The Socio-Psychological Determinants of Preferences toward Ecosystem Services: a Choice Experiment study with Posterior Analysis of Conditional Preference Distributions

Abstract

Aim of this paper is to analyze the determinants of social preferences toward measures to improve water ecosystem services, that European countries should implement in compliance with the Water Framework Directive 2000(60). A Choice Experiment study has been conducted to evaluate social costs and benefits associated with measures to improve water ecosystem services in Sardinia, Italy. Socio-psychological factors complement usual socio-demographic and economic factors to analyze the determinants of individuals' preferences. After fitting the choice data by means of a Random Parameter Logit model, we apply a set of Posterior Analysis methods to examine the conditional distributions for identification of socioeconomic, demographic and psychological factors influencing individual preferences and WTP. This approach proves useful to uncover a variety of causal effects that could not be estimated efficiently by Mixed Logit models with heterogeneity in mean and/or variance.

Introduction

The Water Framework Directive (WFD) 2000(60) has been established with the aim of improving water quality in Europe and achieving a good quality status for all European river basins by 2021, promoting a common management framework. The cost of achieving full compliance could be high but the Directive allows for derogations if the costs of meeting the environmental objectives are considered disproportionate (Metcalf et al., 2012). Even though the Directive does not explicitly demand a Cost-Benefit Analysis, disproportionate costs are practically identifiable after a CBA (as also indicated in the so called WATECO (2003) guidelines and other related documents), where benefits are assessed through elicitation of citizens' willingness to pay for achieving a good level of water quality and related ecosystem services. Stated Preference methods can be applied to elicit such values, as seen in Hanley et al., 2006; Alvarez-Farizo et al., 2007; Brouwer, 2008; Kataria et al., 2012; Metcalf et al., 2012; Bliem et al., 2012; Garcia-Llorente et al., 2012; Doherty et al., 2014.

An emerging issue in environment valuation studies, especially if based on stated preference methods, is the analysis of the determinants of preferences, and consequently of WTP, for specific use and non use values associated with the project. As suggested by Halkos and Matsiori (2014) there are "links between water resources values, human beliefs, norms and environmental behavior" that are worth investigating. This approach is especially useful when it is important to understand who are the winners and losers from a specific project, particularly when the project entails land use changes or modifications in the property rights allocation. In a similar situation, it is important to deepen the analysis of the socio-psychological determinants of the households' preferences in order to correctly identify those elements that could be a hinder to the adoption of effective measures.

This type of investigation has been relatively disregarded in previous studies dealing with valuation of ecosystem services of water resources: only in a limited number of published papers we could see a specific focus on social-psychological determinants of the preferences and WTP for specific water ecosystem services attributes. For example, Alvarez-Farizo et al. (2007) use three psychological constructs: perception of current ecological condition of the river, perception of the current uses, and perception of the impacts on local economy of current (poor) state of river quality. Cooper et al. (2011) insert different psychometric variables that indicate attitudes towards water restrictions and intention to compliance; values, perceived behavioral control, level of information, network effects. Hunter et al. (2012) identify three psychological factors related to attitude toward environmental and health risk, both in general and in relation to water pollution; Halkos and Matsiori (2014) identify four factors of perceived importance of direct/option use values, bequest values, existence values, indirect values. Buckley et al. (2016) identify two socio-psychological factors: perceived importance of economic development, perceived importance of environmental protection.

In the present study we employ a battery of psychometric scales explicitly designed to uncover the socio-psychological determinants of stated preferences toward specific water ecosystem improvement scenarios. A Choice Experiment study has been implemented to evaluate social costs and benefits associated with measures to improve water ecosystem services in Sardinia, Italy. Psychological factors will complement usual socio-demographic factors to analyze the determinants of individuals' preferences.

Another innovative feature of our study is methodological. Building upon previous work by Train (2003), Hess (2007), Richter and Weeks (2016), after fitting the choice data by means of a Random Parameter Logit model, we apply a set of Posterior Analysis methods to examine the conditional distributions for identification of socioeconomic, demographic and psychological factors influencing individual preferences and WTP. This approach proves useful to uncover a variety of causal effects that could not be estimated efficiently by Mixed Logit models with heterogeneity in mean and/or variance.

The paper is structured as follows: the first paragraph contains a review of previous stated preference studies on valuation of improvements of water ecosystems and related use and non use values. The second paragraph exposes the methodological methods applied in this paper. The third section focuses on the description of the case study and survey administration; the results of the statistical analysis, and the WTP estimates are reported respectively in section 4 and in section 5; the last section contains conclusions and policy suggestions.

1. Review of Stated Preference studies on water quality

A wide range of Stated Preferences studies deals with water resources. In this short review, we firstly focus on the attributes inserted in Choice Experiments studies on the improvement of water quality. Afterwards, we go through papers dealing with the determinants of respondents' preferences.

Attributes

Many studies consider the ecological status as an indicator of water quality, i.e. the presence of a variety of animal and plant aquatic species living in the water body (Hanley et al., 2006; Alvarez-Farizo et al., 2007; Brouwer, 2008, 2015, 2016; Martin-Ortega e Berbel, 2010; Martin-Ortega et al., 2011; Garcia-Llorente et al., 2012; Kataria,2012; Tait et al., 2012; Doherty et al., 2014). In other studies the water quality variable is related to the presence of biodiversity, but also to elements that define its appearance, such as clarity, turbidity, smell, presence of algae etc. (Martin-Ortega e Berbel, 2010; Garcia-Llorente et al., 2012; Kataria et al., 2012; Doherty et al., 2014; Meyerhoff et al., 2014; Marsh e Phillips, 2014, 2015; Dauda et al., 2015).

The recreational use of the water resource directly influences the perception and the valuation of quality (Martin-Ortega e Berbel, 2010; Stithou et al., 2012; Hynes et al., 2012; Bliem et al., 2012; Kataria et al., 2012; Buckley et al., 2016); users are more willing to pay to support policies directly affecting the attributes that reflect the particular use of water (Garcia-Llorente et al., 2012; Doherty et al., 2014).

Tap water service is another important element in valuation studies: see Alvarez-Farizo et al., 2007; Rungie et al., 2014; Latinopoulos, 2014; Brouwer et al., 2015; Czajkowski et al., 2015 ; Dauda et al., 2015.

Another attribute often considered in studies dealing with valuation of water ecosystem services is flood risk, and the general conditions of the banks of water bodies (Hanley et al., 2006; Hensher et al., 2006; Alvarez-Farizo et al., 2007; Garcia-Llorente et al., 2012; Kataria et al., 2012, Doherty et al., 2014; Ryffle et al., 2014; Brouwer et al., 2016; Stithou et al., 2012).

Determinants of preferences

The willingness to pay for quality improvement is influenced by several elements, such as income (Alvarez-Farizo et al., 2007; Buckley et al., 2016; Brouwer et al., 2016 find that the willingness to pay is increasing as environmental quality grows and is positively linked to income) and education (Alvarez-Farizo et al., 2007; Bliem et al. (2012); Garcia-Llorente et al. (2012); Buckley et al., 2016 find that higher educated people are more willing to pay to support policies addressed to the improvement of environmental quality).

Generally, it is assumed that those who have had experience of water restrictions are more sensitive to these issues, and therefore more likely to choose alternative scenarios to the status quo. Martin-Ortega et al. (2011) find that awareness of the problems of water scarcity in the area is positively correlated with willingness to pay to solve the problem; however, previous experience of problems may also induce lack of confidence in measures, so that the effect on willingness to pay is negative.

In their study on the Danube, Brouwer et al. (2016) show that previous experience of floods does not influence the willingness to pay to mitigate the risk.

Brouwer et al. (2015) find mixed evidence on the effect of past experience of restrictions in the service, while in Latinopoulos (2014) the effect is significant. The author also finds that respondents who are well informed about water quality and consume a lot of bottled water prefer alternatives that lead to improved water quality.

Another important issue that influences willingness to pay is information. Kataria et al. (2012) find a certain asymmetry in the trust in information: people show low confidence in the positive information provided to them on water quality, but higher confidence in negative information. The results indicate that respondents who believe that both the status quo information and the proposed scenarios are credible have a willingness to pay higher than average; however, the effect appears to be significant only for those living near the water bodies.

Only few studies insert variables to take into consideration attitudes, perception and behavior. Buckley et al. (2016) find that those respondents who believe that economic development should not be constrained by environmental legislation have a lower willingness to pay than those who believe that it is important to protect the environment in order not to affect future generations, even if this means bearing current economic losses (see also Garcia-Llorente et al., 2012). Alvarez-Farizo et al. (2007) find that participants who are either members of environmental pressure groups or work in public sector with decision responsibilities (people identified as being motivated by altruism) have a high willingness to pay, both when they have to evaluate a private choice and when they have to evaluate a collective choice. Furthermore, these authors use three perception variables: a variable about perception of the current ecological condition of river, perceptions of current uses to which the river can contribute and perceptions on extent of impacts on local economy of current (poor) state of river quality. They find that only two of these variables are significant determinants of the respondents' choice: the perception of ecological condition and the perception of impacts on local economy are significant with a positive sign for people with no selfish interest, while perception of uses is always not significant.

Heterogeneity is modeled in Choice Experiment studies dealing with evaluation of water ecosystem services through Random Parameter models with heterogeneity (Alvarez-Farizo et al., 2007; Martin-Ortega et al., 2011; Bliem et al., 2012; García-Llorente et al., 2012; Kataria et al., 2012; Doherty et al., 2014; Latinopoulos, 2014; Ryffel et al., 2014; Brouwer et al., 2015; Brouwer et al., 2016); or Latent Class models (Cooper et al., 2015); or both (Glenck et al., 2015). We are not aware of previous works that adopt a Posterior Analysis on conditional distributions in this field.

2. Econometric models

The Choice Experiments approach is based on Lancaster's Theory of Value (1966), according to which every asset can be described from a set of features and the levels they assume, and McFadden's Random Utility Theory (1974). Choice experiments data estimation is based on a utility model:

$$U_{njt} = \beta' x_{njt} + \varepsilon_{njt}$$

where the x_{njt} vector includes both choice j attributes and individual n characteristics, and t stands for the choice situation (each individual facing several choice exercises).

In a Logit framework the parameters are assumed to be homogeneous across individuals and ε_{jti} to be IID as a Gumbel; the CDF is the following:

$$F(\varepsilon_j) = \exp[-\exp(-\varepsilon_j)]$$

and the probability of choosing the alternative j is

$$\text{Prob(option j)} = \text{Prob}(U_j > U_k)\ \forall\ k \neq j$$

$$= \frac{\exp(\beta' x_{njt})}{\sum_j \exp(\beta' x_{njt})}, \qquad j = 0, \ldots, J$$

The probability of observing a sequence of choices is the product of logits:

$$P(y_n \mid x_n, \beta) = \prod_{t=1}^{T} \frac{\exp(\beta' x_{njt})}{\sum_j \exp(\beta' x_{njt})}$$

The Mixed Logit extension allows the parameters to vary across individuals and the error components to be correlated. The Latent Class model is a type of mixed logit, which assumes a discrete distribution (usually, a Logit) for the individual parameters, which are grouped into classes.

In order to allow these specifications the vector of parameters β and the stochastic component are expanded as

$$\beta_{nk} = \beta_k + \sigma_k v_{nk}$$

where β_k is the population mean, v_{nk} represents the heterogeneity across individuals, with zero mean and standard deviation equal 1, and σ_k is the standard deviation of the β_{nk} distribution around β_k.

Thus we can formulate utility as

$$U_{njt} = \beta_n' x_{njt} + \eta_{nj} + \varepsilon_{nj}$$

where η_{nj} is a random term with zero mean, which can be correlated across the alternatives and depends on parameters and observed data related to alternatives j and individuals n, while ε_{nj} is a random term with zero mean, IID and independent from parameter or data.

Since we do not know β_n, the probability of the person's sequence of choices is the integral of $P(y_n \mid x_n, \beta)$ over the distribution of β:

$$P(y_n \mid x_n, \theta) = \int P(y_n \mid x_n, \beta) g(\beta \mid \theta)\, d\beta$$

where $g(\beta \mid \theta)$ is a distribution with hyperparameters θ. This is the unconditional distribution of β.

The mean β conditional on choosing y_n when facing x_n is

$$\bar{\beta_n} = \frac{\int \beta \, P(y_n|x_n, \beta) g(\beta|\theta) d\beta}{\int P(y_n|x_n, \beta) g(\beta|\theta) d\beta}$$

Maximum likelihood estimation is not possible as the denominator of the equation does not have a closed form solution. The alternative option is to simulate conditional distributions using a discrete approximation: for example, we can write the conditional mean for consumer n as

$$\widehat{\beta_n} = \frac{\sum_{r=1}^{R} \beta_r \, P(y_n|x_n, \beta_r)}{\sum_{r=1}^{R} P(y_n|x_n, \beta_r)}$$

where β_r are the multidimensional draws, independent from $(\beta|\theta)$ for the estimated values of θ .

After fitting the choice data using Random Parameter estimators, we apply a set of Posterior Analysis methods (Train, 2003; Hess, 2007; Richter and Weeks, 2016) to examine the conditional distributions for identification of socioeconomic, demographic and psychological factors influencing individual preferences and WTP. Indeed, among the potentialities of the Random Parameter models is that of allowing to realize forms of Posterior Analysis (Train, 2003) which, as Richter and Weeks point out (2016), allow to analyze the conditioned estimates in order to exploit the information linked to the choices made by individuals.

Train (2003) suggests that conditional distributions can be analyzed by means of non parametric statistical tools, first to explore correlations between attributes' coefficients, and then to examine their association with socio-demographic variables. Richter and Weeks distinguish two components of the total variance of conditional distributions: a variance of the between variation and variance around these averages (within). If the between variance is able to capture a sufficient portion of the total variance of a coefficient (around 50-60% according to Richter and Weeks, 2016), then individual conditioned averages should allow separate groups of individuals to be identified (Train, 2003). Richter and Weeks (2016) carry out tests of difference in averages with respect to different categories of values of the covariates, and a cluster analysis with respect to evaluations, testing the difference between clusters of average values of demographic and socio-economic characteristics. This approach is further pursued by Richter and Pollitt (2016), who apply a cluster analysis to identify consumer groups that would accept contracts with similar characteristics.

Posterior Analysis can also be useful for the calculation and analysis of willingness to pay, as suggested by Hess (2007). When the monetary attribute follows a random distribution, calculation problems arise due to the fact that this distribution may include values close to zero, from which excessively high ratios result. In this case, it is possible to estimate individual WTPs using the ratio between couple of draws of the simulated conditional distributions, or to calculate the ratio between the means of the conditional distributions. Hess (2007) finds that estimation of WTP using conditional averages produces more reliable results compared to what obtained through simulation of the relationship between distributions.

3. Case study

Sardinia is characterized by a hydrological system typical of Mediterranean regions, with highly irregular seasonal flow patterns observed in nearly all rivers. About 34 large reservoirs (artificial lakes) store and provide raw water for residential, agricultural and industrial uses. High temperatures and lack of rainfalls affect the quantity of water stored in the reservoirs, so that water restrictions are applied in drought periods. These conditions have also an effect on water quality, due to eutrophication and anoxia processes.

Although the regional territory of Sardinia includes several river basins, a single River Basin District has been established. This political decision is grounded on the fact that in the last 50 years a complex infrastructure system has been created, to connect dams and reservoirs located in different regional areas. This system makes possible, up to a certain extent, to redistribute water from well-off to lacking areas. However, quantity and quality issues still affect hydrological ecosystems and water provision, especially in years of drought.

Figure 1. Main hydrological basins in Sardinia

Source: Esri, USGS, NOAA

Relevant investments have been planned by the public decision makers in order to improve water quality and tackle the water provision difficulties. In the perspective of the WFD, it is important to see whether citizens support public investments in water infrastructures, or the involved costs could be deemed disproportionate. We adopt a Choice Experiment methodology to estimate the willingness of residents in the River Basin District of Sardinia to pay for public policies aimed at improving the quality and quantity of water resources and ecosystem services.

The research has been realized in three phases. The first was a desk analysis of the data contained in the Hydrographic District Management Plan on the quality status of water bodies and the causes of pollution, and of citizens' perception of the situation of local water resources through a research of articles published on local press in the last 5 years. The second consisted in a qualitative analysis based on in-depth interviews with privileged interlocutors and focus groups with citizens. Participants in the focus groups appeared interested in conservation of water resources, although they showed little knowledge of lakes and rivers and scarce awareness of their conditions. Some had experience of water service problems, flood and restrictions in their place of residence. In general, participants seemed aware of the human impact on water quality and quantity, yet underestimated the role of agriculture.

The results of the two research phases described above informed the design of the questionnaire and the Choice Experiment exercise. The questionnaire included items on demographic and socio-economic characteristics; perception of citizens about the quality of water supplied and tap water consumption habits; knowledge of and familiarity with rivers and lakes of Sardinia; values, beliefs, attitudes regarding rivers and lakes of Sardinia; knowledge of the theme "water resources"; experience of critical issues related to the water system or to floods and risk perception; sources of information on water-related issues (traditional media, internet or reference network) and citizens' perception of easy access to them.

The Choice Experiment (MNL d-efficient) design consists in a set of 36 combinations. Each respondent faced 6 cards and each card was made up of three scenarios: one scenario representing the status quo and two intervention scenarios. Scenarios were made of the following attributes and levels (in bold, status quo levels):

- Water Ecosystem Improvement (**30%** of water resources classified as “scarce quality”; 15%; 0%)
- Water Service Improvement (**10%** of municipalities with water service problems; 0%)
- Jobs lost as a result of the renaturation of river belts (**0 jobs lost**; 180 jobs lost; 400 jobs lost)
- Reduction of Hydrogeological Risk (**30%** of municipalities with areas classified as areas at high hydrological risk; 10%)
- Improvement of Recreational Activities (**recreational activities only in few rivers and lakes**; recreational activities in most rivers and lakes)
- Increase of Local Taxes (**0 tax increase**; +40€/year; +90€/year; +150€/year).

Figure 2. Choice card example

	Scenario A	Scenario B	Status Quo
Percentage of rivers and lakes classified as "SCARCE quality" ecosystems	**0%**	**15%**	**30%**
Percentage of municipalities with serious water service problems	**10%**	**0%**	**10%**
Jobs lost as a result of the renaturation of river belts	**400**	**180**	**0**
Percentage of Sardinian municipalities with areas classified as at "higher hydrological risk"	**30%**	**10%**	**30%**
Recreational uses in rivers and lakes	Possible **only in a few**	Possible **in most**	Possible **only in a few**
Annual increase of Local Taxes	**40 euro**	**90 euro**	**0**

Before the CE exercise, an informational sheet was handled to the respondents, which explained the scenarios with the status quo, and the proposed project improvements. The questionnaire was administered between February and May 2017 to 804 residents in the administrative centers of the 8 Sardinian provinces (Cagliari, Iglesias, Sanluri, Oristano, Sassari, Olbia, Nuoro, Tortolì) with quota sampling on the adult resident population (see map in Figure 1).

4. Results

A Multinomial Logit model, a Latent Class model and a Random Parameter Logit model were fitted to the data to estimate utility coefficients for the different attributes.

The estimation results are presented in Table 1. In ML and RPL models all the estimated coefficients are significant and with the expected sign; the first class estimated with LC indicates similar results. This means that respondents perceive a benefit from a reduction in the percentage of water bodies with low ecological status, a reduction in the percentage of municipalities with water supply problems due to qualitative or quantitative problems, a reduction in the percentage of municipalities with areas characterized by high hydrogeological risk, and an increase in the number of water bodies where recreational activities are possible. Their utility is diminished by the proposed increase in taxes and the possible loss of jobs due to the proposed renaturation of river areas. The variable indicating the choice of the Status Quo also shows a negative sign: this means that on average the interviewees perceive a loss of utility if the current situation is maintained, and that they generally prefer the project scenarios presented. 58 respondents (7% of the sample) always selected the status quo option; prompted by a follow-up question, these individuals stated that they had no confidence that the relevant authorities would make effective investments and would not accept higher taxes.

Respondents in second class perceived less increase in utility associated with a reduction in the percentage of water bodies with low ecological status, a reduction in the percentage of municipalities with water supply problems due to qualitative or quantitative problems, a reduction in the percentage of municipalities with areas characterized by high hydrogeological risk. The attributes representing an increase in the opportunities of recreational activities in water bodies and the choice of the Status Quo are not significant.

Table 1. Choice models

Variables	**Multinomial Logit**	**Latent Class**		**Random Parameter Logit**	
	Means (St. err)	*Means (St. err)*	*Means (St. err)*	*Means (St. err)*	*Std. Devs. (St. err)*
Ecosystem_15	0.536*** (-0.055)	0.799*** (0.083)	0.374*** (0.118)	0.952*** (-0.086)	--
Ecosystem_0	0.651*** (-0.057)	0.966*** (0.093)	0.471*** (0.129)	1.094*** (-0.095)	0.863*** (-0.125)
Water service	0.120*** (-0.04)	0.228*** (0.054)	0.156* (0.089)	0.258*** (-0.058)	--
Jobs_180	-0.712*** (-0.061)	-0.316*** (0.099)	-1.583*** (0.132)	-1.194*** (-0.107)	1.459*** (-0.156)
Jobs_400	-1.226*** (-0.054)	-1.073*** (0.084)	-2.033*** (0.133)	-2.156*** (-0.117)	1.343*** (-0.134)
Hydrogeological risk	0.512*** (-0.041)	0.753*** (0.062)	0.274*** (0.097)	0.784*** (-0.076)	1.066*** (-0.103)
Recreational activities	0.214*** (-0.038)	0.344*** (0.052)	0.093 (0.086)	0.316*** (-0.068)	0.948*** (-0.097)
Tax	-0.051*** (-0.005)	-0.052*** (0.008)	-0.111*** (0.012)	-0.096*** (-0.009)	0.100*** (-0.012)
Status Quo	-0.222*** (-0.068)	-1.154*** (0.122)	-0.185 (0.132)	-0.637*** (-0.125)	1.822*** (-0.121)
N. of individuals	804	804		804	
N. of observations	4824	4824		4824	
Log likelihood	-4911.36	-4435.46		-4328.39	
AIC	9840.72	8924.93		8730.76	
BIC	9899.06	9099.92		8834.46	
R^2 Adj.	0.071	0.161		0.178	

***1%; **5%; *10% significance level

If we compare the coefficient associated with the variable that indicates a reduction from 30% to 15% of the percentage of water bodies with bad ecological status, with the one that indicates a reduction from 30% to 0%, we observe a less than proportional increase: this would imply decreasing marginal utility, unless an embedding effect is present and people did not distinguish between the two different levels of quality improvements proposed (as also seen in Bliem et al., 2012; Metcalfe et al., 2012; Brouwer et al., 2016).

The RPL specification, with all attribute coefficients specified as Normal distributions, but Ecosystem_15 and Water Service which are fixed, fits better the data as indicated by the adj. pseudo R-square, and is preferred according to standard model selection criteria (AIC, BIC).

In order to identify the determinants of individual choices, we first attempted fitting RPL models with heterogeneity in mean and/or in variance, but the results have been quite disappointing. Almost all covariates resulted either not significant, or significant with "wrong" sign, depending on the specifications. In practice, it seems that more complex models (with many covariates) are under-identified, i.e. our data does not support estimation of such models.

In order to overcome this problem and analyze the factors that influence respondents' choice, we take a posterior analysis approach.

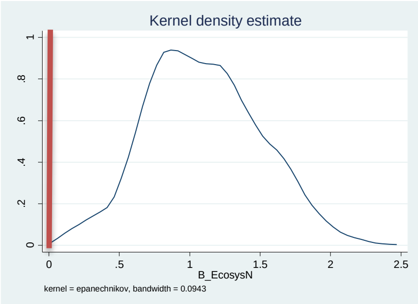
Table 2 reports averages and standard deviations of the individual conditional distributions, and the unconditional coefficients' means and standard deviations. The comparison of conditional and unconditional means shows that the RPL model is correctly specified: the average of the coefficients is very close to the unconditional mean for all attributes (see Train, 2003). The last column indicates the portion of variance pertaining to between variation (across individuals) compared to the within variation (across different choices made by the same individual). For all attributes, the share exceeds the threshold of 0.40, which, according to Richter and Weeks (2016), should allow identification of different profiles of individuals in Posterior Analysis.

Table 2. Statistics on conditional parameters distributions

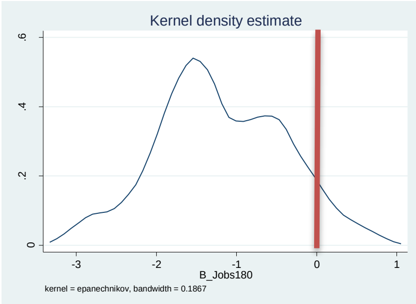
	Average of Conditional Means	**Standard Deviation of cond. mean (SD)**	**Min**	**Max**	**Unconditional mean ($\hat{\mu}$)**	**Unconditional Standard Deviation ($\hat{\sigma}$)**	**SD/ $\hat{\sigma}$**
Ecosystem_0	1.099	0.399	0.107	2.376	1.094	0.863	0.463
Jobs_180	-1.197	0.790	-3.144	0.864	-1.194	1.459	0.542
Jobs_400	-2.156	0.771	-3.556	0.650	-2.156	1.343	0.574
Hydrogeological risk	0.779	0.606	-0.696	2.429	0.784	1.066	0.569
Recreational activities	0.321	0.505	-1.315	2.199	0.316	0.948	0.533
Tax	-0.097	0.053	-0.229	0.036	-0.096	0.100	0.530

An inspection of the kernel densities (Figure 3) estimated on the conditional means distributions of individual coefficients reveals that the conditional distribution of the Ecosystem_0 coefficients is fairly well behaved, as the entire distribution is in the positive domain. For the two attributes relative to Jobs losses, we find that the shape of the curve is bimodal; moreover, a tail of the conditional means distribution is in the (wrong) positive domain for both attributes: 5.6% of Jobs180 distribution, 0.6% of Jobs400; while for the Tax distribution the percentage of "wrong" signs is at 1.1%. On the other hand, the 6.6% of the Risk attribute conditional means distribution is (wrongly) in the negative domain. The shape of the Recreational activities conditional means distribution resembles very closely a Normal distribution; in this case the reverse sign is observed for a consistent part (24%) of our sample: it can be inferred that a part of the respondents would feel a loss of utility if the paid taxes were used to improve recreational opportunities in water basins.

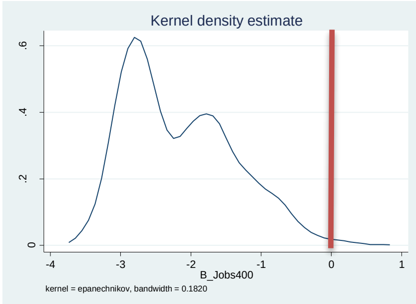
Figure 3. Kernel density of the conditional means distributions



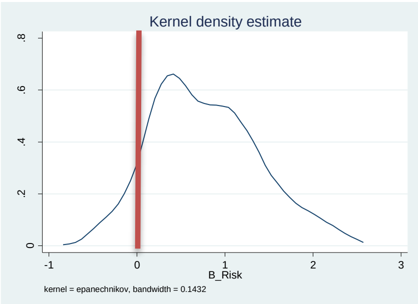
Ecosystem_0. % negative: 0.0



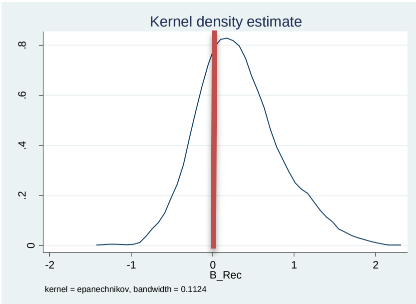
Jobs_180. % positive: 5.6



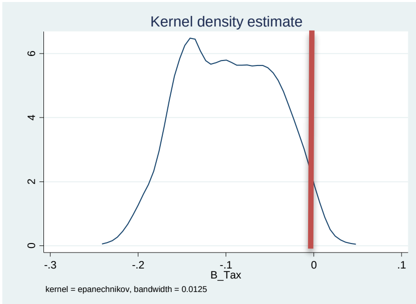
Jobs_400. % positive: 0.6



Risk. % negative: 6.6



Recreation. % negative: 24.0



Tax. % positive: 1.1

A first elementary analysis of conditional distributions consists in verifying the existence of correlations between individual preferences for attributes. Table 3 shows the correlations between pairs of coefficients and their level of significance. Positive correlations imply that individuals with high utility values for one attribute will tend to have high values for the other attribute as well; and low utility values for one attribute will tend to be associated with low utility values for the other attribute. Conversely, if the correlation is negative, high values for one attribute will be associated with low values for the other attribute.

Since the coefficients of attributes related to job losses and tax have a negative sign, a positive correlation between these and the other attributes implies that high utility for one of the attributes of improvement of water resources is associated with low disutility from loss of jobs and tax increases. For example the Tax attribute is positively and significantly correlated with all the environmental attributes: this means that those who give greater importance to money give less importance to the environmental improvements, and vice-versa. The correlation between Hydrogeological Risk and Jobs_400 suggests a trade-off between these two elements of the scenarios: people who are more sensitive to the risk of floods are less sensitive to the loss of jobs that a renaturation of the river banks may cause. The same kind of trade-off is seen between the Recreation activities and both jobs losses attributes. A negative correlation is found, as expected, between all project attributes and the status quo alternative indicator: lower values to the environmental attributes of the project, and higher values to the social and private costs, are associated with a more likely choice of the status quo option.

Table 3. Pairwise correlations in distributions of conditional means

	Ecosystem_0	**Jobs_180**	**Jobs_400**	**Hydrogeol.risk**	**Recreation**	**Tax**	**Status Quo**
Ecosystem_0	1.000						
Jobs_180	0.041	1.000					
Jobs_400	0.060*	0.184***	1.000				
Hydrogeol. risk	0.009	0.037	0.208***	1.000			
Recreation	-0.048	0.175***	0.059*	0.114**	1.000		
Tax	0.235***	0.223***	-0.024	0.228***	0.140***	1.000	
Status quo	-0.237***	-0.290***	-0.256***	-0.284***	-0.205***	-0.468***	1.000

***1%; **5%; *10% significance level

A Cluster analysis (using the algorithm K-means in STATA™) on the individual coefficients of the attributes estimated by the RPL shows the existence of two distinct groups. Afterwards, a comparison of the two clusters has been done, through t-test analysis of the means of our socio-economic, demographic, socio-psychological variables, by cluster. The individual characteristics for which the difference in means across clusters was found significant at least at 10% level are reported in Figure 4.

Figure 4. Cluster characteristics: a synthesis

Cluster 1 (55%)	Cluster 2 (45%)
Higher (utility) coefficients: Ecoystem_0; Hydrogeological Risk; Recreation	Higher (disutility) coefficients: Jobs_180; Jobs_400; Tax
Younger Higher education levels Higher income levels Have experience of water service problems Aware of the impacts of individuals' behavior on water quality Perceive future flood risks Aware of causes of flood risk Perceive impact of water conditions on local economy Diversified information Better informed Residents in Nuoro more likely in this cluster Nobody has always selected Status Quo scenario	Older Lower education levels Lower income levels Water measures important to secure quality of drinking water in household Against improvement of recreational activities opportunities Environmental protection is not an individual's responsibility Water conditions do not affect local economy Environment protection is a hinder to economic development Mainly informed through traditional media Less informed Residents in Oristano more likely in this cluster Some have always selected the Status quo scenario

People in Cluster 1 are, on average, relatively younger, more educated, and with higher income than their counterparts in Cluster 2. They have more probably experienced problems related to the water service and believe that they are likely to suffer in the future damage or inconvenience related to hydrogeological risk. They are more aware of the consequences of their own behavior and of the health consequences of water pollution. They show greater interest in improving environmental conditions, and believe that critical issues in terms of water quality and quantity have a negative impact on the different economic sectors of the island. They are on average better informed about the real state of water resources, and make less use of traditional media to collect information on the quality and quantity of water resources. Individuals in Cluster 2 are older, less educated and with a lower household income. They choose more often the status quo option, and their interest in water quality improvements is mainly related to improved quality of drinking water. They are less interested or even opposed to an investment aimed at improving recreational uses of water ecosystems. They tend not to recognize individuals' responsibility in protecting the environment, and do not believe that problems on the quality and quantity of water resources affect economic activities. They are on average less informed about the real state of water resources and prefer to be informed using traditional media.

This data can be analyzed in a multivariate framework, through a Logit model. The dependent variable is a dummy where 1 refers to people associated to Cluster 1 and 0 otherwise. This model is compared in Table 4 with a Latent Class model fitted on the choice data, where class membership is conditional on covariates.

The best specification of the Latent Class model takes two classes, confirming the results of the cluster analysis on the conditional distributions. The two models retain all variables that resulted significant at least at 5% level in the previous analysis based on the t-test of means by cluster. Income appears as an important factor that conditions Cluster membership; but it seems also clear that ethical values (Environmental consciousness), as well as perception of risk, awareness and information, shape the individuals' preferences toward water quality improvement measures. The only difference is that Education level is significant in LC model, but not in the Logit on the cluster membership.

Table 4. Logit model for Cluster 1 membership and Latent Class

	Logit Model	**Latent Class**
Variables	Coeff. (std. err.)	Coeff. (std. err.)
Constant	-0.231* (0.123)	-0.567*** (0.204)
Income	0.549*** (0.153)	0.547*** (0.192)
Environment Conscious	0.232*** (0.077)	0.263*** (0.094)
Utilitarians	-0.131* (0.076)	-0.137 (0.095)
Flood causes	0.202*** (0.076)	0.251*** (0.092)
Future_floods	0.159** (0.074)	0.177** (0.090)
Traditional media	-0.246*** (0.076)	-0.373*** (0.096)
Nuoro residents	-0.497* (0.294)	-0.925*** (0.358)
Education	-	0.475** (0.212)
N. of individuals /obs	804	804
N. of observations	804	4824
Log likelihood	-523.79	-4435.46
R^2 Adj.	0.057	0.16

***1%; **5%; *10% significance level

These results provide an evidence on the robustness of the results we obtained with Cluster analysis. The LC model provides results closer to Cluster analysis but it has been rejected on the basis of AIC/BIC tests, which indicate that the RPL model fitted best our data. Posterior Analysis on conditional distribution on individual coefficient estimated with the RPL model provide more detailed information on the heterogeneity of preferences among respondents.

5. Willingness to pay

Table 5 reports the values of the willingness to pay obtained from the MNL, LC and the RPL model. For the MNL the estimates are calculated from the ratio of the estimated coefficients of the non monetary attributes and the tax coefficient.

For the RPL model we report two sets of WTP estimates: the WTP obtained from the individual draws, and the WTP obtained as a ratio of the means of the conditional distributions of the non monetary attributes and the tax attribute, as in Hess (2010). The RPL WTP estimates are calculated after eliminating not significant utility coefficients for all attributes; and "wrong" sign coefficients for the Jobs_180, Jobs_400, Risk and Tax attributes (tail observations: see percentages in Figure 3). For the Recreation attribute we retain both positive and negative significant individual mean coefficients, since it may be reasonable that an individual may have either utility or disutility from public spending on this type of service. Finally, outliers (i.e. values exceeding the 99% percentile of the WTP distribution) have been eliminated. The resulting samples are reported in the last row of each cell.

For the LC model, the WTP values reported in the table are the weighted average values of the estimated individual WTP.

Table 5. Estimated WTP values

Variables	**MNL**	**Latent Class**	**RPL* (Ratio of Cond. Distr. Means)**	**RPL* (Ratio Ind. Draws)**
	Mean (St. Error) [Confidence Interval] *n. obs*	Mean (St. Dev.) [min max] *n. obs*	Mean (St. Dev.) [min max] *n. obs*	Mean (St. Dev.) [min max] *n. obs*
Ecosystem_15	105.18 (13.20) [79.30 131.06] *804*	93.72 (53.19) [33.68 152.66] *804*	156.17 (177.52) [41.61 1307.25] *797*	152.76 (235.50) [3.36 1909.86] *619*
Ecosystem_0	127.87 (13.84) [100.75 154.99] *804*	114.11 (63.54) [42.39 184.51] *804*	194.13 (263.48) [12.32 1881.87] *778*	184.00 (312.53) [0.28 3040.88] *636*
Water service	23.59 (7.42) [9.04 38.13] *804*	28.99 (13.19) [14.10 43.61] *804*	42.78 (49.44) [11.29 357.63] *772*	40.83 (62.38) [0.10 539.46] *660*
Jobs_180	-139.85 (19.54) [-178.14 -101.56] *804*	-101.15 (36.74) [-142.62 -60.43] *804*	-181.58 (168.93) [-1236.41 -5.05] *735*	-207.47 (336.29) [-3877.47 -1.53] *572*
Jobs_400	-240.70 (20.84) [-281.54 -199.86] *804*	-194.25 (9.79) [-205.10 -183.2] *804*	-353.15 (424.44) [-3073.37 -11.46] *791*	-285.45 (396.23) [-3705.22 -0.22] *648*

Hydrogeological risk	100.59 (10.55) [79.92 121.26] *804*	84.85 (53.33) [24.65 143.94] *804*	156.35 (213.06) [3.31 1687.32] *728*	208.82 (595.90) [0.23 6781.61] *569*
Recreational activities	42.04 (8.01) [26.33 57.75] *804*	37.33 (25.66) [8.37 65.77] *804*	65.48 (149.08) [-269.26 1205.35] *712*	38.92 (224.48) [-1007.98 1611.83] *719*

*The mean values of RPL models have been calculated after eliminating not significant and "wrong" sign individual parameters, and WTP outliers

It can be noticed that the WTP values obtained from both RPL models are scaled up with respect to those obtained from the MNL and LC models. If the WTPs associated with project improvements are ranked in order of magnitude, we can observe that the estimates obtained from the ratio of the means of the conditional distributions maintain the same order as those of the MNL/LC models; while this is not true for the ratio of the individual draws. We can see for the latter, larger standard deviations and larger min-max ranges than what observed for the ratio of the means of conditional distributions; and the number of removed observations is higher for all attributes but Recreation. Table A12 in the Appendix reports the kernel density estimates of the WTP values obtained from the ratio of the means of the conditional distributions and from the ratio of the individual draws.

In the following we refer to the WTP values obtained from the RPL obtained from the ratio of the means of the conditional distributions.

The values of the willingness to pay show that the respondents are willing to support the quality improvement of the waters of rivers and lakes in Sardinia, accepting an increase in local taxes. In particular, they are willing to spend €156.17 extra per year to reduce the percentage of water bodies with low ecological status from 30% to 15% and 194.13 to reduce it from 30% to zero: as we can see, the willingness to pay for this second attribute is less than proportional compared to the first (similar results are in Bliem et al., 2012; Metcalfe et al., 2012; Brouwer et al., 2016). Our results are within the range of values obtained in other Stated Preference studies: using Contingent Valuation, Brouwer (2008) estimates an average value of €90 - €105 per household; using Choice Experiments, Metcalfe et al. (2012) find that the average willingness to pay for improving water bodies quality in England and Wales ranges from £242.3 (approximately €272.3) to £268.5 (approximately €300); in Ireland, Doherty et al. (2014) find that the willingness to pay for good ecological status is €71.

The value associated to a reduction of water service problems is €42.78; in other studies that consider a similar attribute, the willingness to pay varies from €16.9 in Latinopoulos (2014), to €39.53 in Martin-Ortega et al. (2011) and about €60 for Italian respondents in the study of Brouwer et al. (2016).

Hydrogeological risk mitigation is valued €156.35, a value in the range estimated by Ryffle et al. (2014) from 110€ to 304€ for renaturation interventions aimed at reducing flood risk.

The willingness to pay for an increase in the number of rivers and lakes where recreational activities are feasible, €65.48. This value is higher than what found in other studies: Doherty et al. (2014) found a willingness to pay of €14 and Stithou et al. (2012) of €22.67.

As regards the social costs caused by environmental interventions of renaturation of river banks, as actions that could affect agriculture and other activities located close to the riparian area, respondents would accept a compensation of €181.58 for the loss of 180 jobs (approximately €1 per job) and €353.15 for the loss of 400 jobs (approximately €0.88 per job). These results are in line with the findings of Marsh and Phillips (2014) and Latinoupoulos (2014) who find a willingness to accept equal to €0.88 and €0.68 per job respectively.

Finally, we analyze WTP differences across Clusters. Individuals pertaining to Cluster 1 have higher willingness to pay for all project attributes, but also higher values requested in compensation for jobs losses. This means that, depending on the social costs and benefits associated with a project, even areas characterized by a prevalence of “Cluster 1” people may be unwilling to support some specific measures aimed at improving water ecosystems.

Table 6. WTP for changes in attributes, by Cluster

Attributes	**Cluster 1**		**Cluster 2**	
	N. Obs.	**Mean WTP***	**N. Obs.**	**Mean WTP***
Ecosystem_15	410	227.03	356	105.90
Ecosystem_0	423	268.38	356	105.90
Service	423	55.39	356	27.79
Jobs_180	376	-205.28	341	-155.44
Jobs_400	418	-435.50	355	-256.18
Hydrogeological risk	396	223.59	315	71.82
Recreational activities	393	89.34	319	36.07

*All differences between WTP Means across Clusters are significant at 1% level

Conclusions

The results of our work show that on average residents in Sardinia are willing to support public policies aimed at improving the quality of aquatic ecosystems; at reducing problems in the water service; at mitigating the hydrogeological risk. The valuation of improvements in the recreational use of water bodies is mixed, with a relevant percentage of respondents (24%) who valued negatively this project attribute. On the other hand, also the social costs that improving measures may entail (especially the renaturation of rivers) are important to the citizens, and in some situations may even compensate the benefits. Specific evaluations should be made for each proposed measure, in order to properly assess net benefits, and indicate whether the costs can be deemed disproportionate (as requested by the WFD).

We have shown the advantage of applying Posterior Analysis tools (Train, 2003; Hess, 2007, 2010; Richter and Weeks, 2016) to the conditional distributions of individual parameters obtained after estimation of an RPL model. While joint estimation of an RPL model with heterogeneity in mean (and/or variance) did not produce satisfactory results, the Posterior Analysis uncovered correlations between attributes' coefficients and socio-economic, demographic and socio-psychological variables. Hence, it has been possible to get a grasp of the main determinants of the preferences in our context: besides Income, and the level of Information, other relevant variables are some socio-psychological characteristics (retrieved through psychometric scales designed ad hoc), such as ethical values (Environmental Consciousness vs Utilitarianism), perception of flood risk and awareness of its causes.

The Posterior Analysis on the conditional distributions gives more and richer information on heterogeneity among individuals. The results obtained are confirmed by fitting a Logit model on the probability of cluster membership, and a Latent Class model on the original choice data. Both methods give evidence of the existence of two clusters, with the same determinants of membership probability. These findings can be useful to target communication campaigns and actions to promote support of the adoption of the measures required to achieve the WFD objectives.

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Appendix

Table A1. Statistics of covariates

	Obs	Mean	St. Dev.	Min	Max
Income	804	0.62	0.49	0	1
Environmental Conscious	804	0	1	-5.99	1.15
Utilitarians	804	0	1	-3.75	2.44
Aware of causes of floods	804	0	1	-4.16	0.76
Perceive risk of future floods	804	0	1	-1.63	2.50
Traditional media	804	0	1	-2.36	1.95
Nuoro residents	804	0.07	0.26	0	1

Table A.2 PCA: Perceptions on pollution, health risk and liability

	Environmental conscious	Pessimists	Utilitarians
The effects of river and lake pollution on health are worse than we believe	0.251	**0.723**	0.045
Although some rivers or lakes may be polluted, the effects on the regional water system are minimal	0.045	**-0.832**	0.097
Maintaining the quality and quantity of Sardinia's rivers and lakes is also my responsibility	**0.764**	-0.111	-0.296
Pollution of a river or lake affects everyone's health	**0.766**	0.220	0.076
The maintenance of the quality and quantity of water in the rivers and lakes of Sardinia is responsibility of the Region and the authorities in charge	0.112	0.162	**0.777**
Rivers and lakes protection benefits my health	**0.737**	0.128	0.243
Environmental protection restricts too much the economic activities	-0.059	-0.246	**0.644**

Table A3 PCA: Experience of water service or flooding problems

	Water service experience	Flood experience
No water supply for several consecutive days	**0.694**	0.069
Non potable tap water for several consecutive days	**0.863**	0.030
Muddy or bad smelling water	**0.815**	0.049
Damages to your house or furniture or car caused by floods	0.047	**0.841**
Difficulties created by a flood to the municipality you live in (lack of electricity, interruption of public services, etc.)	0.060	**0.839**

Table A4 PCA: Sources of pollution affecting poor water quality

	Point sources	Diffuse sources
Urban sewage wastewater plant discharges	**0.895**	0.037
Industrial activities discharge in water	**0.870**	0.157
Lack of water in rivers and lakes	0.176	**0.762**
Animals grazing near rivers and lakes	0.003	**0.832**

Table A5 PCA: Causes that contribute to reduce the amount of water

	Firms
Water waste in agriculture	**0.837**
Water waste in industrial activities	**0.837**

Table A6 PCA: Causes that contribute to reduce the amount of water

	Residential & tourism sector
Water waste in residential sector	**0.925**
Water waste in tourism sector	**0.925**

Table A7 PCA: Causes that contribute to floods

	Flood causes
Cementified river banks and riverbeds	**0.832**
Diversion of the river path	**0.832**

Table A8 PCA: Probability to incur in water service problems or flood in near future (5 years)

	Future_water service problems	Future_floods
No water supply for several consecutive days	**0.814**	0.048
Non potable tap water for several consecutive days	**0.900**	0.055
Muddy or bad smelling water	**0.886**	0.120
Insufficient tap water pressure not ensuring daily use	**0.747**	0.210
Damages to your house or furniture or car caused by floods	0.138	**0.905**
Difficulties created by a flood to the municipality you live in (lack of electricity, interruption of public services, etc.)	0.086	**0.911**

Table A9. PCA: Damages that the individual would incur if water service problems or flooding happened by next 5 years

	Damages_water service	Damages_flood
No water supply for several consecutive days	**0.808**	0.239
Non potable tap water for several consecutive days	**0.837**	0.129
Muddy or bad smelling water	**0.855**	0.176
Insufficient tap water pressure not ensuring daily use	**0.714**	0.212
A flood in the municipality where you live in (please refer to your house/furniture/car etc.)	0.186	**0.912**
Difficulties created by a flood to the municipality you live in (lack of electricity, interruption of public services, etc.)	0.232	**0.897**

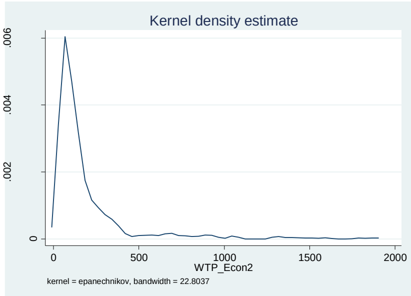
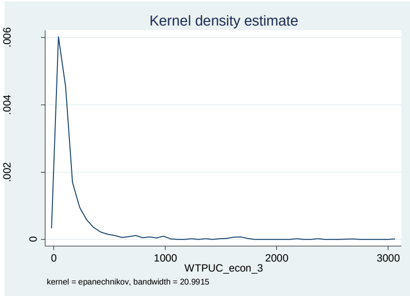
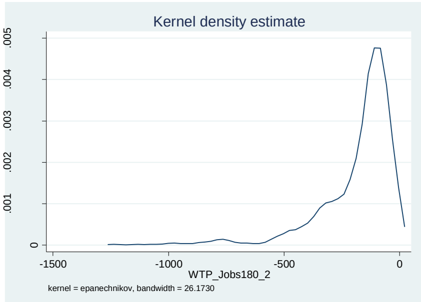
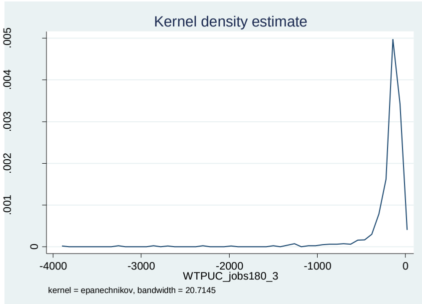
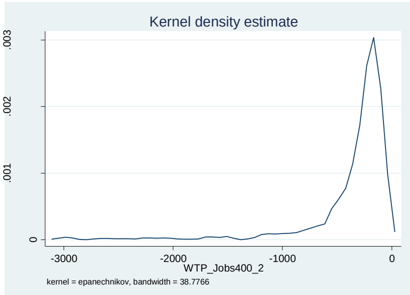
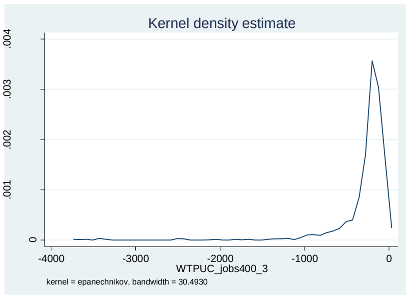
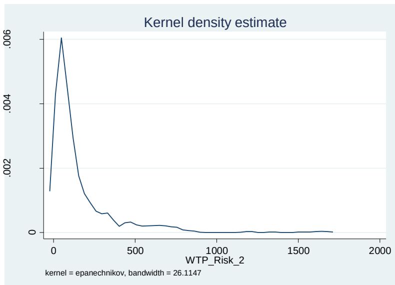
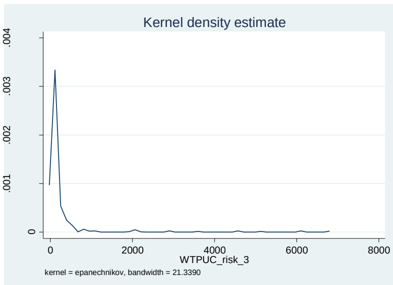
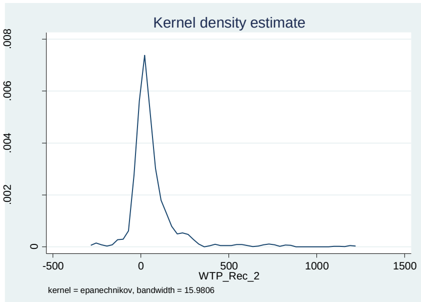
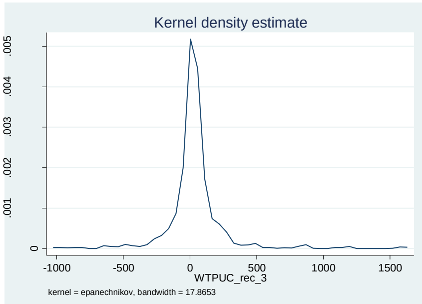
Table A10 PCA: Economic damages caused to the Sardinian population by water bad conditions

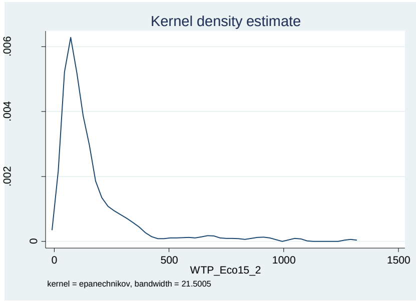
	Economy damages
Reduced water supply to agriculture	**0.723**
Difficulty in providing a sufficient amount of water with good quality to the tourism sector	**0.765**
Reduced water supply for industrial activities	**0.706**
Poor quality water for agri-food activities	**0.772**

Table A11 PCA: Sources of information

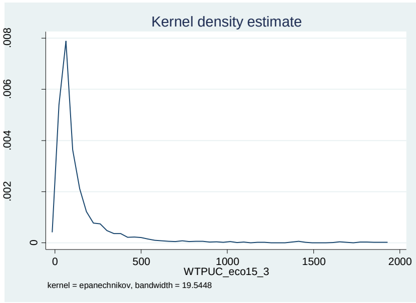
	Various sources	**Traditional media**
Traditional media (radio, television and newspapers) are my main source of information on the status of the rivers and lakes in Sardinia	0.411	**0.718**
The Internet is my main source of information on the state of the rivers and lakes in Sardinia	0.416	**-0.714**
I believe I am sufficiently informed about the state of the environment of the rivers and lakes in Sardinia	**0.714**	0.027
Citizens have easy access to all relevant information on the quality of drinking water	**0.732**	-0.025

Table A12. Kernel density of the individual WTP values

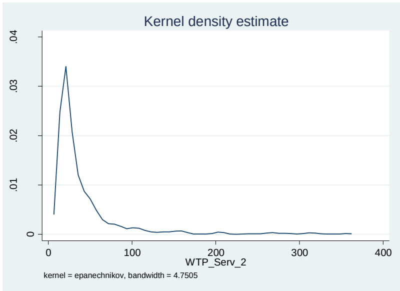
WTP - RPL (Ratio Means Cond. Distr.)	WTP - RPL (Ratio Ind. Draws)
 Ecosystem_0	 Ecosystem_0
 Jobs_180	 Jobs_180
 Jobs_400	 Jobs_400
 Hydrogeological risk	 Hydrogeological risk
 Recreational activities	 Recreational activities



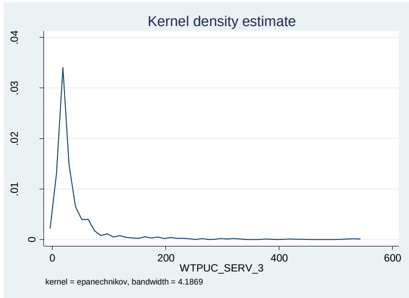
Ecosystem_15



Ecosystem_15



Water Service



Water Service