DOI: 10.24850/j-tyca-2019-01-07
Articles

Value of river restoration when living near and far. The Atoyac Basin in Puebla, Mexico

Valor de la restauración de ríos cuando se vive cerca y lejos. La Cuenca de Atoyac en Puebla, México

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Abstract

On analysing data from a Contingent Valuation (CV) survey to restore the Atoyac River Basin in Puebla, Mexico, we found that households obtain differentiated benefits due to their condition of closeness to or distance from the river, which are in turn often associated with conditions of vulnerability to water pollution and poverty. Our approach was to estimate Willingness to Pay (WTP) for restoration of the Atoyac River that crosses the Puebla State, using models for two population groups: those residing nearby and those living farther away. As expected, the bid offered and the household's income are significant determinants of WTP; however, the remainder of the variables change, denoting that poor people are more concerned about river pollution.

Keywords: Distance decay, willingness to pay, rivers, developing countries, river pollution, contingent valuation, water quality.

Resumen

A través del análisis de una encuesta de Valoración Contingente (VC) para la restauración de la Cuenca del Alto Atoyac, Puebla, se encontró que los hogares obtienen beneficios diferentes, acordes a su condición de proximidad al río, relacionados generalmente con aspectos de vulnerabilidad a la contaminación del agua y a condiciones de pobreza. El estudio se enfocó en la estimación de modelos de disposición para pagar el rescate de la cuenca del río Atoyac en su cruce por el Estado de Puebla. Se diferenciaron dos grupos de población: uno cerca del río y otro lejos. Como se esperaba, el precio ofrecido y el nivel del ingreso del hogar determinan de manera significativa la disposición a pagar en ambos modelos; sin embargo, el resto de las variables cambian y manifiestan que las personas de bajos ingresos están más preocupadas por la contaminación del río.

Palabras clave: efecto de distancia, disposición a pagar, países en desarrollo, contaminación de ríos, valoración contingente, calidad del agua.

Recived: 24/01/2018

Accepted: 04/07/2018

Introduction

Despite the valuable uses of natural superficial bodies of water, such as rivers and lakes, these have undergone increasing exploitation and degradation in Mexico Carabias, Landa, Collado & Martínez, 2005;

Jiménez, Torregrosa & Aboites, 2010). A great proportion of superficial water ecosystems at present have a reduced capacity for providing fundamental environmental services that are related to water provision, regulation, ecosystem support, and cultural and recreational assets (Turner, 2004; Brouwer & Pearce,2005; Ruelas, Chávez, Barradas, & Miranda, 2010).

These negative impacts on the environment, known as externalities, has not been quantified, but it affects several sectors of the population, as well as local and regional ecosystems. This trend has been accompanied by degradation in the quality of surface and groundwater by wastewater discharges from cities, industries and agricultural activities Carabias, Landa, Collado & Martínez). The low level of wastewater treatment is a serious problem because only 46% of wastewater is treated, which explains that most of the rivers in and around most cities are contaminated. The highest levels of pollution of surface water are in the Basins of Lerma, Alto Balsas, Bajo Bravo, and Alto Panuco (Conagua, 2016).

Being the majority of rivers around urban and industrial areas depositories of untreated wastewater effluents, there are innumerable environmental “bads”, including health problems, bad odor, losses in biodiversity, reduction in the agricultural production, pollution through solid waste, vector proliferation, among others (Aquino, Rodríguez & Morales, 2014; Rodríguez et al., 2014).

Extreme rainfall events, produce floods that combine rainwater with sewage water from these polluted rivers, and generates not only material losses but also health risk problems among the local population. Another problem is that untreated wastewater is used for agricultural irrigation which impacts negatively the quality of crops, produce health effects on farmers and consumers, and impacts negatively on the soil, the groundwater and the environment of the affected regions (Domínguez-Mariani, Carrillo-Chávez, Ortega & Orozco-Esquivel, 2004). There is an international consensus that poor water quality affects not only the quantity and availability of the resource, but also generates negative effects on countries’ economic development (Palaniappan, 2010; WWAP, 2012). In Mexico, INEGI estimated that about 57,403 million pesos were lost due to water pollution in 2015.

Regarding water management in urban areas, the service provision is operated by a total of 2 688 water operators registered, mostly public entities (INEGI, 2014). Their administration has been strongly criticized because they operate with high physical losses due to leaks in the pipeline and low commercial profitability, which results in an inability to finance improvements in the system and invest the necessary resources to sustainably manage the resource, including the installation of wastewater treatment systems (Pineda-Pablos, Salazar-Adams & Buenfil-Rodríguez, 2010; IMCO, 2014; IMCO, 2014).

For instance, the urban sector loses approximately 43% of the water in the pipes and does not give any treatment to wastewater to 43% of the contaminated water (Conagua, 2016). The National Water Commission (Conagua) created a system of indicators with the purpose of evaluating the performance of water utilities, which show elements of physical, commercial and global efficiency for cities in Mexico. The global index shows as the lowest level the Chetumal water operator with 25% of global efficiency and as the highest level the Tijuana water operator with 78% of efficiency. It is worth mentioning that the index does not consider the impacts of externalities generated by the provision of potable water and sewage services (INEGI, 2014). The case of industrial wastewater is more alarming because 66% of industrial wastewater does not receive treatment and this often has toxic components.

The financing of wastewater treatment projects aimed at improving ecological conditions of superficial water bodies is not a priority for municipal authorities and neither seem to be for state or federal authorities. Once the water resource is polluted, restoration projects entail great cost, while the benefits are often difficult to calculate, because of insufficient information regarding pollution costs to different communities, or estimates about negative impacts on economic activities, as well as a lack of markets in terms of the value of diverse environmental services (Loomis, Kent, Strange, Fausch & Covich, 2000).

When a project of this nature emerges, it is necessary to justify that benefits exceed costs, here cost benefit analysis is a tool that involves balancing benefits and costs of a given policy intervention in order to determine the net gains or losses in welfare terms for the society. When there is competing priorities requiring financing, there should be evidence demonstrating that there are gains from ecology restoration projects. From a theoretical perspective, the benefits are given by beneficiaries' willingness to pat (WTP) for the proposed change and the cost by the estimation of the investment required to execute the project (Turner, 2004).

Expressed preference methods have been employed to measure the value that populations afford to restoration projects of rivers and other surface water bodies by measuring individual consumer preferences, expressed through an individual's WTP (Brower & Pearce, 2005). Analysis focused on how the benefit received by an individual is influenced by the specific characteristics of the river, the individual's contact with this resource, the location of beneficiaries, the substitution of recreational sites, and socioeconomic characteristics (Hampson, Ferrini, Rigby & Bateman, 2017).

The closer the resource identified for restoration, the greater the reasonable certainty that improvement truly does provide benefits to the population. However, there is evidence that individuals do indeed value resources even when they do not have direct contact with a resource (Loomis, Kent, Strange, Fausch & Covich, 2000).

This study uses the data of a Contingent Valuation (CV) survey aimed at estimating households' WTP for clean-up of the Atoyac River and the Valsequillo Dam. The Atoyac River flows through the city of Puebla, the fourth largest metropolitan area in Mexico and the Puebla state capital. The survey was undertaken in 2009 as input for a Cost Benefit Analysis (CBA), in which the challenge was to justify the great cost involved in the clean-up of superficial water bodies, given that several benefits do not necessarily result in commercial returns (Survey results were described by Soto & Ramírez, 2017).

In this research, we explore the data of this survey to consider the policy-relevant possibility that WTP for river improvement is determined by different variables, depending on whether people live near the resource or far from it. On considering this, we proposed to estimate WTP models for two types of population groups: those living near to and those living far from the Atoyac River. This can aid in identifying what is relevant to each population group, the members of which may value the same resource, but obtain differentiated benefits from a restoration project due to their condition of closeness to or distance from the river. This paper contributes to the literature of spatial-preference heterogeneity with methods that enhance welfare estimates where evidence in developing countries and in Mexico is limited.

Importance of valuation of river restoration projects: theoretical approach

A recurrent issue regarding this valuation of river restoration projects includes the accuracy of the estimates, given that benefits vary with the distance from the water bodies, and this in turn is complicated by different levels of water pollution and income inequality. The analysis should consider the benefit perceived by the individual as deriving from the specific characteristics of the resource, the contact with the resource, and the individual’s socioeconomic characteristics (Hampson, Ferrini, Rigby & Bateman, 2017).

A first step is to define the population impacted by damage to the natural resource. This population could be residents in the area, visitors to the area, or persons who hold non-use values and who are not necessarily restricted by geographical locations. Thus, defining the population receiving the benefits from the proposed change might be challenging because there are different considerations based on the study’s objective. In this regard, some consider closeness to the resource, and others, administrative limits, economic areas, or other criteria (Hanley, Schläpfer & Spurgeon, 2003; Bateman, Day, Georgiou, & Lake 2006).

As in other contexts, we argue that the benefits of improving resource conditions depend on the nature of the resource and the type of exposure derived from the resource’s deterioration, as well as on the sensitivity and adaptability of the individual to a determined impact (IPCC 2007).

Vulnerability to river contamination is explained not only by the magnitude of the pollution problem, but also by the capacity of an individual to cope with the problem. River pollution is amplified for communities that are more exposed because they depend on the water resource and/or live in areas with high exposure to bad odors, mosquitoes, or garbage deposited on river banks.

Furthermore, greater sensitivity would be experienced by individuals living under marginal socioeconomic conditions and who are thus less prepared to manage the harmful impacts of pollution, for instance, lack of health services or reduced possibilities for producing household adaptations, such as any system to prevent bad odors or to install mosquito nets (Palaniappan, 2010; WWAP, 2015).

Exposure depends on whether individuals are direct or indirect users of the river resource (Hanley, Schläpfer & Spurgeon, 2003; Bateman, Day, Georgiou & Lake. 2006; Kozak, Lant, Shaikh & Wang, 2011; Jørgensen et al., 2013). However, natural resources produce not only use values, but also non-use values, and in addition an intermediate category of option values.

Use values refer to direct interaction with the resource, such as water consumption for agricultural, industrial, and domestic uses, together with recreational and other ecological functions including flood prevention or sediment control. Non-use values may be motivated by altruistic motives; such as concern for the welfare of future generations or concern for wildlife for its own sake. Option values refer to usefulness derived from knowing a service is available for its use in the future, given the uncertainty of the demand (Hanley, Schläpfer, & Spurgeon, 2003; Turner, 2004).

That is, users will demonstrate a higher WTP for improved resource conditions than non-users, regardless of distance, because they might pass through or live next to the river and, if the river is contaminated, they are involuntarily exposed to bad odors, mosquitoes, garbage, etc. In fact, as suggested by Bateman, Day, Georgiou & Lake. (2006), those who live nearby but are not voluntary direct users -for instance, recreation- might become users of the environmental goods generated in the case of an improvement in the resource.

Aside from this, a difference is likely to be found between WTP for preserving a resource that is in good condition at present but that may deteriorate in the future (equivalent surplus measure), and WTP for improving a resource that in the future will have better conditions but that is now contaminated (compensatory surplus measure) (Bateman, Day, Georgiou & Lake, 2006).

Water quality in terms of the course of rivers may change, particularly in upstream rural areas that may enjoy good conditions, with respect to downstream areas that might receive agricultural, industrial, and urban discharges (Tait, Baskaran, Cullen & Bicknell, 2012). Here, the link between poverty and environment is important within a developing-country context, because rural areas typically possess greater socioeconomic marginality.

There is evidence showing that natural resources provide direct services to the poor that are free or low-cost, such as water and food. For instance, poor rural communities in Brazil, Indonesia, India, and Zimbabwe receive ecosystem services of between 40 and 90% of the so-called “Gross Domestic Product [GDP] of the poor” (Sukhdev, Schröter-Schlaack, Nesshöver, Bishop, C. & Brink., 2010). Here we are interested in exploring the perceptions of poor communities living in upper rural areas regarding the possibility of river restoration, but this is more likely to occur when there is proximity to the resource.

Previous research has estimated the benefits of interventional actions through models using distance as a function of the WTP regression. We argue that this type of analysis reduces the possibilities for observing how different individuals respond to the project proposal. Certain determinants of the households’ WTP in the groups of persons living close to and far from the resource may change, the latter explained with regard to their location.

Several authors have previously employed the stated preference methods to estimate the value of improvements in water quality, emphasizing the distance-decay effect, different preferences between users and non-users, the importance of the water-quality status quo, and the presence of substitutes (Pate & Loomis, 1997; Hanley, Wright & Alvarez-Farizo, 2006; Bateman, Day, Georgiou & Lake, 2006; Hanley, Schläpfer & Spurgeon, 2003; Brouwer, Martin-Ortega & Berbel, 2010; Shang, Che, Yang, & Jiang, 2012; Vaughan, Russell, Rodríguez, & Darling, 1999).

In certain cases, research found interesting results such as significant spatial decay for both use and non-use values, but a more rapid distance-decay effect exists for use values than for non-use values (Hanley, Schläpfer & Spurgeon, 2003, Jørgensen et al., 2013).

The authors also have found differences among stretches of rivers, indicating that not only distance and substitutes, but also the resource’s characteristics, are relevant (Meyerhoff, Boeri, & Hartje, 2014). Also, respondents living in the vicinity of low-quality waterways are willing to pay more for improvements vs. those living near high-quality waterways. These authors found that disregarding the influence of the respondent’s local water-quality data exerts a significant impact on the magnitude of welfare estimates (Tait, Baskaran, Cullen & Bicknell, 2012).

In Mexico stated preference methods have been applied to assess water sources services. Ojeda, Mayer & Solomon, (2008) studied overexploitation in a water-scarce region of the Yaqui River Delta and found that households' WTP in Ciudad Obregon was 73 pesos monthly ($5.6 USD) for preserving ecosystem services.

At the Apatlaco River area in Morelos, Mexico, its estimated 101 pesos per household per month (7.78 USD) for a program offering wastewater treatment, improved solid waste management, the expansion and strengthening of municipal services, and strategic basin management. Ayala-Ortiz & Abarca-Guzman (2014) used the CV method to analyze the case WTP to improve water quality in a section of the Lerma River in Guanajuato. They estimated that households' WTP in La Piedad is 50.4 pesos monthly, while in Santa Ana Pacueco, 43.7 pesos. Nevertheless, none of these studies have analysed the effect of distance on household´s WTP.

It is noteworthy that many studies consider the importance of substitute sites because recreational use plays an important role in the value of the resource. This differs from our case study, in which the population is exposed to environmental "bads" to a greater extent-; therefore, the substitution effect is not as relevant as in previous studies.

Case study: Contamination of the Atoyac Hydrological Basin and survey description

The study case is that of the Basin of the Atoyac River in Puebla, which belongs to the Balsas region. The Atoyac River and its tributaries cross through the Metropolitan Area of Puebla-Tlaxcala, the fourth most important urban area in Mexico, with a population of 2.72 million inhabitants in 2010, the majority of whom (88%) live in the state of Puebla (INEGI, 2010). The Basin of the High Atoyac comprises four sub-basins: Zahuapan; Atoyac; Alseseca, and the Valsequillo Dam. It covers an area of 4,011 km^2 and the Atoyac River has a length of 113.7 km, of which 20 km belong to the neighbouring state of Tlaxcala (see Figure 1) (Conagua, 2007).

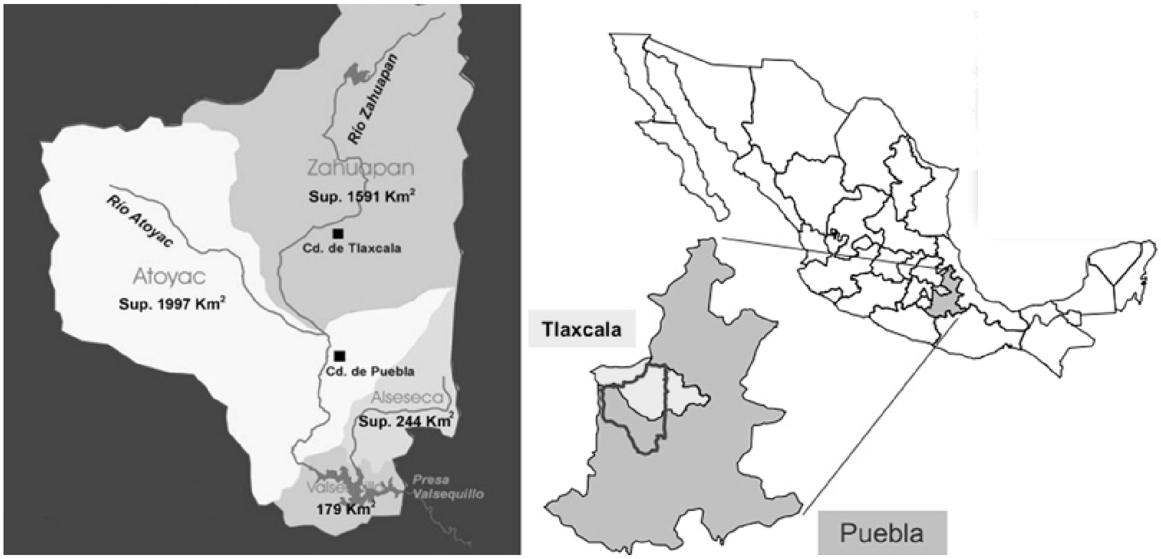

Figure 1. Location of the Alto Atoyac Basin. Source: CONAGUA (2007).

According to the National Water Commission (Conagua, its acronym in Spanish), the Alto Balsas sub-basin, where the Alto Atoyac is located, was among the fourth most polluted surface water bodies in the country (Conagua, 2016).

The registered pollution levels render it difficult to utilize the water resource directly in nearly any activity in some areas. In most of this basin, infrastructure for treating wastewater is non-existent and, in some parts, treatment levels fall very much below those permitted. It is estimated that, of the total wastewater produced in the region, 70% is discharged by municipal sources and 30% by industry, although the latter is considered highly polluted (GEP, 2011).

The consequences for failing to treat sewage include biodiversity loss, bad odor, a reduction in agricultural production, undetermined health problems among the population residing on the river banks, and pollution through solid waste. During various periods throughout the year, the amount of floating water lilies in the Valsequillo Dam is an alarming problem, contributing to the reduction of the dam's storage capacity by roughly one half (Conagua, 2007).

These water lily plants can cover a great surface of the dam, given that they prefer to live in a polluted environment. The local media and a few academic articles highlight the effects of contamination that include gastrointestinal diseases (Aquino, Rodríguez & Morales, 2014), reduction of leisure activities, and negative impacts on agricultural production, among others (Soto & Ramírez, 2017; Rodríguez & Morales, 2014).

Survey description

A Contingent Valuation survey was undertaken in 2009 as input for a Cost Benefit Analysis (CBA). Results of the economic benefits of river restoration were described in the work of Soto & Ramírez (2017), with a broad description of the survey and results of the CBA, where distance was considered as part of the regression function. The Contingent Valuation (CV) method involves the use of a carefully designed survey with a series of structured questions posed to a household member with the objective of determining the maximal amount of money that the individual would be WTP for the proposed change in the characteristics of the environmental good or service (Mitchell & Carson, 1989; Arrow *et al*., 1993; Bateman *et al*., 2002).

The scenario proposed to the respondents refers to improvement from an intermediate level of water quality as the result of hypothetical wastewater treatment of industries to a higher quality level that can be obtained by installing treatment plants for municipal wastewater. The scenario mentioned that execution of the project would exert a positive effect on recovery of water color and odor, biodiversity enrichment, and aesthetic conditions, among others (Soto & Ramírez, 2017).

The population for the study included all homes in the 138 towns located within the Basin in the area of Puebla, who would directly benefit from the treatment plants. The National Population and Housing Census indicated that 2.1 million inhabitants lived in the area, in 497,000 households (INEGI, 2010). To select a sample from the population, a probabilistic stratified random sampling strategy was developed with a three-stage selection process. The 138 villages were organized into five strata according to population size (Soto & Ramírez 2017). The survey was pretested on three focus groups prior to administration of the survey. There were 1,220 complete responses from a total of 2,832 households visited; these surveys showed a response rate of 43%.

The survey consisted of the following five sections: the first section covered attitudes and opinions concerning general environmental problems in Puebla; the second section contained perceptions about the pollution problems of the Atoyac River, its effluents, and the Valsequillo Dam; the third section comprised questions on the participant's knowledge of the contamination problem; the fourth section provided information concerning the restoration project and the WTP question, while the remaining section contained questions on demographics.

The payment vehicle was a bimonthly fee added to the water or electricity bill, considering that the latter is invoiced to practically all households. The WTP elicitation format selected was a single bound Dichotomous Choice (DC) bid, followed by one follow-up question (one half of the first price offered) for respondents who rejected the first price proposed (DeShazo, 2002), and an open-ended question eliciting maximal WTP. The price range was between 30 and 500 Mexican pesos bimonthly and was offered randomly among the persons included in the sample of surveyed households.

Distance was calculated through the Geographic Information System (GIS) tool considering the nearest point of the riverbank for each selected town. In the case of Puebla City, by far the largest town in the Basin, the distance from the selected basic geographic statistical area (AGEB, the acronym in Spanish) to the bank of the river was calculated. Pollution levels throughout the river were also considered, because water quality changes from upstream to downstream; in particular, upstream rural areas enjoy good conditions with respect to downstream areas, which receive industrial and urban discharges.

Thus, the course of the Atoyac River was divided into four sections, taking pollution criteria into account as follows: Section 1 starts from the Valsequillo Dam to Km 17 and presents a medium-high level of pollution; Section 2, which includes from Km 17.1-Km 37, presents a medium pollution level; Section 3, which, including from Km 37.1-Km 65, presents the maximal level of pollution, and Section 4, which included upstream rural areas from Km 65.1-Km 85, presents the lowest pollution level. As observed, there were water-quality problems in three of the four sections, from Km 0-Km 65.

The information obtained from the survey was analyzed through statistical and econometric methods using the SPSS statistical software program. Data were processed with expansion factors for the number of households projected for 2010 for the study area.

Results

Introductory questions presented a range of interesting general results regarding the perception of respondents with respect to environmental issues and Atoyac River conditions. First, water supply and sewage services were mentioned in the survey as the third most important problem at the state level, immediately after those of public security and unemployment. Pollution in the Atoyac River, its effluent, and in the Valsequillo

Dam were consistently mentioned as the second most important environmental concern, preceded only by inappropriate solid-waste management. Regarding perceptions, the majority of respondents readily identified the water courses, but stated that they lived far from these or that they did not pass through the area where the water courses are located. A total of 62% of the respondents noted that their place of residence was far from the rivers and the dam, while the remaining 38% reported that they lived near the Atoyac, near another river in this area, or near the Valsequillo Dam.

The perception of the pollution level of these water bodies for the majority of survey respondents (>90%) was either poor or very poor. When asked about the main causes of water pollution, the most frequently mentioned sources were wastewater discharge by industries, wastewater discharge by households, and garbage disposal. Respondents worried about the impact of water pollution, particularly with regard to health problems (27%), unpleasant odors (22%), and the creation of invasive fauna (17%).

The effect of distance a priori was assumed to determine that WTP exhibits significant explanatory power. Considering the whole sample, distance ranged from 0-18.89 km, with a mean value of 5.73 km and a

Standard Deviation (SD) of 5.46 km. In the original analysis, Soto & Ramírez (2017) used an inverse exponential function 1/1 + exp (distance-mean/SD) to capture the effect of distance in the WTP function. The exponential inverse-distance variable was significant at the 99% Confidence Interval (CI) and referred to that the probability of WTP is higher near the river, but that it decreases rapidly at a distance of about 4.5 km.

Considering this information, the question is how to define a distance point at which the benefits received from river water-quality improvement are reduced. Table 1 depicts the effect and significance of different distance values, by means of the beta, the 95% CI, significance (z), and the percentage of the sample that includes different distances. The CI demonstrated the change in behavior of the effect of distance on WTP, with values between 4.2 and 5 km, while for 4.26 km, the beta was 0.274 -with a significance level of 3.522-, and for 5 km, the beta reduced its influence to 0.186, with a lower significance level of 2 359. From the results of these tests, it was decided to take the median distance value, 4.2 km, as the point at which to divide the population.

Thus, the total population was divided into two groups: those residing within 0 and 4.2 km of the river and those living more than 4.2 and 18.89 km from the river, which is the maximal value. The independent-sample Student *t* test revealed that the means are significantly different (*p* <0.001) between these two groups.

Table 1. Distance effect on Willingness to Pay (WTP).

Distance (Dis) value	Beta	95% Confidence Interval (CI)	Z	Sample percentage (%)
Dis2km	0.257	(0.097-.418)	3.140	34.4
Dis3km	0.315	(0.160-0.469)	3.991	42.6
Dis4km	0.275	(0.122-0.428)	3.532	48.4
Dis4.2km	0.274	(0.122-0.426)	3.522	50.0
Dis5km	0.186	(0.031-0.340)	2.359	58.
Dis6km	0.192	(0.036-0.348)	2.417	60.7
Dis7km	0.144	(0.027-0.315)	1.652	73.0

WTP models of households close to and far from the resource

For an overview of variables in the two samples, see Table 2. In addition to socioeconomic characteristics, the Table includes variables denoting the respondent's experience with the Atoyac River and his/her response to the WTP question. Mean values of age of respondents, income, gender distribution, education of respondents, offered bid, number of members in the household, and presence of children broadly lie in the same order of magnitude in both samples. Logically, spatial distribution of households with reference to river-water quality and contact with the river change.

The gender of respondents is 60% and 57% of females in the two samples, which is not statistically different. The age structure of the respondents lies within 45 years in both cases. Differences between samples can be observed in the proportion of households with higher education and regarding income.

Years of education are higher among households living closer to the river, with 9.4 years compared to 8.2 years of persons living farther away. Average income is also higher: 4,196 pesos monthly for households living close to the river compared with 3,202 pesos monthly for households residing farther away. This can be explained by that these areas exhibit greater economic activity in the particular case of Puebla, and we should consider that there is a positive correlation between income and education (Pearson correlation, 0.421; 99% CI).

Table 2. Descriptive variables of households living close to and far from the river.

		Households living near (up to 4.2 km)					**Households living far (more than 4.2 km)**				
		N	Min.	Max.	Mean	Std. Error	*N*	Min.	Max.	Mean	Std. Error
WTP	Willing to Pay X Mexican pesos	599	0	1	0.5	0.02	586	0	1	0.42	0,02

		Households living near (up to 4.2 km)					**Households living far (more than 4.2 km)**				
	every 2 months for a program to clean household drainage and improve the water quality of rivers and dam (1 = YES; 0 = NO)										
Amount	Bid amount for DC valuation question ($30, $70, $180, $330, and $500)	616	30	500	222	7	604	30	500	222	7,07
Concern	Level of concern from 0-4 on current water quality of the rivers or dam. 0 = Not worried to 4 = Very worried	608	0	4	3.69	0.02	601	0	4	3.6	0.02
Pass by river	Passing by a river or a dam to perform daily activities or to get to work	616	0	1	0.01	0.00	604	0	1	0.04	0.00
River use	Any activity using the rivers or dam (domestic activities, for cattle, irrigation, fishing, commercial purposes, recreation, drainage disposal, garbage disposal) = 1	616	0	1	0.2	0.01	604	0	1	0.18	0.016
Age	Age in years	616	18	86	45.73	0.60	604	18	86	45.02	0.59
Gender	Female = 1	616	0	1	0.6	0.02	604	0	1	0.57	0.02
Education	Education in years: None = 0, Elementary = 6, Middle school = 9, High school	616	0	19	9.45	0.19	604	0	19	8.2056	0.16

		Households living near (up to 4.2 km)					Households living far (more than 4.2 km)				
	= 12, Undergraduate = 17, Postgraduate = 19										
Income	Mid-points of household-income categories: $1,500, $2,250, $4,500, $7,500, $12,000, $22,500, $30,000	549	1,500	30,000	4,196.7	189.09	532	1500	22500	3,202.4	103.25
Members	Number of members living in the household	615	1	15	4.45	0.08	603	1	20	4.61	0.08
Children	Children under 12 years = 1	616	0	1	0.54	0.02	604	0	1	0.6	0.02
Section1	Km 0.0-17.0 Km-medium-high level of pollution = 1	616	0	1	0.25	0.01	604	0	1	0.27	0.01
Section2	Km 17.1-37.0 Km-medium level of pollution = 1	616	0	1	0.44	0.02	604	0	1	0.58	0.02
Section3	Km 37.1-65.0 Km-maximal level of pollution = 1	616	0	1	0.06	0.01	604	0	1	0.11	0.01
Section4	Km 65.1-85.0 Km-lowest level of pollution = 1	616	0	1	0.24	0.01	604	0	1	003	0.00

As expected, both groups presented significant statistical differences in the case of the WTP response, while 49.7% (95% CI, 0.46-0.53) of respondents living close to the river declared that they would be WTP the bid proposed. This proportion fell to 39.7% (95% CI; 0.38-0.45) for respondents residing far from the river.

Table 3 presents the results of the two probit models when separating the population into these two groups, allowing for the evaluation of specific factors influencing the households' WTP based on being close to or far from the resource. As expected, in both groups, the bid variable exerts a negative and significant effect on households' WTP (99% CI). Likewise, the household-income variable is significant in both groups, with a positive effect and significance level of 99%. However, the remainder of the variables change.

Table 3. Willingness to Pay (WTP) regression models of households living close to and far from the Atoyac River.

Households living near (up to 4.2 km)				**Households living far (more than 4.2 km)**		
Variable	Coefficient	SE	Student *t*	Coefficient	SE	Student *t*
Amount	-0.004^{a}	0.000	-10,634	-0.003^{a}	0.000	-8,453
Income logarithm	0.431 ^{a}	0.144	2,995	.0354^{a}	0.114	3,112
Female	2,923^{b}	1,498	1,951	n.s.	n.s.	n.s.
Female *income_log	-0.349^{b}	0.186	-1,875	n.s.	n.s	n.s
income lower than $1,500*Section4	0.555^{a}	0.269	2,062	n.s.	n.s	n.s
Pass by/use river	n.s.	n.s.	n.s.	0.432$_{a}$	0.140	3,079
Age	n.s.	n.s.	n.s.	-0.009^{a}	0.004	-2,48
Intercept	-2,737^{a}	1,163	-2,353	-2,066^{a}	0.929	-2,225

(SE = Standard Error; ^{AP} <0.01; ^{b}p <0.05; ^{c}p <0.10; n.s. = not significant).

In the model of households living close to the river, the gender variable exerts an effect: while poor women are more likely to pay when living near the resource, the negative sign of the interaction between income and the women shows that high-income women are less likely to pay. We have observed this effect in other studies, and this might be explained by the vulnerability of poor women in terms of problems related to the water supply and to other environmental assets (Soto & Bateman, 2006; Meyerhoff, Boeri & Hartje, 2014).

In this case, due to their role in food preparation and in the care of children during illness, women might perceive a greater benefit of river restoration (WWPA, 2015). In addition, poor women may be less prepared to deal with the problems of bad odor, mosquitoes, or garbage around river banks. In other words, low-income women are more vulnerable and/or more exposed to problems related to the quality of the resource compared to high-income women. Confirming this hypothesis, the gender variable possesses no significant effect among households living far from the resource; thus, this relation appears to be significant only when there is closeness to the environmental "bad".

Low-income households living in the upper rural area (Section 4), where best water quality is found, are more likely to be WTP the offered bid (Interaction income of fewer than 1,500 pesos *living in Section 4). This effect demonstrates that poor households exhibit a higher WTP for preserving the river in good conditions, which might be due to their dependence on the resource in that, as explained earlier, they might obtain free environmental goods and services from the river's existence, particularly access to clean water and fishing (Sukhdev, Schröter-Schlaack, Nesshöver, Bishop, C. & Brink., 2010). The quality variable was also significant in other studies such as in Canterbury, New Zealand, where Tait, Baskaran, Cullen & Bicknell, (2012) found that respondents living in the vicinity of low-quality waterways were WTP more for improvements. Brouwer, Martin-Ortega & Berbel, (2010) also found that in Guadalquivir River basin in Spain respondents valued more improvements in their own sub-basin, but only for the highest level of water quality.

For households residing far from the river, the variable involving contact with the river exerts a positive and significant effect. Respondents who reported using the river directly (for recreation, cattle raising, fishing, etc.) and those who reported passing by the river daily are more likely to pay the bid offered. This result is consistent with other international studies, such as Jørgensen *et al.* (2013) who found the distance decay effect for restoring the Odense River in Denmark had a lower impact when respondents were users. The question that emerges is: Why being user is not significant for households living nearby? As we explained previously, these households already have contact with the river on a daily basis, and when the river is polluted, household members are involuntarily exposed to bad odors, mosquitoes, garbage, etc. Therefore, direct contact with the resource is mostly involuntary.

The model for the group of households living far from the river includes the age variable with a negative and significant effect at the 95% CI. This reveals that older respondents might be less concerned with the restoration of natural resources that are not found near their household. This age effect was found in other studies (Soto & Bateman, 2006). However, this variable is not significant for the group of households living near the river, which may indicate that households living close to the resource prefer to pay or not to pay for improved resource conditions regardless of their age, given their proximity.

Figure 2 shows how these distance buffers from the river are represented. The results across these two special units indicate that a stated preference study should consider a spatially stratified sample of respondents that lie at a range of distances from the river resource. In this case, the first buffer, from zero up to 4.2 km indicates that household´s WTP is larger, than for second buffer of more than 4.2 km up to 18.3 km.

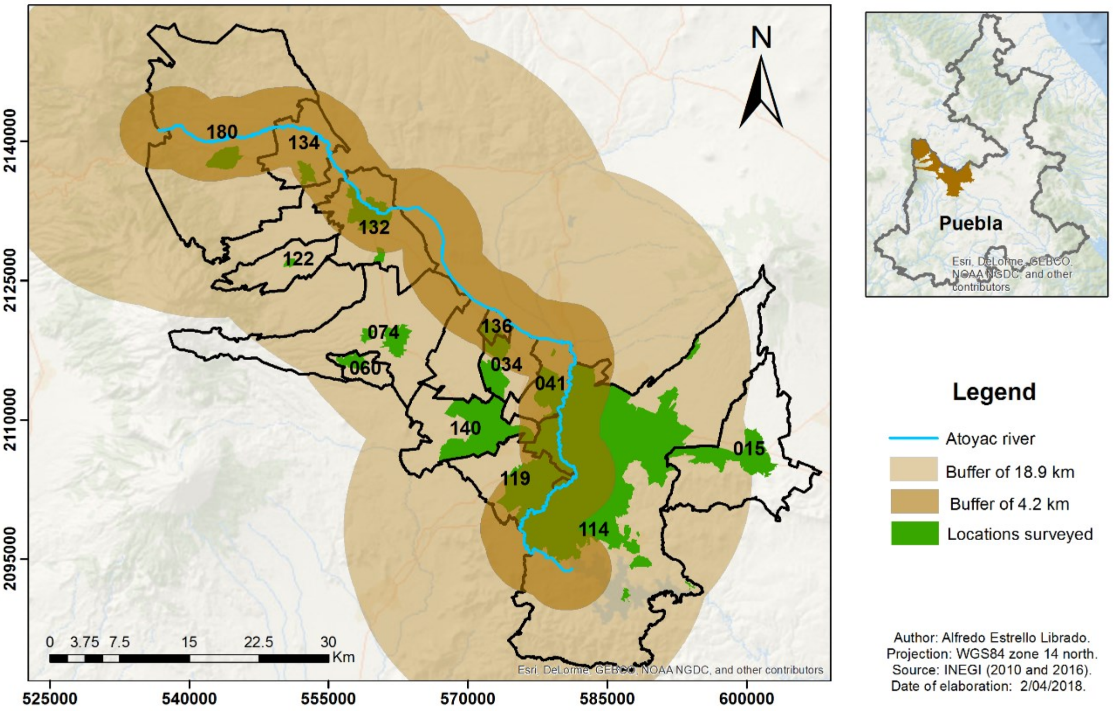

Figure 2. The Atoyac River with the two areas denoting differentiated households' WTP.

Table 4 presents a summary of the households' WTP values estimated through the Cameron model (Cameron, 1998). In the case of households living close to the resource, that is, up to 4.2 km, the estimated mean WTP per household was 220.6 pesos bimonthly, with a median of 213.5 pesos. In the case of households living far from the resource, that is, farther than 4.2 km, the mean WTP is 135.4 pesos bimonthly, with a median of 121.5 pesos.

Table 4. Estimated measurements for households' Willingness to Pay (WTP).

	Close (Up to 4.2 km)	**Far (more than 4.2 km)**

Estimated mean WTP (Mexican pesos/bimonthly) ($)	220.6	135.5
Median WTP (Mexican pesos/bimonthly) ($)	213.5	121.5
Standard Deviation (SD) WTP (Mexican pesos/bimonthly) ($)	57.09	92.4

This is a reduction of 39% for people living far from the resource, which demonstrates a clear distance-decay effect and confirms that residents living in close proximity to the resource perceive greater benefits from the proposed project than those living farther away. If we compare this with the results obtained by Soto & Ramírez (2017) from the general model, which only included the distance variable, the estimated WTP was 186.8 pesos bimonthly.

Aggregated WTP was estimated for the two populations, employing mean WTP per household multiplied by the number of households in the population corresponding to each group (INEGI, 2010). The aggregated WTP was 324 million pesos annually for households living closer, up to 4.2 km to the resource, and 192.8 million pesos for households living farther than 4.2 km from the resource, yielding a total of 516.8 million pesos annually (Table 5). These aggregated benefits are 15% lower than those estimated with the general model, which comprised 609.7 million pesos (Soto & Ramírez, 2017). This confirms that restoration possesses a great value for the affected population, but that the value is perceived differently by those living close to and far from the resource, this impacting the aggregated benefit.

Table 5. Annual benefits per household and aggregated benefits.

	Close (Up to 4.2 km)	**Far (more than 4.2 km)**	
Annual WTP per household (Mexican pesos) ($)	1,323.6	813	
Number of households	244,838	237,171	

in the basin			
Aggregated annual WTP (Mexican pesos) ($)	324,067,576.8	192,820,023	516,887,599.8

Conclusions

This study examined the benefits of restoring the Atoyac River and its tributaries with the objective of emphasizing the differences between the group of households living near and the group living far from the resource. With the data of a Contingent Valuation (CV) survey administered in 2009, we defined more precisely the variables that determine households' WTP in each group.

Using the survey data, we estimated the distance at which the probability of being WTP was significantly reduced, this being up to 4.2 km. Once the two groups of households were defined, independent models were generated that incorporated the variables that explained the WTP for each group. The WTP probit models were useful for confirming that people perceive greater benefits when they are more exposed or vulnerable to poor water-quality conditions. It is well known that water-quality problems exert a typically uneven effect across societies, with poorer households enduring more problems.

Results showed that persons who live near the resource and those who visit the area afford more value to resource improvements because they are users, although involuntary ones when living close to the resource. In addition to use values, the model captured the importance of the river's specific water-quality conditions. A greater probability of WTP was observed for low-income households in the upper rural area with better water quality, -an equivalent loss scenario-, which might be explained by that low-income households rely more on the natural resources that supplement their income, as has been reported in other studies.

Low-income women are more likely to pay when they live near the resource, but this effect disappears for women living far from it. This can be observed as a sign of greater vulnerability to the environmental pollution. On the other hand, age exerts a negative effect when living far from the resource, but not when living close to it, meaning that inhabitants living near the resource are WTP independently of their age, due to the benefits that would be obtained from the change, -values of use, non-use, and option-, while older inhabitants living far from the resource perceived lower benefits (non-use and option values).

The two models registered different factors influencing WTP estimates, and we argue that these factors would be difficult to capture by including the distance variable in a general model. Knowledge of benefits associated with vulnerable groups can provide a start in designing restoration projects with a perspective of social equity. To the best of our knowledge, this result is novel and clearly highlights the importance of separating populations in the analysis of spatial heterogeneity in terms of preferences.

In relation to aggregation of WTP, estimation of benefits for the two population groups defined by the effect of distance provides more precise estimates compared to a single general model that includes the distance-decay effect. Here we found that the two models produced an estimation that was 15% lower compared to that of the original model. However, it is noteworthy that while households' mean WTP was 39% lower for persons living far from the resource, the aggregated WTP was reduced by only 15% because the two models allow capturing the greater WTP of households living nearby.

The WTP results show an important potential to finance restoration of the Atoyac basin, which ensure the investment to treat municipal wastewater. The expectations linked to peoples' WTP are a fundamental area that needs consideration for future water policies in Mexico. This study found that users and non-users understand that their participation is fundamental to solving the water pollution problem in the region. However, the authorities have maintained a minimum and erratic communication with the population. Water policy changes based on direct economic contributions of the population require the authorities to gain credibility and social support.

Although users and non-users of river natural assets might understand the necessity of increasing water prices or giving economic contributions for restoration projects, this requires that the authorities improve their capacity to work at the social level. Actions designed to interact directly with people at different levels are necessary, such as information, education, and public participation.

Giving information about both the severity of the problem and, later, about the policy changes aimed to solve the problem is an important element for the any project's success. "Transparency" in all the phases is important to avoid corruption and to inform the population regarding the progress of the actions being undertaken. Also, members of the community should be involved in the discussion, design, planning, implementation, and evaluation phases of the water policies.

Any future policy considering the contribution of direct and indirect users of superficial water bodies needs to strengthen the administrative aspects of the service system. The invoicing capacity to charge a payment to everybody remains a central issue.

The research showed that people generally support water tariff increases based upon payment equity basis. Three principals for payment equity should be considered. First, everybody should pay at least some amount for the money regardless of income or any other condition. Having sectors of the population or a great number of households not paying provokes others to feel that payment is unfair. Second, the level of payment should reflect the distance effect, thus the efficacy of the invoicing system to capture the preferences of people living far and close is fundamental to achieve this objective. Third, a differentiated contribution according to the income level of the household or neighbourhood in order to reflect both households' ability and willingness to pay should also be evaluated.

This is coherent with our recommendation of acknowledging the distributional aspects of WTP.

The above results reflect some of the recommendations that diverse international conferences and authors have noted previously (UNDP 1990; United Nations 1992; Le Moigne et al. 1994; Water Academy 1997). This is also the tension that has been recognised in the economic valuation literature, where the importance of being aware of people's preferences determines the projects' success.

These elements indicate the possibility of implementing long-term water management policies financed with resources coming from users of environmental goods and services. Essentially this means that the government could improve public support and safeguard water policies based on WTP grounds by recognising public preferences in a broader sense.

Acknowledgments

This research was carried out as part of the Project to Evaluate the Ecological Restoration of the Atoyac and Alseseca Rivers, and the Valsequillo Dam, sponsored by the Government of Puebla, which was submitted for a CBA to the National Water Commission (CONAGUA) and the Secretariat of Finance and Public Credit (SHCP). We would like to thank to the Grupo Interdisciplinario de Agua (GIA).

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