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Article

Economic valuation of ecosystem services in the Aconcagua River watershed of Chile

Valoración económica de servicios ecosistémicos en la cuenca del río Aconcagua, Chile

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Abstract

The preferences of rural communities for improvements in ecosystem services within a watershed, such as the factors that determine the valuation of those services, have not been studied sufficiently in developing countries. By administering a questionnaire, the value placed on ecosystem services by farmers in the Aconcagua River watershed in central Chile was determined using a choice experiment method. Environmental services attributes related to the condition of the river's flora and fauna, the security of water availability for irrigation, the protection of water quality, and the watershed's water storage capacity were studied. Attitudinal and socio-economic factors that determine farmers' Willingness to Pay (WTP) for improvements that protect ecosystem services were also identified. All the attributes considered in the study were found to be significant in terms of WTP for the implementation of policies to improve the current situation. Younger farmers with fewer years of education and lower incomes and who leased the fields they worked were less willing to pay for improvements to protect ecosystem services. The interviewees who stated they had insufficient funds to pay, little information to make decisions and felt the payment was unfair were also more reluctant to pay for environmental improvements. This study contributes to the understanding of demographic and attitudinal variables in interviewee preferences for improving the protection of watersheds.

Keywords: Ecosystem services, economic valuation, preferences, water resources, attitudes, Chile.

Resumen

Las preferencias de las comunidades rurales por mejoras en los servicios ecosistémicos de las cuencas hidrográficas, así como los factores que determinan la valoración de estos servicios no han sido lo suficientemente estudiados en los países en desarrollo. A través de una encuesta se realizó la valoración económica de los servicios ecosistémicos por parte de agricultores de la cuenca del río Aconcagua, en Chile central, utilizando el método experimento de elección. Se estudiaron atributos de los servicios ambientales relacionados con la condición de la flora y fauna del río, seguridad en la disponibilidad de agua para riego, protección de la calidad del agua y la capacidad de almacenamiento de agua en la cuenca. Además, se identificaron los factores actitudinales y socioeconómicos que determinan la disposición a pagar (DAP) de los agricultores por mejoras en la protección de los servicios ecosistémicos. Todos los atributos estudiados fueron determinantes significativos de la DAP por la implementación de políticas para mejorar la situación actual. Los agricultores de menor edad, menos años de educación, bajos ingresos y que arriendan el predio donde trabajan estuvieron menos dispuestos a pagar por mejoras en la protección de servicios ecosistémicos. Los encuestados que declararon contar con insuficiente dinero para pagar, escasa información para tomar una decisión y que consideraron injusto el pago estuvieron más reacios a pagar por mejoras ambientales. Este estudio demostró la contribución de las variables demográficas y actitudinales para comprender las preferencias de los entrevistados por una mejor protección de las cuencas hidrográficas.

Palabras clave: servicios ecosistémicos, valoración económica, preferencias, recurso hídrico, actitudes, Chile.

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Introduction

Ecosystem services (ES) are defined as benefits obtained from nature that satisfy human needs (Millennium Ecosystem Assessment, 2005). Watersheds provide ES that are greatly valuable to society, such as drinking water (provision services), control of soil erosion (regulation services), wildlife habitat (support services) and aquatic recreation (cultural services) (Smith, De Groot, & Bergkamp, 2006). However, given that some ES are outside traditional markets, they are undervalued and consequently overexploited. As the importance of ES in watersheds is better recognized, it becomes more important to determine the value of these services (Emerton & Bos 2004; Pattanayak 2004).

Valuation of ES was originally used to create awareness of the importance of biodiversity for human wellbeing as a use value (Westman, 1977) and to support decision-making in the design of environmental policies (Fisher, Turner, & Morling, 2009). Later, refinements to valuation techniques allowed for the design of market mechanisms to create financial incentives for conservation, giving ES an exchange value (Daily & Matson, 2008; Kosoy & Corbera, 2010). One of the most well-known mechanisms is Payment for Environmental Services (PES), which has been defined as a set of voluntary and conditional transactions, for well-defined ES, between at least one offering party and a consumer (Wunder, 2005). While the original idea is that the system is administered by private parties, in most cases the government is a participant in financing a large part of the mechanism (Schomers & Matzdorf, 2013). There have been criticisms of PES-type mechanisms due to increased commercialization of ES (Gómez-Baggethun, De Groot, Lomas, & Montes, 2010). And Hackbart, De Lima, and Dos Santos (2017) state that the different categories used for ES valuation are not yet sufficient to adequately guide water resource management.

ES valuation techniques can be grouped into revealed preferences and stated preferences (Pearce & Özdemiroglu, 2002). The former identifies the way in which a good without a market (which applies to most ES) influences the market of an associated good, while the latter technique is based on building hypothetical markets and interviewees are asked directly about the value they place on a good or service. The present study applied the Choice Experiment method (CE) (i.e. stated preferences), as it has been widely used in recent years. The CE method builds the economic preferences of people based on choices they make in hypothetical valuation scenarios during an interview (Louviere, Hensher, & Swait, 2000). Each scenario is based on the combination of attributes of a good or service relevant to its value and respective levels of provision.

The CE method has been applied satisfactorily in the economic valuation of ES in watersheds. It has been used to analyse the importance of attributes related to the ecology of rivers, such as the presence of aquatic plants, fish, birds and other animal species (Morrison & Bennett, 2004; Hanley, Colombo, Tinch, Black, & Aftab, 2006a; Álvarez-Farizo, Hanley, Barberán, & Lázaro, 2007), as well as river quality and the size of protected areas (García-Llorente, Martín-López, Nunes, Castro, & Montes, 2012). Studies have also looked at attributes associated with the possibility of recreation, such as boat rides, fishing and swimming (Morrison & Bennett, 2004), ecotourism facilities (García-Llorente *et al*., 2012), and aesthetic aspects (Hanley, Wright, & Alvarez-Farizo, 2006b). Other studies have analysed the importance of river flow (Hanley *et al*., 2006a) and water availability (Álvarez-Farizo *et al*., 2007). Socio-economic attributes have also been studied, such as local employment (Hanley *et al*., 2006a) and the presence of traditional agriculture and wind farms (García-Llorente *et al*., 2012).

There is evidence from studies on stated preferences that demographic and attitudinal characteristics of individuals influence interviewees' preferences for improvements in watersheds (Poppenborg & Koellner, 2013). Interviewees with pro-environment views are more willing to pay for the quality of a river ecosystem than those with more pro-development views (Morrison & Bennett 2004). Interviewees who are aware of the poor ecological condition of a river and have commercial interest in the resource are more willing to pay for improvements to water quality (Álvarez-Farizo *et al*., 2007). Individuals who perceive payment for environmental improvements as unfair have been found to be less willing to pay for environmental improvements (Jorgensen, Syme, & Nancarrow, 2006). And those who believe they have the right to a clean environment and that the government should use existing resources to improve the quality of the environment are less willing to pay (Jorgensen & Syme, 2000). Other reasons to object to payments may include budget restrictions and the belief that environmental improvements are not worthwhile (Jorgensen, Wilson, & Heberlein, 2001). Consideration of these factors can greatly improve the capacity of choice models to represent the heterogeneity of preferences (Garrod, Ruto, Willis, & Powe, 2014; Greiner, 2015) and contribute to a better understanding of interviewee preferences in stated preference studies.

This economic valuation study was carried out using the choice experiment method to analyse the preferences of farmers for improvements to the protection of ecosystem services in the Aconcagua River watershed, applying a set of agro-environmental measures and investments. The Aconcagua River watershed lies in the region of Valparaiso, Chile, and has severe problems with ES provisions, such as low water availability and quality, and problems with biodiversity conservation, due to intensive industrial and agricultural activities, among other factors (Ribbe, Delgado, Salgado, & Flügel, 2008; PUC, 2008; CIREN, 2010). Preferences were studied based on the interviewees´ Willingness to Pay (WTP) for the implementation of measures to improve the current situation of the watershed. The influence of socio-economic and attitudinal variables on the preference of the interviewees for environmental improvements to the watershed was also analysed. This information can contribute to better understanding the environmental behaviour of the interviewees and can support the design and evaluation of local agro-environmental policies.

This article is organised as follows. Section 2 (methodology) describes the study area and information gathering, the choice experiment design, the variables studied and the data analysis. The results and discussion are presented in section 3, and section 4 describes the main conclusion drawn from the study.

Methodology

The Aconcagua River watershed is located in the region of Valparaiso in central Chile, covering an area of 7 340 Km^2 (Cade Idepe Ingeniería y

Desarrollo de Proyectos, Ltda., 2004). The climate is predominantly Temperate Mediterranean, with a long dry season with average temperatures of 14.5° and precipitation between 261 and 467 mm (Figure 1). Due to severe water shortages over recent years, water redistribution has been applied among the different sections of the river through water use restrictions (Hidrometría Chile Ltda., 2012). The main use of water is for farming irrigation, followed by industrial, mining and hydroelectricity activities. Urban wastewater treatment has improved since 2000 due to investment in treatment processes, reaching 100% coverage (SISS, 2016). However, water pollution from agricultural pesticides and fertilisers, and from some industrial facilities, is an ongoing issue.

Current policies promote financial incentives to improve storage, distribution and efficiency of water use, and for programs to encourage good farming practices and conservation in agriculture, among others (Urquidi, Seeger, & Lillo, 2012). Despite these efforts, there continues to be a high demand for environmental improvements and improved infrastructure in the region of Valparaiso. These include investments to improve the use of increasingly scarce water resources, reduce widespread pollution from intensive farming, improve treatment of industrial wastewater from local industry and define minimum ecological watersheds (Ministerio de Medio Ambiente, 2012).

In order to analyse the preferences of individuals for environmental improvements in the watershed, a survey was conducted (n=105) by interviewing farmers from the districts of Quillota and La Cruz, which are part of the Aconcagua River watershed. The sample includes farmers who have been participating in PRODESAL (Local Development Programme), set up by INDAP (Institute for Agricultural Development) in the two districts that cover the most representative type of farming in the region. A questionnaire was used to gather information through personal face-to-face interviews conducted by three fully-trained interviewers. The questionnaire, which was tested before final application, contains three main sections: (1) knowledge, use and attitudes about ES in the Aconcagua River watershed, (2) choice experiment (valuation), and (3) socio-economic aspects.

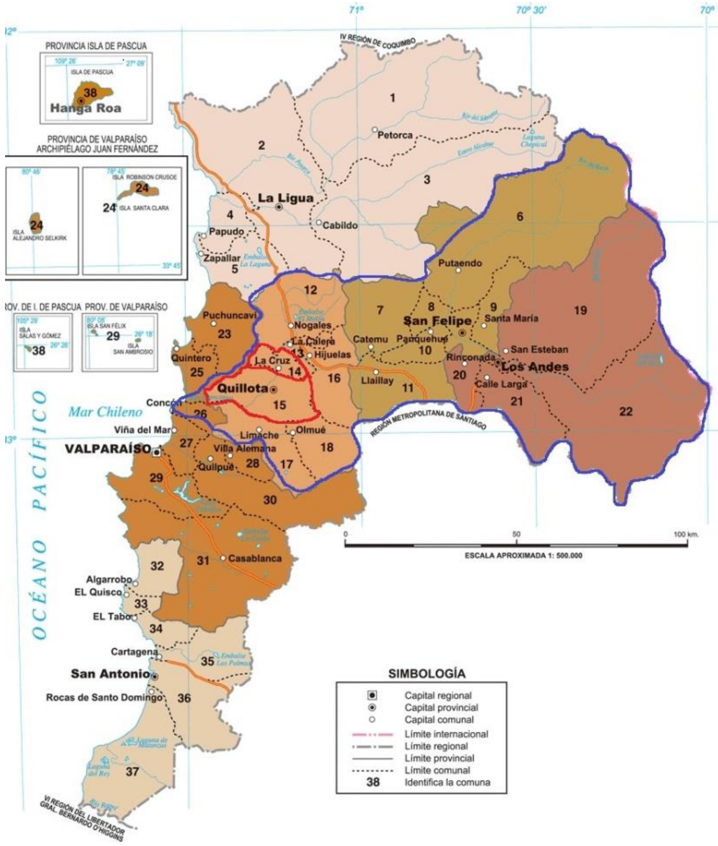

Figure 1. Aconcagua River Watershed, Region of Valparaíso, Chile (blue lines).

Experimental design

Via meetings and interviews with representatives of public institutions and researchers in the area, together with a review of the available literature (Cade Idepe Ingeniería y Desarrollo de Proyectos, Ltda., 2004; PUC, 2008; Conama, 2008; SISS, 2013), four ES attributes relevant to the watershed were selected. These were: (1) status of the conservation and protection of the river's flora and fauna, (2) protection of water quality in the watershed, (3) water availability for irrigation, and (4) capacity for water storage in reservoirs (Table 1). The flora and fauna of the river, such as aquatic plants, fish and insects, are a good indication of water quality as they are sensitive to pollution. Hence, improved conditions in flora and fauna means improved water quality of the river. The current condition of the flora and fauna of the Aconcagua River is "deficient to bad" in general, with variations in some sectors. If there were better monitoring of water quality, together with more investment to protect the water quality, the current situation may improve to "moderate" or "good". Measures to improve and protect water quality include wastewater treatment plants and vegetation to protect river banks. Most districts currently have treatment plants, giving the watershed a level of "moderate" in terms of water quality. However, there are populated sectors without such services and there are no programmes to protect river banks with vegetation. The implementation of new investments could improve the water to the level of "good" or "very good".

Water availability for irrigation is currently "low" in the Aconcagua River watershed. Only 56% of agricultural operations in the watershed have some type of irrigation (ODEPA, 2013). If there were an improvement in how water use is managed, together with more investment to improve water use efficiency and water storage, the current situation may improve to the level of "moderate" or "high". One option for increasing water availability during dry periods is the construction of reservoirs. These allow regulation of the river flow and offer opportunities for recreation and electricity generation. However, they may also have a negative impact on the environment due to loss of flora and fauna, and displacement of people. The Chacrilla Reservoir (in the district of Putaendo) began functioning in 2014. It has a capacity of 27 million m^3, which is a "low" level of storage. However, there are projects to build other reservoirs that would increase the storage capacity by 120 million m^3 ("moderate" level) and 300 million m^3 ("high" level).

Each attribute has three levels of provision: two levels representing improvements in the current situation and one level representing the current situation (status quo, SQ). One payment attribute was given five levels representing the interviewees' Willingness to Pay for environmental improvements described in the scenarios. The mode of payment was represented as an additional charge on the monthly electricity bill for a period of 10 years. In order to determine the levels of payment, the average costs in the study area were used as reference (Chilquinta Energía, S. A., 2014).

Using a factorial design with 4 attributes having 3 levels each, plus one attribute with 5 levels, a total of 240 combinations were obtained. Applying an orthogonal design of the main effects, it was possible to generate a reduced experimental design with 23 different scenarios represented by "A" choice cards (Hensher, Rose, & Greene, 2005:115). By permutating the levels of the attributes on the choice cards, 23 other options were obtained, represented by “B” cards (Chrzan & Orme, 2000). The paired options were assigned randomly to each choice set. Therefore, each choice set was composed of two scenarios representing environmental improvements (A and B), and one scenario representing the current situation, for which there is no environmental improvement and the payment requested is zero (C). The levels of the attributes in each set showed no significant correlation. The 23 choice sets were then divided into three sub-samples during the questionnaire. Each interviewee was asked to select a scenario from each choice set (figure 2).

Table 1. Attributes and level in the choice experiment.

Attribute	Definition	Levels
Flora and fauna	Condition of the river’s flora and fauna	Bad (sq); Moderate; Good
Water quality	Protection of water quality	Moderate (sq); Good; Very good
Water availability	Availability of water for irrigation	Low (sq); Moderate; High
Water storage	Storage capacity for water within the watershed	Low (sq); Moderate; High
Payment	Monthly charge on electricity bills for a period of 10 years (CLP$)	0 (sq); 1 000; 2 500; 4 000; 5 500
sq: current situation (*status quo*). CLP: Chilean Pesos (USD 1 = CLP 607, Banco Central de Chile, December 2014).		

SET n	Condition of river flora and fauna	Protection of water quality	Availability of water for irrigation	Water storage capacity	Monthly charge on electricity bills

	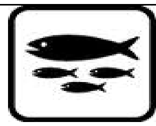		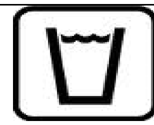		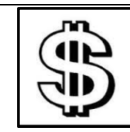
Alternativ e A	Moderate	Good	Low	Low	1 000
Alternativ e B	Good	Good	High	Moderate	5 500
Alternativ e C (sq)	Bad	Moderate	Low	Low	0

Figure 2. Example of choice set.

The questionnaire was subdivided into several sections, including questions about the interviewees' connections with and attitudes regarding water resources, a description of the valuation scenarios, the choice experiment, follow-up questions to identify the reasons for payment or non-payment, and socio-economic questions. The questionnaire was pre-tested in the field, leading to the necessary adjustments to ensure that interviewees adequately understood the questions. The final version of the questions was administered during the last three months of 2014.

Data analysis

The choices made by the interviewees were analysed using a discrete choice Conditional Logit Model (CLM) (McFadden, 1974). The interviewees were asked to choose between different scenarios described in terms of their attributes. If *V* (utility) is linear in its parameters and additive with a constant term "*α*", the indirect conditional utility function is as follows:

$$Vij = \alpha + \beta 1X1 + \beta 2X2 + \dots + \beta nXn$$

where α is the alternative specific constant (ASC), which captures the variation in systemic choices between the status quo option and options A and B which cannot be explained by attributes (Bateman *et al*., 2002); *n* is the number of attributes considered; β is a vector of coefficients; and *X* is a vector of attributes. The ASC is coded as a dummy variable with a value of 1 for the generic options A and B, and 0 for option C (status quo). The terms of the interactions between the demographic and attitudinal variables with ASC and the attributes were generated and included in the model estimate. In order to reduce collinearity between the interaction terms and the attributes without interaction, the demographic and attitudinal variables were standardised before multiplying them by the attribute. Based on the quantification of the parameters in the CLM, the maximum marginal WTP for changes in the levels of the attributes can be estimated as:

$$mWTP = -\beta x \,/\, \beta c$$

where β_x is the coefficient of utility of any of the attributes and β_c is the marginal utility of the income given by the coefficient of the payment attribute. In other words, *mWTP* is the monetary value of the utility for an additional unit of attribute *X*.

The change in wellbeing generated by environmental improvements (Q^0 - Q^1) was calculated as a Compensating Variation (CV) (Louviere *et al*., 2000: 340). *CV* is the amount of money equal to the level of the status quo utility (U^0) for the level of utility perceived by the interviewee with regard to the environmental improvement (U^1). *CV* can also be expressed as the interviewee's maximum WTP to reach a higher level of environmental quality. Using Limdep Nlogit software, the main effects of the attributes of the interaction were estimated and the value of the ES for the respondents in the watershed was calculated:

$$VC\ (Q0 \rightarrow Q1) = -\beta c - 1 * (U1 - U0)$$

Results

Of a total of 105 farmers, 75% were male and most were from the district of Quillota. The average age of the interviewees was 55 years, with a low level of education (60% had 8 years or less of schooling). Twenty-one percent of the households had incomes below the national minimum wage (USD 346), while 42% had income between USD 346 and USD 692. The households were comprised of an average of four members. The average field size was 4.8 ha, with most farmers being the owners of their land (61%), while the others were tenants (37%) or share-croppers (2%).

With regard to water use by the farmers, 90% did not conduct recreational activities, such as fishing, camping, picnicking or swimming. In terms of the households of the interviewees, 60% used water from rural drinking water systems, followed by 23% that used wells, and another 4% that used water springs. Some fields were close to urban areas, allowing 13% of households to receive drinking water from regional water companies. With regard to domestic wastewater treatment, 59% of households had septic tanks, 19% had cesspits, 17% of the households had access to sewer systems and wastewater treatment, and 7% had access to sewers only.

The main production sectors in the study area were vegetables (63%), fruit (24%), flowers (9%) and mixed crop production (4%). The main sources of water for irrigation were surface water from canals (48%) and underground water from wells (45%), followed by production units that used water springs (7%). In relation to the irrigation systems present on the farms in question, 52% used drip or micro-sprinkler irrigation, 32% furrow irrigation, 11% flood irrigation and 5% sprinkle irrigation. With regard to the maintenance of water distribution or storage systems, 48% of interviewees stated that they carried out maintenance once a year, 40% more than twice a year and 12% had never performed any maintenance.

On a scale of 1 to 7, with 1 as “very low/bad” and 7 as “very high/good”, the farmers scored the availability of water for human consumption as high (mean of 5.8) and irrigation as low (mean of 2.9). The quality of water was considered good for human consumption and for irrigation (means of 5 in both cases), moderate for the conservation of flora and fauna (mean of 4.5) and deficient for recreational swimming (mean of 2.6). Using the Likert 5-point scale (1: fully disagree, 5: fully agree), the farmers showed a high level of support for the construction of reservoirs for water storage in the watershed (82% agreed or fully agreed).

The interviewees also expressed their attitudes regarding the valuation scenarios, and while almost all were interested in improvements to water availability and quality, 45% did not possess sufficient funds to contribute to the implementation of the proposed plan. Fifty-eight percent of the sample indicated that they already paid enough tax for water, 79% would need more information before making a decision about paying for improvements, and 46% thought it unfair that they should pay for environmental improvements to water resources. In addition, 51% considered the way the money was collected to be inadequate for the implementation of the proposed plan and 39% did not trust public services to implement the plan.

Of the total number of interviewees, 94% were willing to pay for environmental improvements for at least one of the choice sets presented. Therefore, only 6% preferred maintaining the current situation without any environmental improvement. The attributes were found to be significant for the willingness to pay to improve the current state of water resources so as to obtain the expected effects (Table 2 – model (a)). These were: positive utilities that improve the conditions of flora and fauna, protection of water quality, water availability for irrigation, and water storage capacity. Negative utilities were obtained for increases in the payments required. The inclusion of socio-economic and attitudinal variables notably improved the predictive power of the choice models, increasing from a Pseudo-R^2 of 0.12 (model (a), attributes only) to a Pseudo-R^2 of 0.23 (model (c), including attitudinal variables). A Pseudo-R^2 (*constant only*) between 0.12 and 0.23 corresponds to R^2 values between 0.35 and 0.55, respectively, in the approximately equivalent linear model (Hensher *et al*., 2005: 338-9).

The results of model (b) show that the farmers who were younger, had less education and were tenants on their fields were less willing to pay for improvements to the provision of ES in the watershed in general. Specifically, producers who used wells for irrigation water were more willing to pay for improvements in the conditions of flora and fauna. The older interviewees were less willing to pay for improvements in water storage capacity. Lastly, the farmers with more income were more willing to pay for improvements in water availability for irrigation.

Model (c) showed that the attitudes of the farmers were significantly determinant of their willingness to pay for improvements to the state of ES in the watershed. The interviewees who stated that they did not have sufficient funds to pay, had little information to make a decision, and who considered paying to be unfair were less willing to pay for improvements in the watershed, in general. In particular, farmers who considered paying to be unfair and who had little information for decision-making were less willing to pay for improvements to water availability for irrigation. Those who believed that the water quality in the watershed was good for the purposes of flora and fauna conservation were less willing to pay for improvements to water availability for irrigation.

Table 2. Valuation of ecosystem services in the watershed of the Aconcagua River.

Variable	**Choice models**		
	(a) Attributes alone	**(b) Attributes x Socio-economic Variables**	**(c) Attributes x Attitudinal Variables**
Flora and fauna	0.232 ***	0.256 ***	0.320 ***
Protection of quality	0.526 ***	0.592 ***	0.526 ***
Water availability	0.641 ***	0.666 ***	0.702 ***
Water storage	0.240 ***	0.288 ***	0.327 ***
Payment [&]	-0.27/10^3 ***	-0.27/10^3 ***	-0.30/10^3 ***
Rent x Payment		-0.48/10^4 ~	
Well x Flora and fauna		0.142 **	
Age x Storage		-0.178 *	
Age x Payment		0.88/10^4 *	

Income x Availability		0.231 **	
Education x Payment		0.24/10^3 ***	
Restriction $ x Availability			-0.189 *
Restriction $ x Payment			-0.11/10^3 **
More information x Payment			-0.199 **
Unfair payment x Availability			-0.235 **
Unfair payment x payment			-0.17/10^3 ***
Water quality_f&f x Availability			-0.151 *
ASC not SQ	-0.146 n.s.	-0.055 n.s.	-0.110 n.s.
Log-likelihood function	-723.28	-601.27	-610.53
Pseudo-R^2 #	0.118	0.187	0.225
Sample size	105	105	105
***: significance p<0.001; **: significance p<0.01; *: significance p<0.05, ~: significance p<0.1			
&: Attribute of payment in Chilean pesos; n.s.: not significant			

In terms of the estimates of marginal WTP (Table 3), it can be stated that the most important attributes for the farmers were improvements in water availability for irrigation (USD 3.93/month/home), followed by improvements in water quality protection (USD 3.24/month/home). Less importance was placed on improvements to water storage via reservoirs (USD 1.47/month/home) and the condition of flora and fauna (USD 1.42/month/home). The total WTP for improvements to ES in the Aconcagua River watershed ranged from USD 10.06/month to USD 20.12/month per home. Considering the size of the study sample (n=105), the total WTP for the homes was between USD 1056 and USD 2112. Lastly, taking into account the total number of farming operations in the watershed (n=6 422), the total WTP would be between USD 64,250 and USD 128,500.

Table 3. Estimates of Willingness to Pay for improvement in water resources.

Attribute	***WTP*** **(*Q^0 to Q^1*)** (USD/month)	***WTP*** **(*Q^0 to Q^2*)** (USD/month)
Condition of flora and fauna	1.42	2.85
Protection of water quality	3.23	6.46
Water availability for irrigation	3.93	7.86
Water storage capacity	1.47	2.94
Total WTP/home	**10.06**	**20.12**
Number of homes	105	105
Total WTP for sample	**1 056**	**2 112**
Farming operations in the watershed	6 422	6 422
Total WTP for watershed	**64 589**	**129 177**

Discussion

All the attributes were found to have a significant effect on the farmers' preferences for environmental improvements in the Aconcagua River watershed. The severe drought experienced in the watershed in recent years is the main reason why the most important attribute for the interviewees was improvement to water availability for irrigation. Even with a high degree of support for the construction of reservoirs (82%) to improve water availability and provide opportunities for recreation and electricity generation, this attribute was not the most preferred by the interviewees. They preferred more diversity in the measures applied to improve water availability in the watershed, apart from water storage, such as improvements to water use management and more investment to improve use efficiency. Increasing the supply of water by building reservoirs may be complex, given that it requires a process of assigning water distribution rights in accordance with national legislation regulated by the Water Code of 1981 and its modifications (Ministerio de Justicia, 2010). This regulation states that the assignment and use of water is based on a system of negotiable rights for private water use. The process of administering and managing water is subject to strong debate in terms of the efficiency of the assignment mechanism, which is aimed at setting a price that reflects the true cost of water use in order efficiently reassign activities that provide a low value and those that provide a high value for the resource (CEPAL-OCDE, 2016).

The farmers also showed preferences for improvements in protecting water quality through new investments in wastewater treatments plants and river bank protection with vegetation, though most considered that the water quality for human consumption and irrigation was good. More concern was shown for water quality for the conservation of river biodiversity (flora and fauna) and for recreational activities involving contact with water. Most of the farmers were aware of the importance of water quality, given that the watershed is an area of intensive farming where there is evidence of widespread pollution (Ribbe *et al*., 2008). It can be noted that in Chile the level of fertilisers applied per hectare (318 kg/ha) is one of the highest in Latin America, exceeded only by Colombia (FAO, 2015:212).

Considering that 63% of homes have income below USD 692, the valuation scenario likely captures a considerable portion of the total willingness to pay for improvements to ES in the watershed. This amount may be significant for at least improving water use efficiency and water quality protection. The WTP values were also substantial when considering that a relatively low percentage of the interviewees (<10%) participated in recreational activities in the river ecosystems and surrounding area.

The younger farmers with less education and who were tenants on their fields had a less stable financial situation, impeding them from paying for environmental improvements. This is supported by the result found by model (b) which indicates that the farmers with lower income were less willing to pay for improvements to water availability for irrigation. Despite this, for the particular case of improvements to water storage capacity via reservoirs, the younger interviewees were more willing to pay. Therefore, our results regarding the influence of age on environmental preferences are ambiguous. This was not the case for Rolfe, Bennett, and Louviere (2000), who found that the younger interviewees were always more willing to pay for different environmental improvements to the current situation (*status quo*). Farmers who used wells for their irrigation water were more willing to pay for improvements in the condition of flora and fauna. This result is relevant considering that 45% of the interviewees use this type of water source for crop irrigation and 63% grow vegetables that are normally more sensitive to poor water quality compared to fruit.

In the case of education, the results were similar to those of Biénabe and Hearne (2006), and Alvarez-Farizo *et al*. (2007), who found that the interviewees with higher levels of formal education were more willing to pay for environmental improvements. A lack of access to formal education may therefore represent a substantial barrier to farmers taking actions to improve the quality of ES in the watershed in question. It should be noted that 60% of the interviewees had less than 8 years of schooling. With regard to the influence of income on willingness to pay, the analysis confirms the results of Morrison and Bennett (2004), who found a positive effect on preferences for improvements to river ecosystems, which is to be expected based on simple economic theory. The risk of investing in a rented field is reflected in the results that show that interviewees who were tenants were less willing to pay for improvements to ES. Although the percentage of farmers in this situation was low (37%), its influence is relevant to identifying the determining factors for environmental improvement preferences.

The results of model (c) show that attitudes that were opposed to the valuation scenario were significant for determining willingness to pay for improvements in ES in the watershed. Our results are in line with those of Jorgensen, Wilson, & Heberlein (2001) and Jorgensen, Syme, and Nancarrow (2006). They studied attitudes and beliefs that demonstrate objections in the valuation of environmental good and services. In particular, these prior studies found that considerations of fairness led to objection if the interviewees had doubts regarding the task of valuation (Jorgensen *et al*., 2006). According to Jorgensen *et al*. (2001), objections such as lack of money to pay, high costs of environmental issues, or low utility of payments for environmental improvements actually represent considerations of fairness. Similar to our results, Jorgensen *et al*. (2006) found that the interviewees who reported having doubts related to the information provided about the payment scenario alluded to considerations of fairness when expressing their preferences during the task of valuation.

The interviewees showed a high level of disapproval of the proposed valuation scenarios. A high percentage indicated that: they would need more information to make a decision, they currently paid enough environmental taxes, the way the money was collected was inadequate, and the payments were unfair. Nevertheless, in the CE most of the interviewees (94%) did not object to paying for improvements in the protection of ES in the watershed. Similarly, although 45% said they would not have enough money to contribute to implementing the proposed plan, only 6% persistently opted for maintaining the status quo. Therefore, it can be said that the connection between the answers to the variables and the choices by the interviewees was low despite the significant influence of the former on their WTP. This may be because the variables and the scales used did not adequately capture the beliefs of the interviewees, in which case the impact on their choices would not be clearly detected. A second possible explanation is that the consideration of equity represented by the variables of objection is of little practical importance to the population of an emerging economy such as Chile.

The practical application of economic valuation requires the analysis of various considerations. Our results can be highly useful to analyse the impact of secondary norms related to water quality for the protection of continental surface water on the watershed level in central Chile, as well as to update national emissions regulations related to industrial wastewater entering surface and underground water courses. Since 2005, the Aconcagua River watershed and its main tributaries have had a draft law of secondary regulations on surface water quality, which establishes quality objectives in the watershed. However, this regulation has not yet come into force. One of the aspects mentioned as a limiting factor in the evaluation of the economic and environmental impacts of secondary regulations on water quality is the lack of methodologies for the economic valuation of ES that do not have a market (Centro de Ciencias Ambientales EULA-Chile, 2006). Therefore, the present study can make an important contribution to the process of creating national environmental quality regulations, particularly for the case of the Aconcagua River watershed.

The implementation in Chile of systems for the Payment for Environmental Services has been considered promising (Cabrera & Rojas, 2009). These researchers studied the possibility of implementing a PES system for the provision of drinking water in the district of Ancud, in the Mechaico River watershed in Chile. Given that the PES system is a business initiative by private sector parties, its implementation would not be viable for a municipality or other state-administered body without a change in the legislation. The estimated willingness to pay for water quality is higher than the cost of implementing the system. However, the administration of the system is complex and changes would be required in institutions and legal systems in order to implement it. These results confirm the way in which most PES systems have been implemented in other countries, with strong support and participation from the state (Schomers & Matzdorf, 2013).

There are currently no PES systems functioning in Chile. There are mechanisms that could be called PES-type, where owners of natural resources are subsidised by the state to implement sustainable conservation practices. This is the case with the System of Incentives for Agro-Environmental Sustainability of Farming Soils (Ministerio de Agricultura, 2010), which subsidises farming practices such as the use of biofilters to retain sediments and pesticides from surface runoff from farms. The financial incentive pays for part of the cost of implementing these farming practices. A second case is the Law on the Recovery of Native Forest and Forest Preservation, which also finances the cost of implementing forest conservation practices (Ministerio de Agricultura, 2008). In these two cases, the adoption of conservation practices has been low, since many farmers stop applying the practices when the subsides stop (Soto & Barkmann, 2009) or because the requirements for accessing the subsidies are too complex and costly for small landowners (Reyes, Blanco, Lagarrigue, & Rojas, 2016). This poor performance leads to the need to continue studying economic ES conservation mechanisms that could be efficient and equitable (Kosoy & Corbera, 2010).

Conclusions

This research estimated the economic value of ES in the Aconcagua River watershed and analysed the factors that determine farmer preferences. According to their Willingness to Pay, most of the interviewees showed support for measures to improve the conditions of flora and fauna, the security of water availability for irrigation, protection of water quality, and water storage capacity through reservoirs. The values obtained were significant, considering that most of the households (63%) had total incomes below twice the minimum monthly wage (USD 692).

The inclusion of socio-demographic and attitudinal factors in the analysis improves the predictive capacity of the models and identifies the significant factors that determine the preferences of the interviewees for the ecosystem services in question. Younger farmers with less education, low income and who were tenants on their fields were less willing to pay for environmental improvements. Those who considered payment unfair, who did not have enough money to pay, or who stated that the information provided was insufficient to make a decision were also less willing to pay. However, in the choice experiment, most of the interviewees (94%) did not object to paying for improvements to the protection of ES in the watershed. Therefore, it can be concluded that the manner in which beliefs about payment impact choices cannot be clearly detected. This result requires improvements to the design of the attitudinal variables included in stated preferences studies, in order to adequately express their influence on preferences.

Finally, this study of the economic valuation of ES can contribute to the analysis of the impact of secondary regulations on environmental water quality for the protection of continental surface water on the watershed level. These have not yet been implemented in the Aconcagua River watershed, partly due to the lack of methodologies to determine the value of the ES that do not have a market. Therefore, the application of the economic valuation of ES is a fundamental tool for supporting decision-making in the area of public policies, with particular emphasis on the management of fragile ecosystems such as watersheds.

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