. They also understand the importance of establishing mechanisms for conserving water (Table II).

The individuals who have problems obtaining drinking water are more willing to pay, because they worry about the supply and quality of water. People wanting a better quality of water service are more willing to pay to maintain that quality or to improve it, as were those that gave greater importance to water for improving their daily life. Based on their experiences living in the community, the elderly are less willing to pay because they do not believe that conservation programs will be implemented. Those who already have adequate faucets and service are less willing to pay because their water consumption expenses are already high and they are unwilling to pay more. Members of the fishing cooperative societies are more willing to pay. The members of fishing cooperative societies are groups of fisheries whom the Mexican government has granted the right to catch certain species. They have a higher average income and can afford an incremental rise in payment for water conservation projects. Women are more willing to pay. They are largely devoted to domestic work and resent, much more then the men, the lack of water.

In Model 2, to analyze differences in the WTP according to income level, we used a regression with interactive variables (Dlow income×quantity-WTP and Dhigh income×quantity-WTP). This model is used because, in the algebraic approach to the RUM, income is eliminated since the linear utility function assumes that the marginal utility of income is constant for the two choices. To calculate the interactive variables, the households were divided into those with low income and with high income. The low income category is less than three monthly minimum wages, amount that defines the high income category. Each income category had binary variables (Dlow and Dhigh, for low and for high incomes) and these were later multiplied by the variable quantity of WTP. The results show that there are differences between the variable quantity-WTPs, as they were statistically significant. The goodness of fit, measured by the McFadden R^2 statistic, was higher than in the first model, which confirms the difference between the WTP elements. These results are consistent with economic theory for normal goods: an increase in a respondent's income increases the likelihood to respond 'yes' to the proposed scenario. Kriström and Riera (1996) argue that when there is this positive relationship to environmental goods, it means that these are considered normal goods.

Another regression with interactive variables was used to contrast differences in WTP between households having piped water and those without. This was computed with binary variables and subsequently multiplied by the price offered. The results indicate dissimilarities between the two kinds of WTP, since the variables are statistically significant at 99% and the goodness of fit is larger than the first model. Thus, the piped water variable explains dissimilarities between the WTP of households.

To calculate the WTP, we determined the ratio of the weighted sum of the rest of the coefficients by their respective means and the coefficient WTP-quantity. The WTP additional amount was estimated at US$2.00 per month, while the low income households were willing to pay about US$1.7 and high income households US$2.20. The WTP for piped water was US$1.92, while in those that remain unconnected it was US$2.52. The households WTP represents 14% to 18% of the current water bill (US$12.38/month). In developed countries, WTP for groundwater protection or water quality (Shultz and Lindsay, 1990; Jordan and Elnagheeb, 1993; Spencer *et al.*, 1998; Hite et al., 2002) is higher than the present results; however, the results are within the range of the studies of stated preference valuation in emerging and developing economies (Shultz and Soliz, 2007; Akter, 2008; Kanyoka *et al.*, 2008; Vásquez *et al.*, 2009; Wang *et al.*, 2010). The likelihood to be willing to pay for the hypothetical scenario of implementing a groundwater conservation program is consistent with CVM literature.

After obtaining the mean WTP, it was multiplied by the number of households for calculating consumer surplus, which represents the economic benefit to households and resulted in US$250000. What is important is that the money collected be used to improve water conservation, minimize losses from leaks, build an infrastructure for storing water, restore underground aquifers, maintain water services and delivery, process wastewater, and find alternative sources, such as desalination facilities.

Conclusions and Recommendations

The small coastal communities of El Vizcaino Biosphere Reserve are without permanent surface streams. The region is subject to random, scarce rains that are not stored for future use. The communities pump groundwater. Most of the heavier rainfall in the broad desert region drains into the sea or infiltrates into the upper levels of the ground. Little water reaches the aquifers, and there is insufficient infrastructure to capture rain water. Groundwater is a scarce natural resource that is appreciated, but availability over time decreased as the population increased. Increasing scarcity of water requires delivery in an economically efficient form. The water stored in the aquifer must be considered an environmental asset and it is the only currently reliable source. To find the WTP of households for improving the distribution and sustainability of water is not a simple process of estimation and interpretation, but requires infrastructure design and environmental policies that promote responsible use and management of the water. Among these types of policies are payment schedules for providing water service.

In Mexico, the National Forest Commission implemented a mechanism for payment for hydrologic environmental services from forested areas (INE, 2005). By using fiscal resources, the agency encouraged land owners to maintain the tree canopy in the areas where there is potential to recharge aquifers. Regulations include conservation of vegetation to reduce run-off velocity and increase infiltration of surface water into the aquifers. However, according to this institution, the Reserve is not eligible for access to the funds of the payment program for environmental water services. Other government agencies, the National Water Commission, the State Water Commission, the water department of the municipality of Mulege, the city government of Mulege, the government of the State of Baja California Sur, the National Commission for Protected Natural Areas, and the National Commission of Dry Zones must establish an agreement of common cooperation with the National Forest Commission to generate funds for environmental water services in this arid ecosystem.

It is indispensable to incorporate regulations in the Reserve's Biosphere Management Program for payments by end users of environmental water services. This payment would be an additional charge paid by consumers. This fee should appear in their water bill and set as an obligatory payment for conservation measures. To collect and administer the payments efficiently, it is necessary to create a collateral agency to the present water agency administration. The new agency or company should not be a bureaucratic entity that requires a large income for its maintenance and administration. A local committee of citizens should be built, independent of the government, to protect the funds and supervise transparent management of the income from payments for this environmental water service.

An organization of this type must obtain financial resources, administer it efficiently, and allow access to accounts review. A group of citizens should oversee the money collected and be a link for promoting more active participation of the community at all levels of decision-making on the use and management of water. The funds should be used to improve water conservation, increase the use of water metering, repair or install new water meters, pay supervising personnel to verify that people do not waste water, set fines to stop water waste, minimize loss from leaks, improve water delivery, provide safe and clean water that meets national standards, create an infrastructure for retention of the water resource, artificially refill aquifers, efficiently process wastewater and develop alternative sources.

ACKNOWLEDGMENTS

The authors thank Ira Fogel of CIBNOR for editorial services.

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VALORACIÓN ECONÓMICA DEL AGUA EN UN ÁREA NATURAL PROTEGIDA DE UNA ECONOMÍA EMERGENTE: RECOMENDACIONES PARA LA RESERVA DE LA BIOSFERA EL VIZCAÍNO, MÉXICO

Marco A. Almendarez-Hernández, Luis A. Jaramillo-Mosqueira, Gerzaín Avilés-Polanco, Luis F. Beltrán-Morales, Víctor Hernández-Trejo y Alfredo Ortega-Rubio

RESUMEN

La Reserva de la Biosfera El Vizcaíno es un área natural protegida con recursos hídricos limitados debido a que no hay cursos de agua superficiales. Durante las escasas lluvias aparecen arroyos efímeros. Ello ha llevado a los pobladores a utilizar acuíferos subterráneos. No obstante, el consumo excesivo y las condiciones naturales han llevado a la sobreexplotación del acuífero y la intrusión salina. El objetivo principal del estudio es determinar, utilizando el método de valoración contingente (MVC), el valor económico de mejoras en servicios ambientales de provisión de agua a los habitantes. Los resultados indican una disposición a pagar (DAP) mensual de US$2,20 adicionales a la cantidad que pagan actualmente los consumidores. Las familias de menores recursos parecen dispuestas a pagar cerca de US$1,70 y las de altos ingresos, US$2,52. La DAP para agua por conexión directa es de US$1,92, mientras que en aquellos que permanecen sin conexión es de US$2,52. Los fondos adicionales recolectados deberán emplearse para mejoras en la conservación del agua, tales como restauración de acuíferos subterráneos, mantenimiento de servicios de agua y sistemas de distribución, construcción de infraestructura para el sistema de depósito, construir plantas de tratamiento de aguas servidas, y buscar fuentes de agua alternativas. El estudio ofrece información cuantitativa pertinente y recomendaciones a los tomadores de decisiones para el manejo del agua en la reserva. El Decreto Presidencial de la Reserva de la Biosfera El Vizcaíno de 1988 servirá para apoyar esfuerzos que conduzcan a obtener recursos económicos internacionales para el manejo apropiado de los recursos hídricos.

VALORIZAÇÃO ECONÔMICA DA ÁGUA EM UMA ÁREA NATURAL PROTEGIDA DE UMA ECONOMÍA EMERGENTE: RECOMENDAÇÕES PARA A RESERVA DA BIOSFERA, EL VIZCAÍNO, MÉXICO

Marco A. Almendarez-Hernández, Luis A. Jaramillo-Mosqueira, Gerzaín Avilés-Polanco, Luis F. Beltrán-Morales, Víctor Hernández-Trejo e Alfredo Ortega-Rubio

RESUMO

A Reserva da Biosfera El Vizcaíno é uma área natural protegida com recursos hídricos limitados devido a que não há cursos de água superficiais. Durante as escassas chuvas aparecem arroios efêmeros. Isto tem levado seus habitantes a utilizar aquíferos subterrâneos. Entretanto, o consumo excessivo e as condições naturais têm levado à super exploração do aquífero e a intrusão salina. O objetivo principal do estudo é determinar, utilizando o método de valorização contingente (MVC), o valor econômico de melhorias em serviços ambientais necessários a fim de prover água aos habitantes. Os resultados indicam uma intenção de pagamento (IDP) mensal de US$2,20 adicionais à quantidade que pagam atualmente os consumidores. As famílias de menores recursos parecem dispostas a pagar cerca de US$1,70 e as de altos ingressos, US$2,52. A IDP para água por conexão direta é de US$1,92, enquanto que para aqueles que permanecem sem conexão é de US$2,52. Os fundos adicionais recolhidos deverão empregar-se para melhorias na conservação da água, tais como restauração de aquíferos subterrâneos, manutenção de serviços de agua e sistemas de distribuição, construção de infraestrutura para o sistema de depósito, construir estações de tratamento de águas residuais, e buscar fontes alternativas de água. O estudo oferece informação quantitativa pertinente e recomendações aos tomadores de decisões para a manipulação da água na reserva. O Decreto Presidencial da Reserva da Biosfera El Vizcaíno de 1988 servirá de apoio para tentativas de conseguir recursos econômicos internacionais para a manipulação apropriada dos recursos hídricos.