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Environmental Cost of Groundwater: A contingent Valuation Approach

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ABSTRACT: The Water Framework Directive of the European Union has become a milestone in the water policy for this area. This Directive aims to achieve a "good ecological status" of bodies of water in the Member States of the European Union by 2015. The Water Framework Directive calls for the application of economic principles, economic approaches, tools and instruments. The functions of this economic analysis include identifying methods to estimate resource and environmental costs. The purpose of this paper is to define the applications of Environmental Economics techniques in a groundwater valuation, taking the Gavilán Aquifer, located in the southeast of Spain, as a case study. This aquifer discharges support a very important wetland, with high biological, recreational and landscaping values. As this groundwater is also used for agricultural purposes, it is an ideal case to test a methodology aimed at measuring both environmental and resource costs. Two valuation techniques % Contingent Valuation Method and Production Function Approach% were applied so as to achieve this goal. The total economic value estimated for this groundwater is 0.454 €/m^3, out of which 16.1% is related to environmental and recreational aspects.

Key words: Groundwater, Wetland, Environment, Resource, Cost, Contingent Valuation

INTRODUCTION

The Directive 2000/60/CE, which sets a framework for Community action in the field of water policy, the so-called Water Framework Directive (WFD), is aimed at achieving a good ecological status of the bodies of water in the Member States of the European Union by 2015 (EC, 2000). Among other procedures, the economic analysis plays a crucial role in the WFD, as stated in articles 5, 9 and 11, by which Member States are forced to carry out an economic analysis of water use (art. 5) (Stemplewsky *et al.,* 2008). The principle of recovery of the costs of water services, including environmental and resource costs (art. 9), and the establishment of a programme of measures based on cost-effectiveness criteria (art. 11) should be taken into account (Bateman *et al.* 2006). The WATECO Working Group has developed guidance to implement the economic analysis of the WFD. Thus, environmental costs are defined as "the costs of damage that water uses impose on the environment and ecosystems and those who use the environment". As regards resource costs, they are considered as "the costs of foregone opportunities which other uses due to the depletion of the resource beyond its natural rate of recharge or recovery" (WATECO, 2003). Although these guidelines clearly define resource and environmental costs and propose valuation methods, they are useless from a practical point of view (Bouleau, 2008).

Very little empirical research has been applied to establish environmental and resources costs and only partial determinations about the above mentioned economic aspects have been presented (Custodio *et al.*, 2009). This lack of information is especially significant in the case of groundwater in arid and semiarid regions, where overexploitation of aquifers will lead to depletion and deterioration of water resources (Onate and Peco, 2005; Praveena *et al.,* 2010).

The purpose of this paper is to estimate the environmental and resource costs of groundwater by means of the Contingent Valuation Method (CVM) and the Production Function Approach (PFA). The application of these methods is presented using a case study, the Gavilán Aquifer in the southeast of Spain. CVM is applied to a wetland, Fuentes del Marqués, which is supported by the aquifer discharges. This technique has been applied since the eighties for valuing non-market goods (Carson, 1992), especially natural areas (Dehghani *et al*., 2010) and other environmental goods (Heal, 2000), and can measure use and non-use values. PFA is implemented to

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determine the resource cost of the groundwater (Acharya and Barbier, 2002), which irrigates apricot crops located near the Fuentes del Marqués wetland. By applying these methods, the total economic value for use of the groundwater can be calculated, which allows assessing the relative importance of environmental considerations within the total cost structure of groundwater.

As to determining the value of hydrological ecosystems, a high number of studies have been conducted. Birol *et al.* (2006) perform a review of the available techniques and their application to the assessment and management of water resources; Klessig (2001), Morrison (2002) and Jones *et al.* (2008) evaluate the attributes that increase and decrease the value of wetlands; Stenger and Willinger (1998) study the value of the groundwater quality of the Alsatian Aquifer; Sari (2003), Ojeda *et al.* (2007), Ormerod (2009) and Martínez-Paz *et al.* (2010) investigate the benefits of restoring flows in rivers, especially those which had been diverted for using in irrigation; finally, Mitchell and Carson (1993), Spash (2000) and Connelly *et al.* (2007) do research on determining the value of recreational use of wetlands and other hydrological ecosystems.

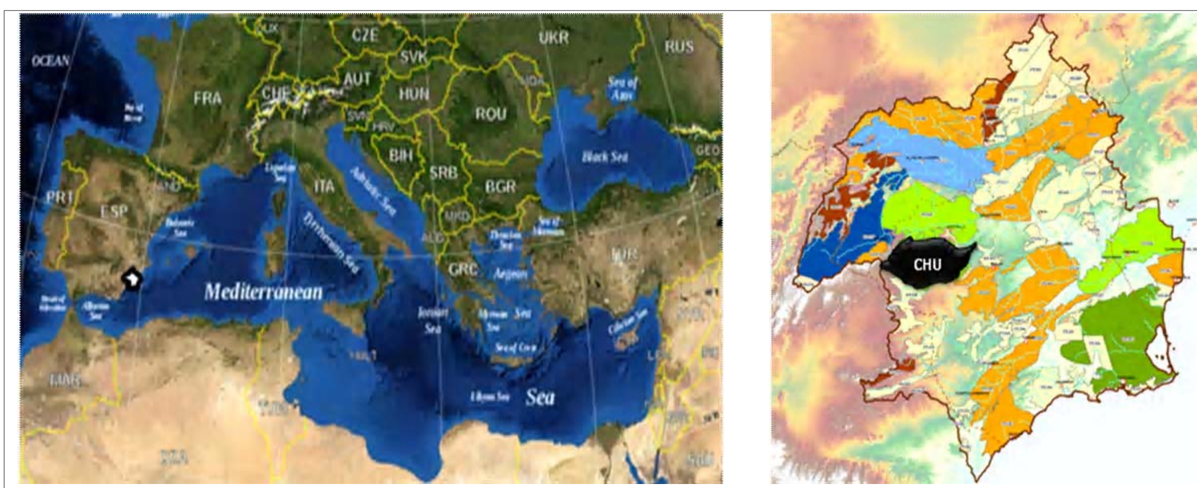
The paper is structured as follows: Next section describes the area of study; the third one displays the methodological framework used to estimate environmental and resource costs; on the forth section the results of the analyses are discussed; and finally, the last one summarizes these results and concludes the paper.

MATERIAL & METHODS

The Gavilán Aquifer, integrated in the Segura Basin District (SBD), is located in the Murcia Region, in the south-east of Spain, as shown at Fig. 1.

The Segura Basin District (SBD) is located in the southeast of the Spanish territory with a surface area of approximately 18,870 Km². The basin politically affects four Autonomous Communities: almost the entire Murcia Region and some smaller parts of Andalusia, Castile-La Mancha and Valencian Community. The whole territory of the SBD presents remarkable climatic contrasts: frequent droughts, torrential rains, recurrent floods, high temperatures and heavy frosts. Generally speaking, it is a semi-arid territory and has an average annual rainfall of around 400 mm, with a pattern of rainfall spatiotemporally very irregular. In addition, a mild temperate climate prevails (mean annual temperature of 10-18 degrees Celsius), with an average potential evapotranspiration of about 700 mm. Among the groups established by Papadakis (1952), the Segura Basin can be identified as Mediterranean with its subtypes temperate Mediterranean, continental Mediterranean, subtropical Mediterranean and subtropical semi-arid Mediterranean.

The Gavilán Aquifer is one of the nine aquifers that make up the Caravaca Hydrogeologic Unit (HU). Caravaca HU has a surface of 676 Km^2 and a total flow of 43.55 Hm^3/year. The aquifer discharges support the Fuentes del Marqués wetland. From among the 154 wetlands of interest catalogued by the SBD, Fuentes del Marqués is the one that has been assigned the greatest part of the environmental flow requirement; more specifically, 12.62 Hm^3/year of 70.41 Hm^3/year allocated by the SBD for the maintenance of wetlands are given to the Fuentes del Marqués wetland, that is, 18% of the total (SBD, 2007). When these flows are



The Segura Basin District | The Caravaca Hidrogeological Unity

Fig. 1. Location of Gavilán Aquifer (Spain) Source: NASA World Wind and SBD (2007)

ensured, the wetland provides environmental goods and services, such as delivering food (water, fish, or crops) and shelter or pleasure (landscape). There are other indirect means of support, such as biodiversity, regulating nutrients, water and its role as a carbon dioxide sink (EEA, 2010).

Table 1 shows a brief characterization of the Caravaca HU, including both quantitative and qualitative aspects (SBD, 2007).

Table 1. Status of the Caravaca Hydrogeologic Unit

Pressures	
Real or potential diffuse pollution	No significant
Point source pollution	No significant
Groundwater abstractions (Hm^3/year)	10.01
Balance (Hm^3/year)	0.00
Index (abstractions / total resources)	0.23
Index (abstractions / available resources)	0.30
Impacts	
Piezometric level decrease	Probable
Nitrates	Probable
Conductivity	Probable
Sulphates	Found
Chlorides	No impact

The groundwater belonging to the Caravaca HU, specifically the Gavilán Aquifer, is relatively much better than the rest of water bodies of the SBD (SBD, 2007). Nonetheless, Gavilán Aquifer presents some potential impacts, stemming from the agrarian activities developed in the northwestern region, which can affect the groundwater quantity and quality. On the one side, the groundwater abstraction to irrigation has reduced the piezometric levels of the Gavilán Aquifer; proof of this is the flow reduction during some springs. On the other side, agricultural activities –especially those dealing with irrigated lands- may be a potential source of diffuse pollution of agrochemical waste (pesticides and fertilizers). Other potential sources of pollution for the groundwater, although not as important as the previous one, are livestock farming (nitrate source) and wastewaters. These factors can have very negative effects on the environmental goods and services of the Gavilán Aquifer, which would lead to an environmental cost.

The environmental demand is a non-consumptive use of the groundwater, so its flow can be subsequently used for other activities. In this sense, it must be highlighted that the Fuentes del Marqués wetland provides important recreational use, which directly depends on the ecosystems supported by the Gavilán Aquifer groundwater. Besides, the presence of a Renaissance building adds historical and cultural value to this area. Nowadays, there are some restored houses and a hostel for rural tourism.

In addition, the Gavilán Aquifer groundwater is used for agriculture irrigation. The aquifer discharges supply water to 450 ha of crops. The main crop of this area is the “Búlida” apricot, irrigated by flood. The water not consumed by crops and not lost by infiltration and evaporation (a small portion of the total) ends up in the Segura River.

The environmental goods and services provided by the Gavilán Aquifer, as well as the agricultural production achieved, are susceptible of economic valuation. Hence, if the Gavilán Aquifer is overexploited or polluted by human activities, these values will be useful to determine the environmental and resource costs, as illustrated in the following sections.

The groundwater economic valuation carried out in this work is based on the set of techniques performed in Environmental Economics. Environmental Economics can be defined as the economic field that deals with economic problems directly related to environment and natural resources (Pearce and Turner, 1995). One of the most developed lines of research within Environmental Economics has been to incorporate environmental nonmarket goods and services values into private and public decision-making processes. These goods and services are mostly public goods (non-rival and non-excludable consumption) or common resources (rival and non-excludable consumption); therefore, they fall outside the conventional resource allocation mechanisms. Groundwater is a clear example of common resource leading to unwanted situations of overexploitation, which can be avoided by measuring the groundwater total value. Within this economic approach, a key concept that will be useful to determine environmental and resource costs is the so-called Total Economic Value (TEV) (Plottu and Plottu, 2007). Regarding groundwater resources, the costs related to groundwater exploitation, as defined by the WFD, are comparable to the loss of groundwater value (Loomis, 2000).

TEV can be subdivided into two categories (Kemper *et al.*, 2006): use value (UV) and non-use value (NUV). On the one hand, UV is for the consumptive or non-consumptive use of a resource in a specific place. First, the resource is consumed by an activity being accomplished in it, such as agricultural irrigation or domestic use. Second, the resource is used as recreation, for instance, when people visit a place to enjoy the landscape. On the other hand, NUV arises when people do not get directly in contact with the resource in natural state, yet the individual obtains some benefit from it. This is the case of ecological or ecosystem support functions (Freeman, 1993).

In this paper, the different groundwater values are articulated as follows (Fig. 2).

1. Use Value, which is divided into Consumptive Use for Crop Irrigation (UVCROP), and Non-Consumptive Use (UVREC), which supports recreational activities taking place in the Fuentes del Marqués wetland
2. Non-Use Value, which is related to the support functions of the wetland (NUVECO).

The Production Function Approach (PFA) was used to calculate the UVCROP. Thus, the implicit value of irrigation water can be measured by calculating the contribution of water to the profit of a crop (Hexem and Heady, 1978).

To estimate the UVREC and the NUVECO, the Contingent Valuation Method (CVM) was implemented, measuring the Willingness to Pay (WTP) for the maintenance and protection of the Fuentes del Marqués wetland. The aquifer discharges are essential to the conservation of this wetland.

The CVM elicits preferences for public goods by asking people about their WTP (Mitchell and Carson, 1990). The elicited WTP values are contingent upon the particular hypothetical market described in the questionnaire presented to the respondents. This method presents consumers with hypothetical opportunities to buy public goods, thus circumventing the absence of a real market for them (Arrow *et al.*, 1993). This method can be used to calculate use and non-use values of nonmarket goods such as ground water quality or recreation sites. The basic principles of the method, stages, limitations, etc. can be found in specialized manuals, such as those by Kopp *et al.* (1997), Bishop and Romano (1998) or Carson (2000). In relation to the CVM applied to groundwater valuation, the following works can be consulted: EPA, (1995), CWCN (1997) or Birol *et al.* (2006).

This study is specifically designed to quantify the WTP for improved water quality and quantity at the Fuentes del Marqués wetland. Besides, we investigate the determinants of their WTP as a way to test the internal validity of the measure. The construction of an equation that predicts WTP for the good with reasonable explanatory power and coefficients with the expected signs provides evidence of the proposition that the survey has measured the intended construct (Carson, 2000). The explanatory variables in the regression model are a set of variables dealing with demographic and socio-economic features. For example, a common theoretical validity test is to the effect of income on WTP, finding of WTP increasing in income (Nicholson, 2004).

A Tobit model was fitted to the data collected in order to generate predictive models of WTP. As WTP is a censored dependent variable, the ordinary least squares (OLS) method cannot be applied in this instance because the WTP values were not normally distributed: they are truncated at zero and there was a large number of zero WTP values. The OLS parameter

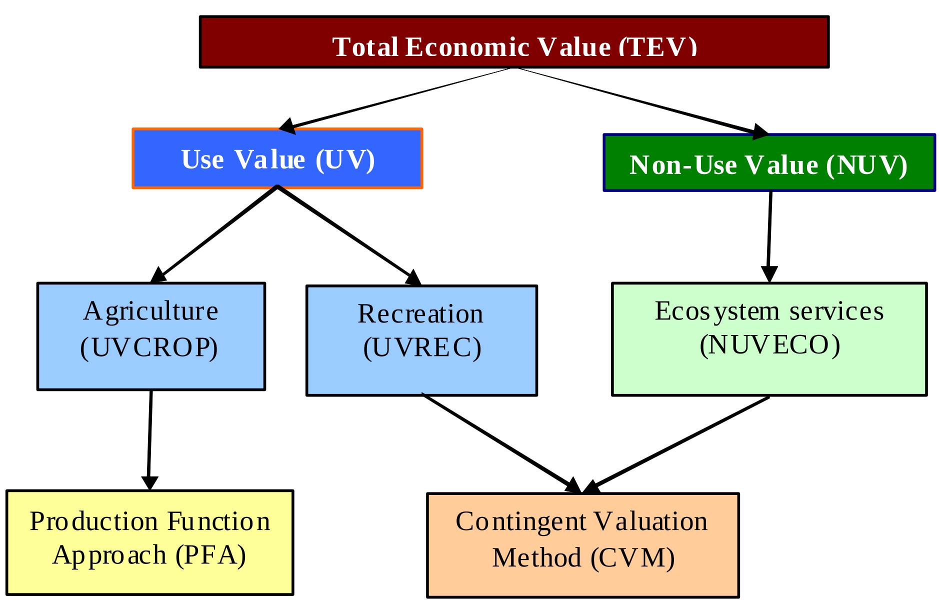


Fig. 2. The Total Economic Value of the Gavilán Aquifer groundwater

will be biased and inconsistent. The degree of bias will also increase as the number of observations that take on the value of zero increases (Greene, 1997).

The general formulation of the empirical Tobit model is given as:

$$WTP_i^* = \beta X_i + \varepsilon_i , \qquad \varepsilon_i \sim N\ [0, \sigma^2]$$

where X is a vector of explanatory factors in the regression for the individual i; β is a vector of fitted coefficients; and WTP* is the stated WTP for individual i. Since WTP* is not observed, it is the underlying latent variable that is related to the observed WTP as follows:

$$WTP_i = WTP_i^* \text{ if } WTP_i^* > 0$$

$$WTP_i = 0 \text{ if } WTP_i^* \leq 0$$

Interpreting estimated coefficients from the Tobit model is more complex than interpreting estimated coefficients from the OLS model. Particularly, the estimated coefficients represent the marginal effect of X on WTP^*:

$$\frac{\partial E\left[WTP_i^* \mid X\right]}{\partial X_i} = \beta$$

By using the McDonald and Moffitt's decomposition it is possible to see that a change in X_i affects the conditional mean of WTP* in the positive part of the distribution and affects the probability that the observation will fall in that part of the distribution (McDonald and Moffitt, 1980). To test validity purposes it is enough to study changes in the mean of the latent dependent variable by directly using the estimated coefficients from the Tobit model (Sigelman and Zeng, 1999).

RESULTS & DISCUSSION

As pointed out in the methodology section, use and non-use values have been calculated by means of the Contingent Valuation Method (CVM). The survey was carried out in the municipality of Caravaca de la Cruz, where Fuentes del Marqués wetland is located, and was conducted by means of face-to-face interviews addressed to respondents randomly selected. It was restricted to individuals over 18 years of age because they have purchasing-decision power, so the target population was 19,807 people. Finally, the survey was conducted on 309 respondents. For this sample the error is 2.99% for extreme variance and 4.98% for intermediate variance (Weisberg, 2005).

The questionnaire comprised many questions about the knowledge of the wetland, its use, environmental awareness, socio-economic information, etc. Besides, there was another set of questions dealing with the subject-matter here studied. Opened questions about the WTP for protecting and preserving the Fuentes del Marqués natural site were also included.

From 309 respondents, 57% had a positive WTP, whereas 43% had a negative WTP. Within the second group, it is necessary to distinguish between the protest responses and the true zero WTP values (Fig. 3), as defined by Carson (2000).

On the other hand, protest responses are given by individuals who value the environmental good but do not agree with the payment method. True zeros may be distinguished from protest zeros, as protest zeros put forward that "it is a matter of the Public Administration", or "I do not want to donate money to a foundation to protect the place" (final payment method chosen in a pilot questionnaire). Fig. 4 shows the final structure of the hypothetical market.

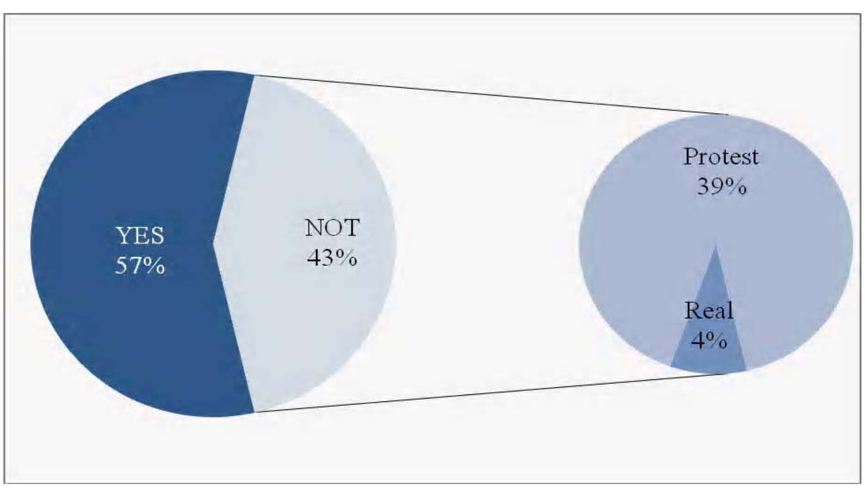


Fig. 3. Analysis of WTP responses

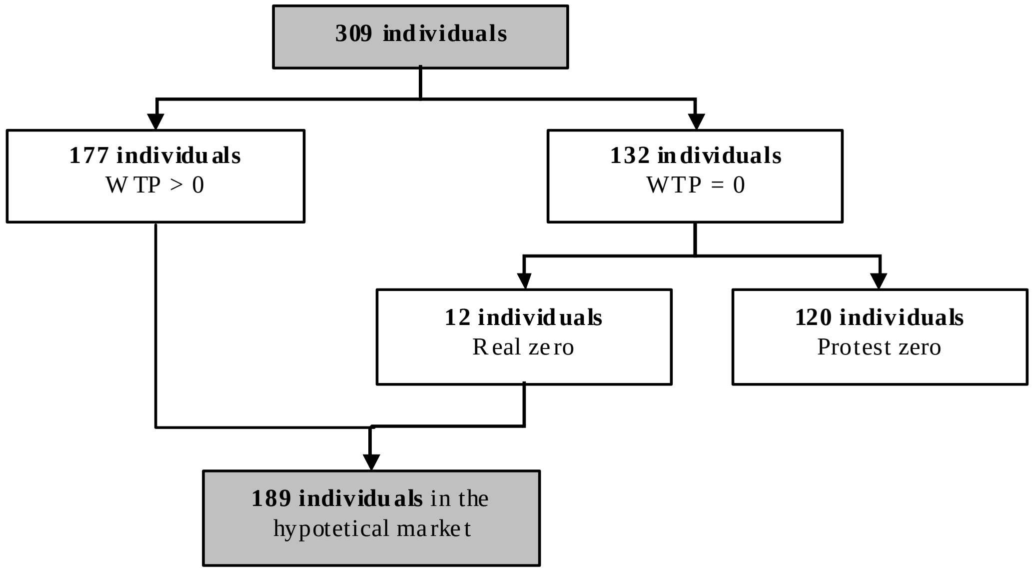


Fig. 4. Final composition of the hypothetical market

The hypothetical market includes 177 people who were willing to pay and 132 people with a negative answer. From these people who were not willing to pay, 120 people considered that it was the Public Administration that should be in charge of this, or that the payment method was not appropriate (a donation to a not-for-profit foundation). The 12 people left are catalogued as true zeros, as they did not really value the good; hence, they are included as participants in the market.

Taking into account that there were 189 respondents who participated in the hypothetical market, the mean of WTP for protecting, conserving and enhancing the Fuentes del Marqués wetland was calculated in 23.52 €/year. This value includes the use (i.e., recreation value) and non-use (i.e., ecosystem services value) values of this natural site. Table 2 summarises the descriptive statistics of the WTP, whereas fig. 5 shows the WTP distribution estimated with its kernel density.A Tobit model was estimated to characterize the WTP. Table 3 reports the results of the parameters, which maximise the likelihood function. Predictors which did not offer sufficient statistical significance were omitted from the valuation functions. The goodness of fit of the model seems appropriate, as shown by the high pseudo R^2 obtained for this type of functions, much higher than 15%, threshold for the credibility of the predictive model (Mitchell and Carson, 1990).

The variable INCOME presents a positive significant coefficient as expected, in order to perform the primary theoretical validity test. People with higher income are more willing to pay for improving and preserving the wetland and it can be deduced from the model that for every extra 1000 € of households income, WTP increases by approximately 2 €. Both AGE and GENDER of respondents had a statistically significant and positive effect on the household's WTP. Older people have a higher WTP than younger population, while men have a lower WTP than women. WTP also increases by 5.4 € for making use of the wetland. People who have a high educational level are willing to pay 2.4 € more than non-university respondents.To continue the analysis, next it is estimated how users and non-users value the Fuentes del Marqués wetland by dividing the previous sample into two sets of individuals: users (those who visited the place at least once in the last year) and non-users. Thus, 159 individuals out of the total are users, and 30 are non-users. Fig. 6 shows that each user is willing to pay 24.66 €/year, while non-users are willing to pay 17.48 €/ year. Table 4 presents a t-test for the mean difference, which is statistically relevant.

Starting from these values, the direct use value and the non-use value of the Fuentes del Marqués wetland can be calculated. The non-use value is directly the NUWTP, 17.48 €/year/person. To obtain the direct use value of the wetland, the NUWTP has to be subtracted from the UWTP. In this way, the WTP for using the wetland is 7.18 €/year/person. Using these values of individual WTP of direct and indirect use, the Recreational Use Income and the Environmental Income provided by the groundwater of the Fuentes del Marqués wetland can be estimated.

Table 2. Descriptive statistics of Willingness to Pay (WTP)

	Mean	Mediam	Minimum	Maximum	Stand dev	Mean 95 % CI
WTP (€/yr)	23.52	15	0	120	24,47	20.21 – 27.04

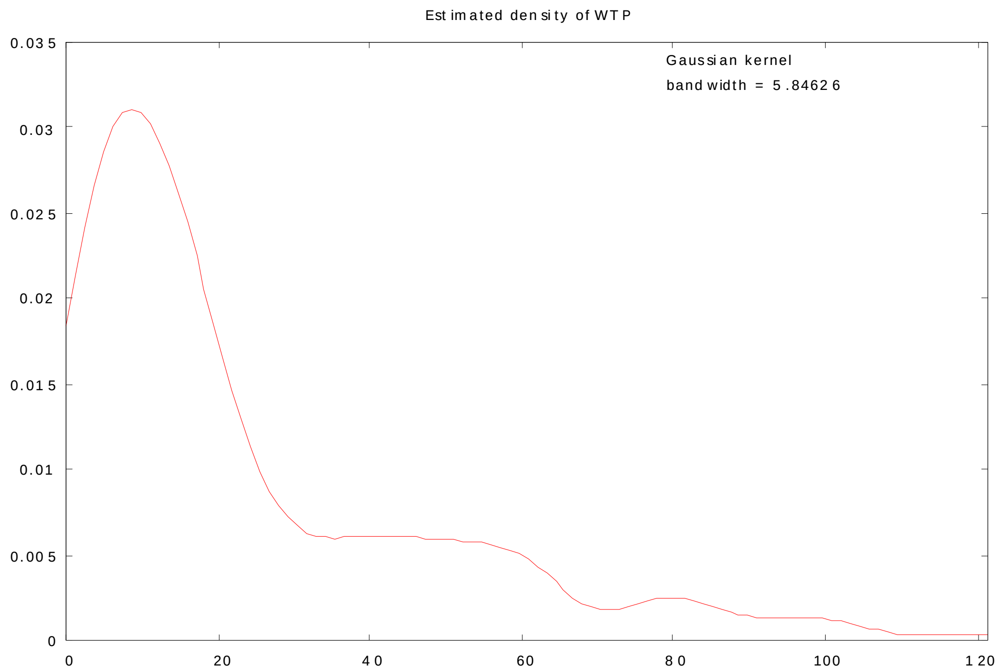


Fig. 5. Distribution of individual WTP

Table 3. WTP determinants: Tobit regression model

Variable	Coefficient	z-statistic	p-value
Constant	-7.061	-3.080	0.002
INCOME (€)	0.002	1.991	0.047
AGE (years)	0.345	2.822	0.005
GENDER (Male = 0; Female = 1)	2.138	1.876	0.052
USER (No = 0; Yes = 1)	5.416	3.197	0.002
UNIVERSITARY (No = 0; Yes = 1)	2.421	2.239	0.028
Log-likelihood	-463.176		
Pseudo R^2	0.371		
Obs. summary:			
Number of obs = 189			
12 left-censored observations at WTP quantity <=0			
177 uncensored observations			

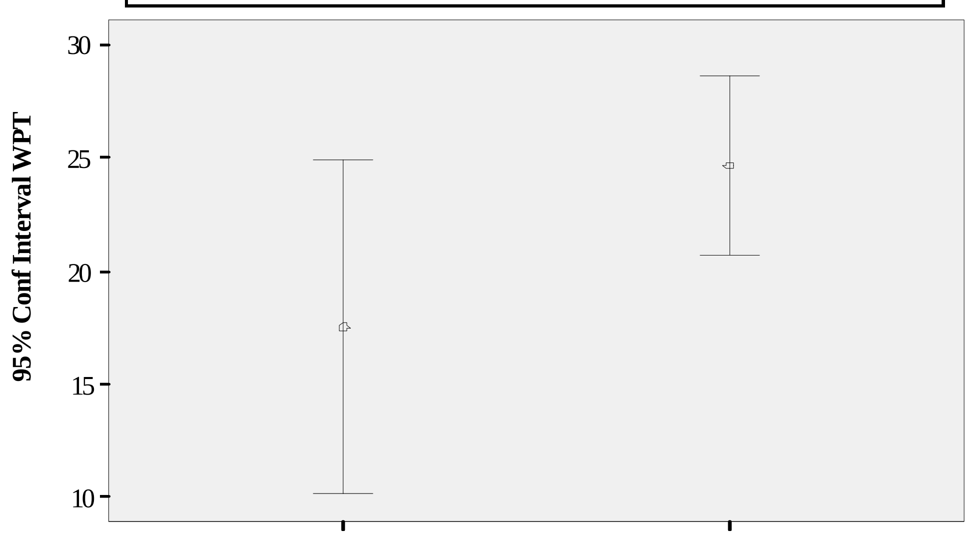


Fig. 6. Averages and confidence intervals (95.5%) of WTP of users and non-users

Table 4. WTP of users and non-users

	N	WTP	t-test
WTP Users (UWTP)	159	24.66	-1.730
WTP Non-Users (NUWTP)	30	17.48	(0.090)

Firstly, the potential users of this natural site have to be chosen. The main users of the Fuentes del Marqués wetland are those people from the local municipality because they visit this site often. As already mentioned, there were 159 (84.13%) users and 30 (15.87%) non-users in the hypothetical market designed in this paper. Taking into account the target population (19,807 individuals), the amount of total users was 16,663 people. Consequently, the Recreational Use Income can be calculated as follows:

Recreational Use Income = 16,663 × 7.18 €/year = 119,640 €/year

Secondly, the Environmental Income has a similar expression. It consists in extrapolating the NUWTP to the relevant population, but it is not easy to quantify in this case (Kopp *et al.*, 1997). This kind of Income includes many set of values, such as existence value and request value. The services provided by aquifer discharges, like wildlife and plants they support, have to be considered as well. Then, the people interested in these natural services are more than the inhabitants of the local municipality. Thus, it was supposed that the relevant population consisted of people from the northern area of the Region of Murcia known as "Comarca del Noroeste", which includes 5 municipalities. Finally, the number of inhabitants used to estimate the Environmental Income was 45,595 people over 18 years of age. Therefore, this income can be calculated as:

Environmental Income = 45,595 people× 17.48 €/year/person = 797,000 €/year

Since the aquifer discharges at the wetland are 12.62 Hm^3/year, UVREC and NUVECO can be calculated as:

$$UVREC = \frac{119{,}640 \ \text{€} / year}{12.62 \ \ Hm^3 \ / \ year} = 0.010 \ \ \text{€} / \ m^3$$

$$NUVECO = \frac{797{,}000 \ \text{€} / \ year}{12.62 \ \ Hm^3 \ / year} = 0.063 \ \text{€} / \ m^3$$

Finally, the results of the estimation of the resource costs, using the Production Function Approach (PFA), are displayed. The gross margins of apricot trees, irrigated by flood, which are the predominant crop in the area, were compared to non-irrigated apricot trees. This information, shown on Table 5. derives from the computation of costs and incomes of fruit trees included in the Agricultural Statistics of the Ministry of Agriculture of Spain (MAPA, 2008). On the one hand, irrigated crops have a gross margin of 5,020 €/ha and consume about 5,200 m^3/ha of water from the Fuentes del Marqués wetland. On the other hand, there are still more than 200 ha of non-irrigated apricot trees in the SBD whose estimated gross margin does not exceed 3,040 €/ha due to the lower yield, the lower spending on productive inputs and crop management.

By operating with such data, the resource use value can be calculated according to the opportunity cost, as proxy to resource cost defined in the WFD. In this case, it comes to 0.381 €/m^3, which is the additional value with which the water use contributes to the production (UVCROP).

Table 6 shows an estimation of the total use value according to the functions, the valuation methods and the assumptions explained throughout this work. Since recreation and environmental are not consumptive uses and irrigation takes place after the flow leaves the wetland, these values can be directly considered additives.It is immediate to move from these unit values to costs. If the resource was modified or even eliminated, and, therefore, their functions were not fulfilled, these values would act as costs for the activity (e.g., overexploitation of the aquifer) responsible for this change of the original status. The resource cost would include irrigation use value, whereas both the environmental value and recreational use value would have to be included in the environmental cost category. In this manner, the groundwater TEV of the Gavilán Aquifer could be incorporated into water policy and management.

Table 5. Gross margin and water consumption in apricot crops

		Non-irrigated	Irrigated
(G)	**Gross Margin** (€/ha)	3,040	5,020
(W)	**Water Consumption** (m^3/ha)	0	5,200
(ΔG)	**Gross Margin difference** (€/ha)	1,980	
(ΔW)	**Water Consumption difference** (m^3/ha)	5,200	
(ΔG/ΔW)	**Gross Margin difference by m^3** (€/m^3)	0.381	

Table 6. Groundwater Total Economic Value

Categories	Value (€/m^3)
UVCROP - Opportunity	0,381
UVREC – Recreational	0,010
NUVECO - nvironmental	0,063
TEV	**0,454**

CONCLUSION

The values, functions and services of the groundwater are clearly defined. These even have a substantial set of economic valuation techniques that can be used to measure the Total Economic Value of ground waters. It is essential to measure the TEV of groundwater resources so as to ensure their sustainable and efficient allocation.

Given the lack of quantitative studies about environmental and resource costs with clear methodology, this paper represents the first step to implement the obligations of the Water Framework Directive. It also provides an application of Contingent Valuation Method (CVM) and Production Function Method (PFM) to capture the TEV of groundwater.The case study was carried out in an aquifer located in Spain, the Gavilán Aquifer, which supports the Fuentes del Marqués wetland and the agriculture located around this area. This paper sets an estimation of the environmental and resource costs, as a result of depletion and degradation of groundwater resources of the Gavilán Aquifer. Thus, the total economic cost would be 0.454 €/m^3. This value would include the price of the services provided by the groundwater of the aquifer in question, including the maintenance of agriculture, recreational activities around the wetland, and the sustenance of the associated ecosystem. For each of these activities, the following unit values were calculated: 0.381 €/m^3 for the maintenance of traditional crops, based on the PFM and the opportunity cost; 0.010 €/m^3 for recreation, and 0.063 €/m^3 for environmental functions, both of them estimated by means of CVM. This result can be considered as conservative, since the opportunity cost is only calculated based on the traditional crop of the area, while there are products and/or water uses with higher added value. In addition, it was also felt that the people enjoying the natural landscape and the environmental services were only those circumscribed to their near surroundings. Thereby, the economic cost shown in this analysis is equivalent to the minimum attributable value to the groundwater of the studied aquifer. As the calculation of the environmental value is much more complex than the opportunity cost, the fraction of the total value estimated for this aquifer related to environmental and recreational aspects (16.1%) can be a representative initial approximation for the water of aquifers of the arid zones with uses competition.Finally, water policy makers should take into account studies like this one in order to incorporate external cost of overexploitation of groundwater resources into decision-making processes. This would allow the implementation of an optimum inflow so as to facilitate ground water resource management.

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REFERENCES

Acharya, G. and Barbier, E. (2002). Using domestic water analysis to value groundwater recharge in Nothern Nigeria. American Journal of Agricultural Economics, **84 (2)**, 415-426.

Arrow, K., Solow, R., Portney, P. R., Leamer, E. E., Radner, R. and Schuman, H. (1993). Report of the National Oceanic and Atmospheric Administration (NOAA) Panel on Contingent Valuation. Federal Register, **58 (10)**, 4601-4614.

Bateman, I. J., Brouwer, R., Davies, H., Day, B. H., Deflandre, A., Falco, S. D., Georgiou, S., Hadley, D., Hutchins, M., Jones, A. P., Kay, D., Leeks, G., Lewis, M., Lovett, A. A., Neal, C., Posen, P., Rigby, D. and Turner, R. K. (2006). Analysing the agricultural costs and non-market benefits of implementing the Water Framework Directive. Journal of Agricultural Economics, **57 (2)**, 221-237.

Birol, E., Karousakis, K., and Koundouri, P. (2006). Using economic valuation techniques to inform water resources management: a survey and critical appraisal of available techniques and an application. Science of the Total Environment, **365**, 105-122.

Bishop, R. and Romano, D. (1998). Environmental resource valuation: applications of the contingent valuation method. (Boston: Kluwer Academic Publishers).

Bouleau, G. (2008). The WFD dreams: between ecology and economics. Water and Environment Journal, **22 (4),** 235-240.

Carson, R. (1992). Constructed Markets. (In: Braden, J.B. and Kolstad, C.D., (Eds.), Measuring the Demand for Environmental Quality (pp. 121-162). Amsterdam: Elsevier Science Publisher).

Carson, R. (2000). Contingent valuation: a user's guide. Environmental Science and Technology, **34 (8)**, 1413-1418.

Committee on Valuing Groundwater, Water Science and Technology Board, Commission on Geosciences, Environment, and Resources, National Research Council (Simply called as CWCN in the paper) (1997). Valuing Ground Water: Economic Concepts and Approaches. (Washington DC: National Academy Press).

Connelly, N., Brown L. and Brown J. (2007). Measuring the Net Economics Value of Recreational Boating as Water Levels Fluctuate. Journal of the American Water Resources Association, **43 (4)**, 1016-1023.

Custodio, E., Llamas, M. R., Hernández-Mora, N., Martínez-Cortina, L. and Martínez-Santos, P. (2009). Issues related to intensive groundwater use (In Garrido, A. and Llamas, M.R. (Eds.), Water Policy in Spain (pp. 143-162). London: Taylor and Francis).

Dehghani, M., Farshchi, P. Danekar, A., Karami, M. and Aleshikh, A. (2010). Recreation Value of Hara Biosphere Reserve using Willingness-to-pay method. International Journal of Environmental Research, **4 (2)**, 271-280.

EEA, (2010). Scaling up ecosystem benefits. A contribution to the Economics of Ecosystems and Biodiversity (TEEB) study. (Copenhagen: European Environment Agency).

EPA, (1995). A framework of measuring the economic benefits of ground water. Environmental Protection Agency, Office of Water, EEUU.

EC, (2000). European Commission, Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy. European Union.

Freeman, A. M. (1993). The Measurement of Environmental and Resource Values: Theory and Methods. (Washington DC: Resources for the future).

Greene, W. H. (1997). Econometric Analysis. (New York: Macmillan).

Heal, G. (2000). Valuing Ecosystem Services. Ecosystems, **3**, 24-30.

Hexem, R. W. and Heady, E. O. (1978). Water Production Functions for Irrigated Agriculture. (Ames: Iowa State University Press).

Jones, N., Sophoulis, C. M. and Malesios, C. (2008). Economic valuation of coastal water quality and protest responses: A case study in Mitilini, Greece. The Journal of Socio-Economics, **37**, 2578-2491.

Kemper, K., Foster, S., Garduño, H., Nanni, M. and Tuinhof, A. (2006). Economic Instruments for Groundwater Management using incentives to improve sustainability. GWMATE Briefing Notes Nº 7. World Bank, Washington D.C. from www.worldbank.org/gwmate.

Klessig, L. (2001). Lakes and society: The contribution of lakes to sustainable societies. Lakes and Reservoirs: Research and Management, **6 (2)**, 95-101.

Kopp, R., Pommerehne, W. W. and Schwarz, N. (1997). Determining the value of non-marketed goods. (Norwell, Massachusetts: Kluwer Academic Publishers).

Lindsey, G. (1994). Market models, protest bids, and outliers in contingent valuation. Journal of Water Resources Planning and Management, **120**, 121-129.

Loomis, J. B. (2000). Environmental valuation techniques in water resources decision making. Journal of water resources planning and management, **126 (6)**, 339-344.

MAPA, (2008). Spanish Survey on area and crop yields. (ESYRCE). Spanish Ministry of Agriculture from http://www.mapa.es/es/estadistica.

Martínez-Paz, J. M., Perni, A. and Martínez-Carrasco, F. (2010). Social preferences and economic valuation for water quality and river restoration: the Segura River (Spain). Water and Environment Journal. In press.

McDonald, J. and Moffitt, R. (1980). The uses of Tobit analysis. The Review of Economics and Statistics, **62**, 318-387.

Mitchell, R. C. and Carson, R. T. (1990). Using Surveys to Value Public Goods: The Contingent Valuation Method. Resources for the Future. Washington: John Hopkins University Press.

Mitchell, R. C. and Carson, R. T. (1993). The value of clean water: the public´s willingness to pay for boatable, fishable and swimmable quality water. Water Resources Research, **29 (7)**, 2445-2454.

Morrison, M. (2002). Understanding local community preferences for wetland quality. Ecological Management and Restoration, **3 (2)**, 127-134.

Nicholson, W. (2004). Intermediate Microeconomics and its Application (9th edn.). (Chicago: Dryden)

Ojeda, M., Mayer A. and Solomon, B. (2007). Economic valuation of environmental services sustained by water flows in the Yaqui River Delta. Ecological Economics, **65**, 155-166.

Onate, J. J. and Peco, B. (2005). Policy impact on desertification: stakeholders' perceptions in southeast Spain. Land Use Policy, **22 (2)**, 103-114.

Ormerod, S. (2009). Climate change, river conservation and the adaptation challenge. Aquatic Conservation: Marine and Freshwater Ecosystems, **19 (6)**, 609-613.

Papadakis, J. (1952). Agricultural geography of the world: climate, growth rate and rhythm, vegetation, soils, crops, agricultural regions. (Buenos Aires: J. Papadakis).

Pearce, D. and Turner, K. (1995). Economics of natural resources and the environment. (London: Harvester Wheatsheaf).

Plottu, E. and Plottu, B. (2007). The concept of Total Economic Value of environment: A reconsideration within a hierarchical rationality. Ecological Economics, **61**, 52-61.

Praveena, S. M., Abdullah, M. H. and Aris, A. Z. (2010). Modeling for Equitable Groundwater Management, Int. J. Environ. Res., **4 (3)**, 415-426.

Sari, M., Kadioglu, M., Arabaci, M. and Ertan, A. (2003). Ecological sharing of water for healthy management of fisheries and irrigation under drought conditions in Bend-I Mahi River, Van, Turkey. Journal of Environmental Protection and Ecology, **4 (1)**, 166-178.

SBD, (2007). Caracterización de las masas de agua subterráneas de la cuenca del Segura. Repercusiones de la actividad humana en el estado de las aguas subterráneas (art. 5 Directiva Marco del Agua). Ministerio de Medio Ambiente, Medio Rural y Marino from http://www.chsegura.es. [In Spanish].

Sigelman, L. and Langche Z. (1999). Analyzing Censored and Sample-Selected Data with Tobit and Heckit Models. Political Analysis, **8**,167-182.

Spash, C. L. (2000). Ecosystems, contingent valuation and ethics: the case of wetland re-creation. Ecological Economics, **34**, 195-215.

Stemplewski, J., Krull, D., Wermter, P., Nafo, I., Palm, N. and Lange, C. (2008). Integrative socio-economic planning of measures in the context of the Water Framework Directive. Water and Environment Journal, **22 (4)**, 250-257.

Stenger, A. and Willinger, M. (1998). Preservation value for groundwater quality in a large aquifer: a contingent-valuation study of the Alsatian aquifer. Journal Environmental Management, **53**, 177-193.

WATECO, (2003). Common Implementation Strategy for the Water Framework Directive (2000/60/EC). Guidance Document No. 1: Economics and the Environment.The Implementation Challenge of the Water Framework Directive. European Commission.

Weisberg, H. (2005). The Total Survey Error Approach. (Chicago: University of Chicago Press).