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# The Economic Value of Ecosystem Conservation: A Discrete Choice Experiment at the Taravo River Basin in Corsica

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January 7, 2019 - preliminary version

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**Abstract:** An economic valuation of some of the ecosystem services provided at the Taravo river basin was conducted, using a stated preferences approach. On average, respondents were willing to pay up to 128 Euros per year for the enhancement of the ecosystem services selected for this choice experiment. This result is in line with those obtained in other studies applying the same approach. This Choice Experiment is part of more comprehensive assessment, which will be published later, and expands the analysis to other ecosystem services and takes into account their biophysical aspect as well.

**JEL :** Q26; Q51. **Keywords:** Ecosystem Services; Economic Valuation; Willingness to Pay; Stated Preferences Methods; Discrete Choice Experiment.

## 1 Introduction

In February 2017, the Taravo River became the first river to obtain the Wild Rivers Label (*Site Rivière Sauvage* in french) in the island of Corsica, France. This label is granted by the environmental non-governmental organizations (NGO) European Rivers Network (ERN), the French Biodiversity Agency, and the French Standardization Association (AFNOR), to those rivers whose ecological conditions are excellent (Charais et al 2014).

Within this context, an economic valuation of some of the ecosystem services provided at the Taravo river basin was carried out, using a stated preferences approach. In particular, the population's Willingness To Pay (WTP) for increased recreational opportunities and water quality was estimated using a Discrete Choice Experiment (DCE). In addition, the conservation of architectural heritage and the eradication of invasive species were also included among the experiment's attributes, even though their classification as ecosystem services *per se* is debatable (*cf.* the Common International Classification of Ecosystem Services: CICES).

Several econometric specifications were tested, but the best results seem to be those obtained with a Random Parameter Logit Model, which allows to relax the Independence of Irrelevant Alternatives (IIA) assumption. On average, the respondents were willing to pay up to **128 Euros** per year for the maximum proposed enhancement of the attributes selected for this DCE. As we will show in this article, this result is in line with those obtained in other studies applying the same approach.

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This DCE is part of more comprehensive assessment, funded by the South Corsica Department, which expands the analysis to other ecosystem services, including their biophysical evaluation. The economic valuation of those additional services was made using alternative approaches, which will not be depicted in this article.

## 1.1 The Notion of Ecosystem Services

While implicitly being a topic of interest for the scientific community for decades, the concept of ecosystem services came into use with the Millennium Ecosystem Assessment (MEA) launched in 2001. This United Nations program was created as a response to the call for a global scientific assessment of ecosystems at the conclusion of some of the Multilateral Environmental Treatments of the nineties, notably the Convention on Biological Diversity (CBD) and the Convention to Combat Desertification (UNCCD).

The results from the MEA, and from subsequent studies, show that biodiversity and ecosystems are being depleted and degraded rapidly, faster than at any point in human history. In order to act on this pressing issue, the Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES) was created following the 2010 Nagoya Protocol to the CBD, with the goal of assisting the implementation of the Convention. This panel provides policymakers with objective scientific assessments, coming from across disciplines and knowledge communities, of the planet's biodiversity, ecosystems and their positive impacts on human welfare (IPBES, 2008).

In short, ecosystem services are the benefits obtained by humans from ecosystems. In order to facilitate their comprehension, they have been classified into four broad categories: provisioning (of food, water and other natural resources), regulating (for instance water purification, or climate and disease control), supporting (such as nutrient cycles and crop pollination, which support the provision of other services) and cultural services (for example spiritual and recreational benefits). This classification notwithstanding, there is a high degree of interdependence between these services (TEEB, 2010).

As the concept popularized among the scientific community, efforts have been made by public and private institutions worldwide to include ecosystem services in decision-making and policy planning, with the goal of finding a balance between economic development, a rational use of natural resources and social well-being (Ruckelshaus et al, 2015). It is important to notice that the identification and assessment of the contribution from ecosystems to the satisfaction of socio-economic needs is a complex task, requiring extensive research and a multidisciplinary approach, which includes economics (TEEB, 2010).

## 1.2 The Stated Preference Methods for Environmental Valuation

Despite the clear benefits obtained from ecosystem services, their economic value remains challenging to quantify, mainly because they are a special type of good in the sense that they are not traded on a market. This means that it is not possible to infer the marginal impact of changes in their provision levels and relative prices on utility from people's behavior as consumers, which is the common practice in economic analyses (Hanley et al, 1998; Johnston et al, 2017).

In that sense, the survey-based approach of stated preference methods could be a practical response to this challenge, enabling the elucidation of both use and non-use values. In addition, these methods can be adapted to many different contexts, and they can be used to estimate the WTP for either current or future services. As a result of these advantages, this approach is not limited to ecosystem services: they have been applied on many different fields, including health, transportation and marketing (Hanley and Barbier, 2009; Johnston et al, 2017).

There are two main stated preference methods that can be found in the literature. They follow the same principle: a hypothetical market is created and presented to a representative sample of the population of interest, in the form of a carefully designed questionnaire.

The first stated preference studies used the Contingent Valuation (CV) method, where people are simply asked whether they would support - financially and, in the case of public goods, also politically - a proposed change on the level of provision of a set of goods or services (Hanley and Barbier, 2009).

The second method, known as DCE, began to be applied in the early eighties, with the works from Louviere and Hensher (1983 and 1989), and Louviere and Woodworth (1983). In contrast to CV, several attributes (with increasing levels of provision) of the proposed good or service to be improved are selected during the design phase of the DCE. Next, people are asked to declare their preferred scenario out of several alternatives with respect to a baseline, which differ on the attributes' provision levels. A hypothetical cost is part of the attributes that the respondents must weigh-in for each scenario.

One of the virtues of this method is to simplify to a great extent the effort from the respondents, as it would be hard for them to state their preferences on a good's attributes if they were asked upfront. In addition, a properly designed DCE allows to present several choice tasks of this type to the respondents (Hanley et al, 1998), thus increasing sample size.

In the context of ecosystem services, the valuations obtained from stated preference methods can be used for making comprehensive policy analyses and environmental damage assessments, which in turn can support decision making by public or private sector entities, court sentencing on environmental damage litigations and advocacy by NGO.

Nonetheless, the validity of the results obtained from these methods is a topic of debate. In that sense, the possibility that respondents give higher bids than their actual WTP as a result of the hypothetical nature of the survey, known as hypothetical bias, remains at the center of the discussion. The clarity on the presentation of realistic baseline conditions, hypothetical changes and their working mechanisms, are essential to overcome this issue. This information must be clearly understood, accepted and seen as credible by the respondents (Johnston et al, 2017).

### **1.3 Description of the Project at the Taravo River Basin**

The project took place between May and November 2017, and was framed within a multi-stakeholder partnership, which included the NGO ERN, whose objective is the preservation of the rivers characterized by having the most intact ecological status in the countries, and the Environment Division of the South Corsica Department Council. The study was requested by the latter, as an ecosystem services assessment was deemed relevant in the context of the ongoing efforts for the ecological preservation of the Taravo watershed, in order to increase awareness of the importance of those actions.

The ecosystem services, or the multiple benefits that the local population obtains from the Taravo river basin, were the main subject of this study. For the purposes of this assessment, the most relevant ecosystem services provided at the Taravo river basin were identified in June 2017, during a meeting with a committee of technical experts from different public entities and private associations at the local and regional level, and whose work concerns the study site.

The results from the meeting with this technical committee were later validated during a meeting with a steering committee, whose members were public and private sector stakeholders. These included the mayors of some of the municipalities and representatives of public entities dealing with environmental and rural development issues. This meeting was an important opportunity to get to know the public's perception regarding the ecosystem services selected and the main issues affecting the Taravo river's ecological status at the moment.

The selected ecosystem services belong to the regulating, provisioning and cultural categories. As already mentioned above (section 1.1), regulating services included flow control, water purification, water streaming, erosion control, climate regulation and pest control. Provisioning services consisted of water, both for drinking and irrigation purposes, wood and biodiversity, as this ecosystem is rich in fauna and

flora, including endemic species such as the macrostigma trout. Finally, cultural services consisted of emblematic landscapes and recreational activities, such as fishing and hunting.

This ecosystem services assessment follows suit from other initiatives, tracing back to 2013, whose results suggest that the Taravo river is in excellent ecological conditions. These efforts include a comprehensive diagnostic study (Lindenia, 2013) and the granting of the Wild Rivers Label.<sup>1</sup> It should be noted that ecological preservation in Corsica is fostered by the relatively low population density of the island with respect to the rest of the country, which translates into a lower stress on natural resources.

In spite of this, there are critical water pollution issues in some of the municipalities that must be addressed. At the opposite end from the previously mentioned initiatives, the national sanitation authorities have banned swimming on 23 km of the river since 2008, as a consequence of the poor results obtained from the routine environmental inspections on water quality. Moreover, these sanitation issues influence the perception of many of the local residents who for instance, during the survey for this study, frequently used the words “sewage” and “trash can” to describe the Taravo when they were asked about their opinion on the current status of the river.

Last but not least, a project to build a large hydroelectric dam in the village of Olivèse - in the middle of the basin - has been discussed for the past 30 years. If executed, this project would imply a drastic change on both the conservation and the development strategy on the river basin because of its significant environmental impact.

## 1.4 Study Questions

The main objective of the assessment is to provide useful and robust information for stakeholders, coming from an evaluation of the benefits obtained from the ecological conservation of the river. The whole project, beyond this article, involved research on the following four questions:

1. Which are the main ecosystem services provided by the Taravo river?
2. What are the biophysical mechanisms involved in the provision of those services?
3. What is the economic value of those services?
4. Based on the obtained results, how does a development strategy based on environmental conservation compare to the execution of the hydroelectric dam project in Olivèse?

This article will mainly answer this third question. A clear response to the first question was given by the results from the meetings with the technical and steering committees, while the answers to the remaining questions were developed in the comprehensive assessment presented to the South Corsica Department Council, which included a Benefit-Cost Analysis of two development strategies, based either on ecological conservation or on the hydroelectric dam project. Given the nature of those services, whose contribution to human well-being can be either direct or indirect, several approaches were tested for their economic valuation.<sup>2</sup>

This article will discuss one of those approaches in particular the application of a stated preferences method, namely a DCE. The attributes of this DCE are directly linked to two ecosystem services: water

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<sup>1</sup>In February 2017, the Taravo river obtained the Wild Rivers label, certified by the French association AFNOR, and, at the time, only 12 French rivers had received the label. A “Wild River” is a living, reference, preserved river that flows freely and welcomes exceptional biodiversity into its quality waters and along its banks (Charais et al 2014).

<sup>2</sup>Among the services included in the economic valuation, there was recreational fishing (which is estimated from fishing expenditure on fishing licences and equipment), soil quality for agricultural productivity (using the European Agricultural Standard gross production as relevant indicator) and provisioning of drinking water (drinking water prices and collection points).

quality and outdoors recreation, and indirectly to the service of scenic landscapes. In addition, even though they are not part of the CICES Classification, architectural heritage conservation and invasive species eradication were also included among this DCE's attributes, as they allows people to better enjoy the river, and then enhance people's welfare, and are taken into account in the river's development strategy.

## 1.5 Plan of the article

What remains of this article is organized as follows. In Section 2, a literature on the economic valuation of the ecosystem services provided by rivers and other watersheds will be presented. Section 3 then describes the methodology, design and execution of the Discrete Choice Experiment, and Section 4 presents and discusses the main findings of our study. Lastly, section 5 will present the conclusions of this article.

## 2 Literature Review

Given the importance of ecosystem services provided by water bodies, their economic value should be taken into account for water policy planning in general, and river restoration and preservation in particular. Extensive research has been done worldwide in the past decades, using the whole spectrum of environmental valuation methods, including revealed and stated preference ones (Brower, 2017; Bergstrom and Loomis, 2017).

On the study by Bagstad et al (2013), spatially explicit Ecosystem Services modeling tools, such as ARIES (Artificial Intelligence for Ecosystem Services) and InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) were applied to the San Pedro river watershed, shared by Mexico and the United States. These tools were used to model the services of carbon storage, water provision and scenic views. Ecosystem service changes were quantified through the construction of several scenarios of urban growth and native vegetation management. The results from this study allow to compare the modeling tools' characteristics in order to assess their potential for resource management support.

Moreover, the replacement cost approach was applied by Honey-Rosés et al (2013) to value the positive effect of stream restoration for drinking water treatment in the Llobregat river in Spain. This approach was complemented with the use of another modeling tool, in this case the SNTMP (Stream Network Temperature Model). In addition, hedonic pricing has been applied to estimate the effect of small dam removal on property prices in the United States. Provencher et al (2008) used this approach in south-central Wisconsin, while Lewis et al (2008) did the same for properties along the Kennebec river in Maine.

Concerning stated preference methods, the Contingent Valuation method has been extensively applied over the years. Biro (1998) did an economic valuation of the environmental impacts associated to the Karyaktepe dam in Turkey. These included the loss of agricultural income, the loss of value from the natural forests and the loss of non-use values. Reynaud et al (2017) estimated households' WTP for different infrastructure projects, which were presented in the form of attribute-differentiated scenarios to be valued using the CV method. Finally, Jones et al (2016) used a CV study for the valuation of both the social and the environmental impact of the Glen Canyon dam on the Colorado river.

Specifically for the method chosen in the present study, Bliem et al (2012), used two identical DCEs, spaced by one year, to test temporal stability of environmental preferences on the Austrian sector of the Danube river. They used flood frequency and water quality as the river attributes and their results suggest that preferences and WTP estimates are stable over a short period of time in the absence of an extreme event.

On the other hand, Lizin et al (2016) tested spatial heterogeneity using a labeled choice experiment on

the Oude Kale and Leie rivers in Belgium. Their results suggest that efforts to restore the latter should be prioritized. In addition to the river specific coefficients generated by the labelled design, the authors also used distance from the rivers and past visit behavior as spatial variables of the respondents. The extent of the restoration, its length in kilometers, water quality, species richness and accessibility were the chosen attributes.

Spatial preference heterogeneity was also tested by Asefaw et al (2016) on their study on the Shiyang river basin in China. Eight attributes were chosen for this DCE, a substantially larger number with respect most studies in European countries, but in line with other studies in China (Shi et al, 2016) or the United States (Zhao et al, 2013). These included tourist amenities, water quality and water quantity. Supported by advanced econometric techniques and tests, such as the Pöe independent empirical distribution equality test, the authors found that there was preference heterogeneity based on the residential location, as the socioeconomic context and the ecological status of the river differs in the three main sub-basins (upper, middle and lower sub-basins).

The application of these methods is not limited to high income countries or to natural water bodies, Kahn et al (2017) used choice modeling to estimate the population's WTP for restoring the Rio Paraíba do Sul in Brazil. The extent of the restoration and the time it would take were the attributes chosen. Furthermore, Perni and Martinez-Paz (2017) applied the method to value the ecosystem services provided by the artificially-created El Hondo wetland in Spain. They selected biodiversity, water provision, area available for fishing, area available for hunting and public access as the wetland's attributes.

The construction of a large dam in Olivèse is a controverted subject. Despite the positive aspects of hydropower, such as being a renewable and reliable energy source with no Greenhouse Gas emissions, there might be strong environmental impacts through other channels. Therefore, the decision to build an hydroelectric facility requires a case-by-case approach. This environmental impact is multi-dimensional, depending to a large extent on site characteristics and on the type and dimension of the hydropower plant (Botelho et al, 2017). A poorly chosen site to develop hydroelectricity would imply a whole array of costly monitoring and mitigation measures later on.

For this reason, environmental valuation and Benefit-Cost analysis could be valuable tools for decision-makers, to the extent that they translate positive and negative impacts into the same measuring unit. Furthermore, given the case-by-case nature of this issue, DCE are seemingly a well-suited method for assessing the environmental impacts of large hydropower plants (Botelho et al, 2017). Impacts on biodiversity, landscape, water resources and historical remains are among the most common effects identified in the literature.

A pioneer on the application of the DCE method for valuing the environmental impacts of hydropower, Sundqvist (2002) did a study on Swedish households. He selected downstream water level (indirectly covering impacts on fauna and flora), erosion and vegetation and impacts on fish life as the attributes. Likewise, Han et al (2008) applied the method for the Tong river in South Korea. Tree population on a protected forest, the number of protected animal species, the number of protected vegetal species and the level of protection of historical remains were the river attributes selected in this case.

Within the French framework, the only application of a discrete choice experiment to support decision-making for river management was undertaken by Creti and Pontoni (2014). This study was focused on the Aspe river in South France, which is also related to the discussion on hydroelectric dams as there were 16 hydropower plants on the river basin at the moment of the study. In addition, the river's ecological status was severely affected in 2007 by an accidental discharge of 17000 liters of Potassium Hydroxide. This shock undoubtedly had an impact on people's preferences, as water pollution was an issue of concern at the time of the study. Water quality, fish population and hydro-morphology were the selected attributes. According to their results, found fish population was the most valued attribute.

Also within the French context, a DCE was conducted for an economic valuation of people's WTP for

the services provided by an urban green spaces and peri-urban forests in the city of Nancy (Tu et al, 2016). Moreover, researchers from the French research institute IRSTEA undertook an evaluation of the WTP for biodiversity preservation in urban forest at the national level (CGDD, 2016).

Finally, a more recent application of the DCE method to estimate people’s WTP for decreasing the environmental impacts of hydroelectric dam was undertaken in Portugal (Botelho et al, 2015). The impacts on the landscape, fauna and flora, noise emission and heritage destruction were the selected attributes. The authors used a Binary Logit model, without the status quo alternative. Remarkably, this study did not target a specific river in Portugal, it addressed electricity production from hydropower in general, with nuanced environmental impacts as the levels.

### 3 Economic Valuation of the Ecosystem Services Provided at Taravo river basin

#### 3.1 Valuation Steps

The main steps towards the completion of this valuation using the DCE method were:

1. *Choice of the preference elicitation method, between contingent valuation and DCE (two weeks in June 2017)*: After a thorough review of the existing literature in economics and validation from the different parties of the project, the DCE method was chosen for this valuation, as the level of detail from the attributes selection is better suited for the expected outcomes of this project.
2. *Selection of the attributes and levels to perform a discrete choice experiment (one month between June and July 2017)*: Attributes were selected with the valuable advice from experts in hydrology and environmental engineering with good knowledge of the study site. The criteria for attribute selection included the ecosystem services provided by the river, the specific characteristics of the local population and data availability. The latter was key for the selection of credible and evidence-based provisioning levels for each attribute.
3. *Survey design and pre-testing (two weeks in July 2017)*: The first versions of the survey were presented to small groups of respondents, in order to draft the final version based on their reactions and feedback.
4. *Survey administration (one month in August 2017)*: The survey was distributed through in-person interviews by a team of four surveyors. In total, 106 people were interviewed for this study.
5. *WTP estimation (one month in September 2017)*: Several econometric models were tested on the data obtained from the survey.

The following section will discuss all the aspects taken into account for the design of the study, starting with a brief description of the study site.

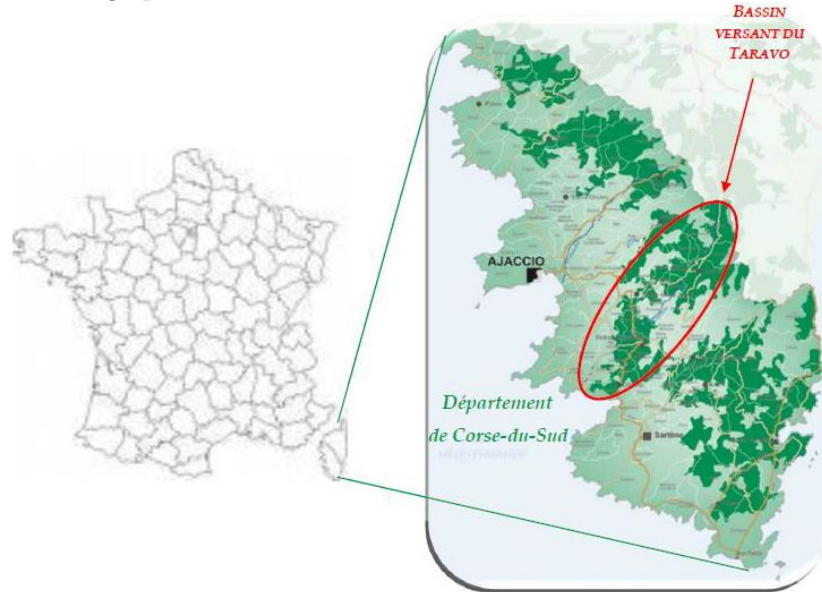
#### 3.2 Study Design

##### 3.2.1 Study Area

The Taravo river basin is located on the South West of the French island of Corsica, between Ajaccio and Propriano (Figure 1), covering a 490 km<sup>2</sup> surface and 31 municipalities. This is a sparsely populated area with a population density of only 15.44 people / km<sup>2</sup>, compared to 122 in France (Institut national de la statistique et des études économiques - INSEE -, and World Bank). The Taravo and its tributary streams



Figure 1: Geographical location of the Taravo river basin, French Corsica island



constitute a hydrographic network of roughly 1500 km (Figure 2). With a length of approximately 65 km, the Taravo river is the third largest watercourse in the island and the first largest in South Corsica. Its source is located in the Flasca forest (to the north of Monte Grosso in Palneca) at an altitude of 1580 meters and its mouth is at the Valinco Gulf, near Olmeto.

### 3.2.2 Survey Design

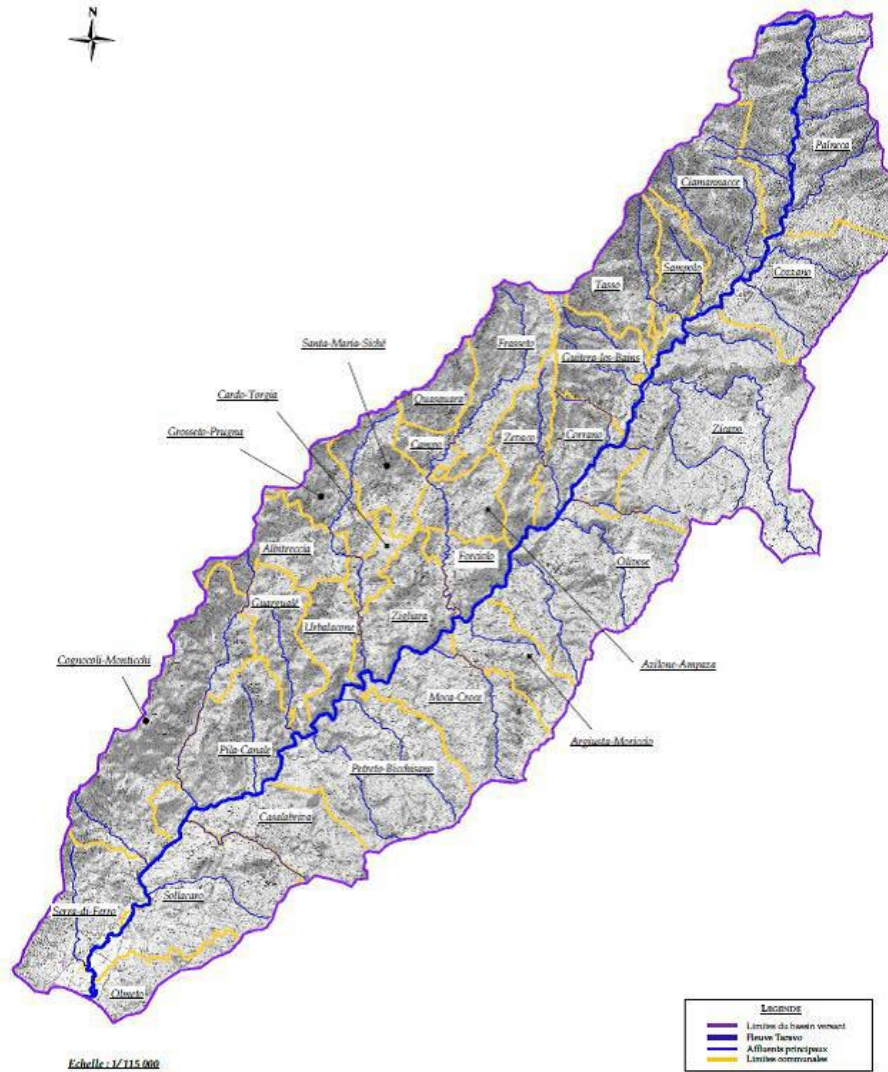
The survey had three parts. On the first part, several questions were asked concerning basic sociodemographic information about the respondents (age, gender, sector of activity, village of residence and distance from their home to the river, etc.), information concerning the use they make of the river (recreational activities, water extraction and frequency of visits, etc.), their perception of its current ecological status and the importance they conceded to its ecological preservation and restoration. In addition, people were asked to rank the main services provided by the river, as a training exercise for the DCE questions.

In the second part of the survey, an introduction with the relevant information regarding the results of the recent studies evaluating the river's current status, the main ecosystem services it provides and the main challenges for its future management were presented. Next, the main attributes of the DCE were presented in detail and the respondents were invited to answer a binary choice set where one scenario dominated the other one, in order to illustrate the structure of this type of questions. Visual aids were used in this part of the survey.

Finally, nine choice sets were presented to the respondents. This is a relatively high number, which could lead to fatigue bias. However, this was deemed necessary in order to compensate for the small number of participants that was expected, given the short time frame to conduct the survey. In addition, a proxy Contingent Valuation question was asked following the nine choice sets<sup>3</sup>. Finally, a poll to find out people's opinion regarding the construction of a large hydroelectric dam in the Taravo river was conducted in parallel by request of the South Corsica Department.

<sup>3</sup>People were simply asked what would be their WTP for obtaining the best possible improvements of all the attributes

Figure 2: Hydrographic network of the Taravo river



It was decided to conduct in-person interviews for this survey, as the evidence from previous studies suggest that it is the best administration method for DCE. Despite the high costs and the risk of interviewer bias, face-to-face interviews guarantee that the questionnaire is well understood by the respondents. Moreover, it was also considered the most appropriate method for this study, given the geographical sparsity and the specific characteristics of the target population.

### 3.2.3 Sample Selection and Descriptive Statistics

The survey was conducted on a sample of 106 people living along the 31 municipalities of the Taravo basin, which has a population of about 11,000 inhabitants according to the 2014 census (INSEE). Admittedly, this sample is rather small in absolute terms, compared to what can be found in the literature, where the smallest sample found was the one from Creti (2014), with 200 people. However, it must be noted this is a sparsely populated sector and this sample amounts to about 1% of the target population. In addition, the results from the econometric regressions suggest that, in spite of this issue, the results are robust, as the main coefficients of interest were statistically significant.

Several observations can be made on the profile of the respondents. Ranging between 19 and 82 years old, the average age of the respondents was 49.7 years old. The average distance from their home to the river was 3,8 km. The respondents seem to have strong sense of belonging to the river, as river preservation was a priority for 87% of them. In addition, 77% of the people stated that they carried out a recreational activity on the river. Finally, the bad reputation of the river was also exposed, as more than half of the respondents considered it was on bad ecological conditions. These and other results are presented in Table 1:

Table 1: Descriptive statistics

	Min	Max	Mean	SD
Age	19	82	49.7	17.7
Distance from the river (meters)	2	15,000	3,770	3,583
	Daily	Once a week	Once a month	Less frequently
Visits frequency	12%	37%	23%	28%
	Very bad	Bad	Acceptable	Good
Opinion on the current state of the river	31%	28%	26%	15%
	Yes	No		
Direct user	50%	50%		
Recreational user	77%	23%		
Priority of river preservation	87%	13%		
	Male	Female		
Gender	71%	29%		
Sample Size	106			

The distribution of the population on the upper, middle and lower sectors of the basin was taken as the baseline for the geographical distribution of the sample. Before conducting the study, it was expected to find a higher WTP from the respondents coming from the lower sector, as they tend to have relatively higher incomes (INSEE). This could be explained because of the benefits of the higher affluence of tourists, due to this sector’s seaside location.

Moreover, the respondents were asked about their sector of activity. At the moment of the statistical analysis, sectors of activity were grouped into three broad categories, based on their expected WTP for the Taravo river’s ecosystem services. The first category concerns business owners in the agriculture and tourism sectors, as they have both relatively high revenues and a direct economic interest on the ecological preservation of the river. Because of their environmental awareness, civil servants were also expected to state a higher WTP and therefore grouped into the second category. Finally, all the other respondents were part of the third group, concerning mostly students and retired workers.

Unlike most stated preferences studies, people’s incomes were not asked upfront in this study. The local partners in Corsica advised against doing so during the survey design phase, as such inquiry would be considered as disrespectful within the island’s culture. The geographical distribution and sector of activity classifications described above were crucial in order to compensate for this shortcoming. Table 2 presents the descriptive statistics of these two classifications, coupled with the total WTP estimated in the proxy CV question. The obtained results seem to confirm the preliminary hypothesis.

### 3.2.4 Selection of Attributes and Provision Levels

Both the underlying ecological processes and the linkages between humans and ecosystems vary across different sites, populations and temporal scales. For that reason, it was essential to understand the

Table 2: Descriptive statistics and WTP based on geographical distribution and sector of activity

	Upper Taravo	Middle Taravo	Lower Taravo	Entire Basin
Official population distribution	31%	25%	44%	100%
Sample distribution	35%	26%	39%	100%
Based on sector of activity				
Business owners	30.5%	29.5%	22.5%	27%
Civil servants	30.5%	18.5%	35%	29%
Other sectors	39%	52%	42.5%	44%
Mean WTP (SD)				
Total	57.22 EUR (28.24)	47.04 EUR (20.72)	74.3 EUR (43.06)	61.18 EUR (34.9)
Business owners	70 EUR (35.77)	42.5 EUR (29.64)	100 EUR (61.85)	71.79 EUR (48.54)
Civil servants	50 EUR (20.98)	52 EUR (19.24)	75.86 EUR (42.37)	62.4 EUR (34.23)
Other sectors	52.86 EUR (24.94)	47.86 EUR (15.78)	59.41 EUR (23.24)	53.47 EUR (21.7)

specific context of the study site, in order to make an adequate selection of the attributes for this DCE. Furthermore, context specificity is a key aspect in the characterization of linking indicators in general, which for instance has major implications for the identification of general guidelines for ecological monitoring, modeling and mapping (Boyd et al, 2015).

During the design phase of this DCE, there were several consultations with technical experts in hydrology and ecology, and whose knowledge of the Taravo river basin was vital for the fulfillment of the context specificity requirement. The meetings with the technical and steering committees, taking place at the beginning of the project and mentioned earlier in the Project Description section, served as the first of those focus groups. The outcome of those meetings - a list of the main ecosystem services provided at the study site - was a key input in the selection of the attributes.

The next technical consultations were carried out with the experts in hydrology who had done the diagnostic study on the ecological condition of the Taravo, and with experts in ecology from the South Corsica Department Council. The goal of this focus groups was to define the attributes for the DCE, taking into account the recommendations found in the literature.

Given the complexity involved in linking biophysical and economic analyses, the selection of the attributes for this DCE shares some of the same challenges with the selection of relevant ecosystem services indicators in general. For that reason, some of the guidelines and recommendations for the selection of ecosystem services indicators were taken into account for this stage of the study. For instance, the combined evidence suggests that using indicators that are more proximate to human welfare within an ecological production framework may improve accuracy and reduce bias, including cognitive errors, confusion, speculation and scenario rejection, of the results (Boyd et al, 2015).

Regarding the discussion on whether to use aggregated or disaggregated indicators for behavioral modeling and valuation, findings suggest that disaggregated, detailed indicators tend to be more relevant for scientific experts, users and those with more extensive experience with the resource in question. Conversely, aggregated, generalized indicators tend to be more relevant to the general public, nonusers and those with little or no experience with the resource.

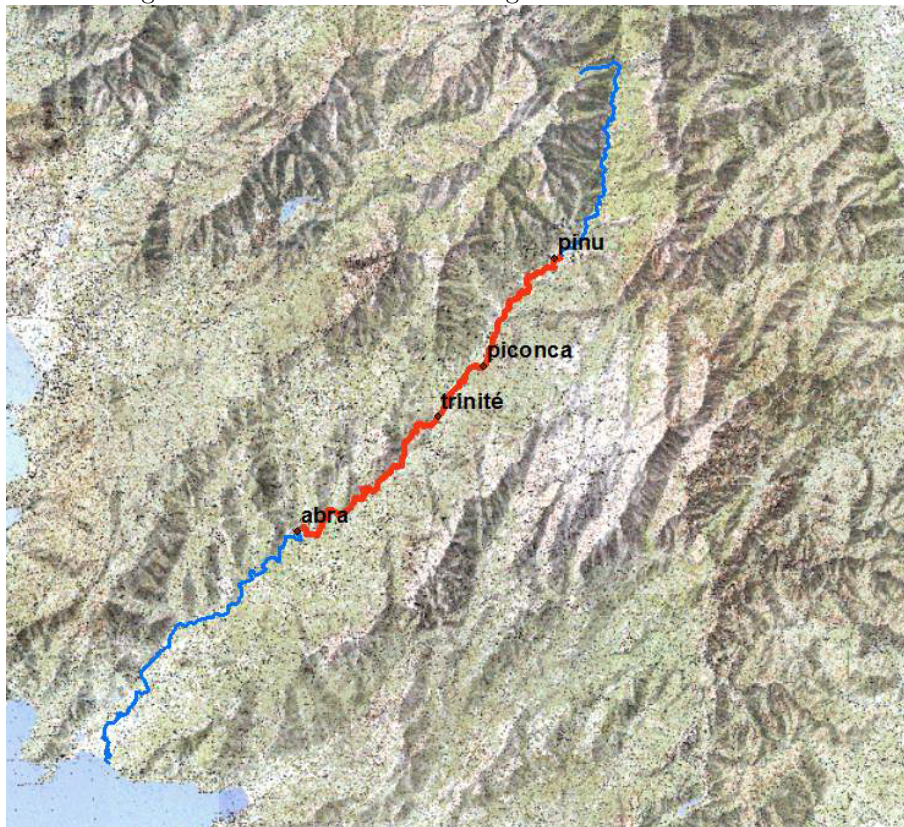
In addition, the identification of linking indicators is a more open-ended process in a nonuse value, than in an use value context. There are certainly fewer clear guidelines, with no insight on that regard from

Revealed Preference studies. However, the fundamental properties of linking indicators remain similar regardless of their use context.

Finally, concerning the units of account, they must fulfill two main conditions: first, they must have unambiguous interpretations, and second, they should enable indicators to be understood similarly by laypersons and experts (Boyd et al, 2015).

Taking all these recommendations into account, three river attributes were selected. Next, a few pilot studies on small groups were conducted, with the goal to test the clarity and relevance of the attributes, the acceptance of the payment vehicle, the amounts of the bids and the reaction to the proposed method. In addition, the number of choice sets presented was also tested in order to minimize fatigue bias. All the feedback obtained from these pilot studies was taken into account for the final experimental design. In particular, the first attribute is linked to the ecosystem services of water quality and outdoors recreation. To that end, the swimming ban on 23 km of the river (Figure 4) was used to determine the levels of provision of this attribute. The number of kilometers where swimming is banned is an excellent linking indicator of water pollution, as it is easily understood, it has a direct impact on human welfare and it is specific to the context of the Taravo river basin.

Figure 3: The 23 km of Swimming Ban in the Taravo river



This attribute's provision levels were determined based on the two main sanitation challenges affecting water pollution in the Taravo river, and a realistic program undertaking the necessary actions to address those issues and lift the swimming ban was proposed on this DCE.

The first issue is the treatment of waste from pig breeding on the upper part basin, as it does not fulfill the basic sanitation standards. In consultation with experts in hydrology who have worked on the Taravo river, it was estimated that a proper treatment of this waste - through centralized collection and incineration - would lead to a reduction of the swimming ban to only 10 km, corresponding to the

distance between Pinu and Trinité bridges. This was designated as the intermediate provision level. The second issue concerns the lack or malfunction of the water sanitation facilities in several municipalities. The second attribute corresponded to the maintenance and restoration activities on the river. It had three provision levels: basic, intermediate and comprehensive maintenance actions. The highest provision level included actions to preserve the proper hydrological functioning of the river, treatment of the riparian vegetation and of *Fallopia japonica*, an invasive vegetal species.

The third attribute corresponded to the enhancement of the cultural (through the restoration of historic remains and buildings) and natural heritage (through the development of infrastructure for outdoors sports and activities).

Finally, the local taxes for the next five years were chosen as the payment vehicle for the cost attribute. It had four levels: 15, 25, 37 and 52 euros. A five-year time frame was chosen, as it was the time frame projected for a comprehensive sanitation plan in accordance with the highest level of the water quality attribute. All attributes and provisioning levels are summarized in Table 3:

Table 3: Attributes and provisioning levels

Attribute	Levels
Water quality (swimming ban length)	- 23 km
	- 10 km
	- 0 km
River restoration activities	- Basic
	- Intermediate
	- Comprehensive
Heritage enhancement actions	- No actions
	- Cultural heritage only
	- Natural heritage only
Investment through local taxes	- For both cultural and natural heritage
	- 15 EUR
	- 25 EUR
	- 37 EUR
	- 52 EUR

### 3.2.5 Experiment Design

Given the number of attributes and provision levels selected, there are 144 possible combinations to be considered as scenarios ( $4^2 \times 3^2$ ). Excluding repeated scenarios and repeated questions which only differ on the order of the scenarios, there are 10,296 unique dichotomous choice questions that could be presented to the respondents. The obvious impracticality of asking all the possible questions justifies the use of a statistical software to find an optimal design. In that sense, it was deemed that the final design had to be efficient both in terms of orthogonality, in order to obtain significant coefficients, and of comfort for the respondents, as to avoid fatigue bias (Johnson et al, 2007). In addition, the experimental design helped alleviate some of the added challenges specific to this study, namely the time constraints, limited resources to conduct the survey and the low population density at the Taravo basin, from which a relatively small sample size was foreseen.

As in Perni and Martinez-Paz (2017), the experimental design was generated using the *support.CEs* package from the R software, which is based on orthogonal main-effects arrays. In particular, the rotational method was used to select and randomize the questions into blocks (Aizaki, 2012).

The final design consisted of 36 questions, which were split into four blocks of nine questions each. The questions consisted of two alternative improvements to the river’s current condition, which implied a hypothetical increase on the respondents’ municipal taxes for the next five years, and the opt-out alternative. Figure 4 presents one of the 36 choice sets of the experiment.

Figure 4: Choice Set Example

**Question 3**

Attribute	Choice A (Baseline)	Choice B	Choice C
Water quality (swimming ban length)	23 km	0 km	0 km
River restoration activities	No actions taken	Intermediate level	Comprehensive level
Heritage enhancement actions	No actions taken	No actions taken	No actions taken
Local taxes investment	0 EUR	15 EUR	25 EUR

### 3.3 Econometric Analysis

The notion that value is derived from the specific attributes of a good or service, rather than the good itself, is in accordance with Lancaster’s (1966) characteristics theory of value. DCE are based on the Random Utility Theory (RUT), which is consistent with choice behavior theory. According to the RUT, the latent utility implied by the choice of one of the alternatives presented is explained by a deterministic component and a stochastic error. Thus, individual  $i$ ’s ( $i = 1, \dots, I$ ) utility associated with alternative  $j$  ( $j = 1, \dots, J$ ) in choice set  $m$  ( $m = 1, \dots, M$ ) is given by:

$$U_{ijm} = b_{ijm}s_{ijm} + \gamma_i z_i + v_{ijm} \quad (1)$$

$$d_{ijm} = \begin{cases} 1, & \text{if } U_{ijm} \geq U_{ikm} \forall j, k \in c_m \\ 0, & \text{otherwise} \end{cases} \quad (2)$$

Where, for each respondent  $i$ ,  $s_{ijm}$  is the  $(s \times 1)$  attribute vector of alternative  $j$ ,  $z_i$  is a  $(g \times 1)$  vector of observable socio-demographic characteristics of the respondent,  $b_{ijm}$  and  $\gamma_i$  are respectively  $(1 \times s)$  and  $(1 \times g)$  row vectors of marginal utility coefficients and  $v_{ijm}$  is an error term. According to equation (2), an alternative  $j$  from choice set  $m$  is selected if and only if it yields maximum utility for the respondent. Once the survey has taken place and the responses are available, a first approach would be to estimate Equation (1) directly, either by using either a Conditional (based on the attributes), a Multinomial (based on the respondents’ characteristics) Logit regression or a combination of the two. However these approaches have been criticized, notably for their IIA assumption, which is likely to be violated in practice. Should the IIA be true, it would imply that the error terms  $v_{ijm}$  are distributed independently from each other and that the parameters are distributed identically within the population, without any respondent-specific variation on the preferences. Thus, either all the respondents would have the same preferences or these would be determined by observable characteristics only. In addition, this would also imply that changes in a choice set would not affect the ratio of choice probabilities between two alternatives in that choice set.

The IIA can be relaxed by using other econometric models that yield more accurate results than the Conditional Logit. Such is the case of the Random Parameters (RPL), also denoted as Mixed Logit Model (MXL), which accounts for unobserved preference heterogeneity (Bliem et al, 2012; Lizin et al,

2016; Asefaw et al, 2016). In other words, the RPL allows the parameters associated with alternative-specific attributes to vary randomly across individuals within a population, thus acknowledging the fact that different respondents may have different preferences. Formally, this can be described as:

$$b_{ijm} = \beta_{jm} + \omega_i \quad (3)$$

Thus, from Equations (1) and (3):

$$U_{ijm} = (\beta_{jm} + \omega_i)s_{ijm} + \gamma_i z_i + v_{ijm} = \beta_{jm}s_{ijm} + \gamma_i z_i + \omega_i s_{ijm} + v_{ijm} \quad (4)$$

Where  $\beta_{jm}$  is a vector of population mean coefficients and  $\omega_i$  is the stochastic deviation representing individual taste relative to  $\beta_{jm}$ . It follows from  $\omega_i s_{ijm}$  on equation (4) that the error term is correlated with the alternative's attributes.

Both the Conditional Logit and the Random Parameters models were used to estimate respondents' indirect utilities associated with their choices. The specific models applied on this study can be expressed as:

$$V_{ij} = ASC_{sq} + \beta_w WQ + \beta_m MR + \beta_{ch} CH + \beta_{nh} NH + \beta_{cnh} CNH + \beta_{tax} TAX \quad (5)$$

Where  $ASC_{sq}$  is the Alternative Specific Coefficient, a dichotomous variable which equals to zero for the observations corresponding to the opt-out alternative of each question, and to one for those corresponding to the choice alternatives. The  $ASC_{sq}$  can be associated to the utility of switching from the status quo. The marginal utilities of the ecosystem services from the river (water quality, ecological maintenance and restoration, and cultural and natural heritage enhancement) and of the payment mechanism are estimated with the remaining coefficients,  $\beta_w$ ,  $\beta_m$ ,  $\beta_{ch}$ ,  $\beta_{nh}$ ,  $\beta_{cnh}$  and  $\beta_{tax}$ .

Based on Kahnemann (1994), and as is common practice in stated preference methods, the ratio of marginal substitution (RMS), which divides each river attributes' coefficients by the monetary attribute, approximates the WTP for each attribute  $k$ , thus:

$$RMS = WTP_k = -\frac{\beta_k}{\beta_{tax}} \quad (6)$$

Likewise, welfare gains from a particular Ecosystem Services provision scenario can be estimated through the Compensating Surplus (CS) with respect to the status quo. More specifically, the CS corresponds to:

$$CS = -\frac{1}{\beta_{tax}}(U_{sq} - U_{sn}) \quad (7)$$

Where the indirect utilities associated with the status quo  $U_{sq}$  and the alternative scenario  $U_{sn}$  are estimated using the coefficients issued from the econometric regression.

## 4 Results and Discussion

Table 6 presents the main results of the estimations, using either the Conditional or the Mixed Logit models (the latter also known as RPL). The coefficients for the attribute variables have the expected signs and are all significant, regardless of the econometric model and the explanatory variables selected for the estimation. For each model, the first specification corresponded to the attribute variables only, while on the second, their interactions with the socioeconomic variables were included.

Those interactions were found to be significant in two cases with the RPL estimation: first, the interaction of the water quality attribute with a dummy variable corresponding to respondents working in the agriculture and commercial sectors; and second, the interaction between the ecological restoration attribute and a dummy variable for the respondents living in the upper sector of the basin. The WTP was found to be above the average for the former and below average for the latter. In addition, according to



Table 4: WTP per attribute (RPL)

Attribute	Sample group	WTP
Water quality (swimming ban removal)	Entire sample	2.12 EUR / km <b>48.65 EUR</b> to completely lift the 23 km ban
	Business owners	3.92 EUR / km 90.09 EUR to completely lift the 23 km ban
River restoration activities (comprehensive level)	Entire sample	<b>45.54 EUR</b>
	Upper Taravo	31.83 EUR
Cultural heritage enhancement actions		17.02 EUR
Natural heritage enhancement actions	Entire sample	24.90 EUR
Cultural and natural heritage enhancement actions		<b>33.89 EUR</b>

the results from the conditional logit model, having a bad perception of the current status of the Taravo was found to have a positive impact on the WTP for improving water quality. However, this result did not hold when relaxing the IIA.

The differences on the WTP for certain attributes can partly be explained by differences in income, as those who had a greater-than-average WTP to reduce water pollution were economically active people, mainly farmers and business owners, while people in the upper sector of characterize for having a relatively lower income with respect to the rest of the basin. Moreover, these results could also reveal some of the specific incentives faced by each group of respondents. Respondents from the first group could have economic incentives to improve water quality: it could increase agricultural productivity for the farmers, while business owners might be interested in making the area more appealing for tourists. In contrast, maintenance and restoration activities could be less appealing for the residents of the upper sector of the basin because of the fewer needs for restoration and maintenance activities and the absence of the invasive *Fallopia Japonica* in that area.

Using the coefficients from the RPL estimation, the WTP per attribute can be found on Figure 6: the whole population has a WTP of 48.65 euros for attaining the maximum provision level of the water quality attribute, 45.54 euros for the full maintenance and restoration activities, and 33.89 euros for the enhancement of both cultural and natural heritage and landscapes. These results are summarized in Table 4.

These results are in line with what is found in the literature. For instance, Bliem et al (2012), found that people were willing to pay 68,21 euros per year to improve water quality from moderate to very good (status quo and highest level). Moreover, people were willing to pay up to 68,47 euros per year for the same attribute and levels according to the results found by Lizin et al (2016), who also found that people were willing to pay 43,45 euros for a major restoration of the rivers. Botelho et al (2015) found that people were willing to pay 50,12 euros per year to avoid the loss of cultural heritage from the construction of hydroelectric dams in Portugal. Regarding WTP for all the attributes, the results from this DCE are close to the 144 euros per year for the Aspe River in South France (Creti and Pontoni, 2014).

Moving out from the European context, it is interesting to see how changes in purchasing power seem to affect WTP for ecosystem services. For instance, Asefaw et al (2016) found that people were willing to pay 19,69 euros to obtain the greatest possible water quality improvement in the Shiyang river in China, which is in line with the 17 euros found by Shi et al (2016) for the Wei River, also in China. Finally, in their study in Brazil, Kahn et al (2017) found that people were willing to pay 32,68 Brazilian Reais (8,80 euros) per year for the full restoration of Rio Paraiba do Sul. A summary of those benchmark studies is

Table 5: Benchmark studies results

Author	Year	Country	Attribute	WTP (Euros)
Bliem et al	2012	Austria	Water Quality	68.21 EUR
Lizin et al	2016	Belgium	Water Quality	68.47 EUR
Lizin et al	2016	Belgium	River Restoration	43.45 EUR
Asefaw et al	2016	China	Water Quality	19.69 EUR
Shi et al	2016	China	Water Quality	17 EUR
Kahn et al	2017	Brazil	River Restoration	8.8 EUR
Botelho et al	2015	Portugal	Cultural Heritage	50.12 EUR
Créti and Pontoni	2014	France	All the Attributes	144 EUR

presented on Table 5.

## 5 Conclusion

The consequences and the imbalances at the scale of the territory are now better understood thanks to our evaluation. The results from this DCE (along those from the more comprehensive assessment presented to the South Corsica Department Council) are robust and relevant indicators of the economic value of some of the ecosystem services at the Taravo river basin. The construction of a hydroelectric dam on this river of high ecological quality would be a game changer in the current situation, with: significant ecological consequences in the long term, affecting biodiversity and the provision of several ecosystem services (Botelho et al, 2017); and huge changes in the uses made of the river and in the region’s development strategy. For the specific ecosystem services evaluated in this DCE, the construction of the dam would severely impact landscape quality and reduce opportunities for outdoors recreation, especially swimming, and fishing.

Moreover, it would also have consequences for the other elements taken into account at the DCE: the erosion of the river banks would increase the costs of maintenance and restoration activities and jeopardize the state of several Genoese bridges in the area, dating back to the 17th century, while eutrophication could foster the proliferation of *Fallopia Japonica* (data from the *Conseil départemental de Corse du Sud*).

Lastly, from a technical point of view, our evaluation contributes to the expansion of non-market evaluation methods, applied for ecosystem services. It should be noted that the application of DCEs is not limited to one type of ecosystem, and that significant progress has been made on other methods as well. Apart from rivers and other watersheds, DCEs have been applied on forests (Tu et al, 2016; CGDD, 2016) or marine areas (Wattage et al, 2011), amongst others. Moreover, an evaluation of the outdoors recreation service based on the travel cost method, using data obtained from social media (Sinclair et al, 2018; Sonter et al, 2016), or the application of a production function approach based on modelling tools, such as ARIES (Bagstad et al, 2013) or InVEST (Ruckelshaus, 2015), are examples of promising alternatives to DCEs that must be considered at the moment of doing an ecosystem services assessment. In spite of the progress made in the development of the DCE method, research efforts are still needed in order to increase the existing knowledge on the issues concerning optimal experimental design (Aizaki, 2012; Johnson et al, 2007), temporal stability of the estimated coefficients (Bliem et al, 2012) and the estimation of the joint WTP for all the experiment’s attributes (Creti and Pontoni, 2014).

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Table 6: Econometric Estimations

	Conditional Logit		Mixed Logit	
	(1)	(2)	(3)	(4)
main				
ASC	16.99 (0.03)	17.59 (0.02)	21.33 (0.01)	22.23 (0.00)
Water Quality	0.140*** (11.37)	0.0891*** (5.54)	0.216*** (8.03)	0.169*** (7.23)
Cultural Heritage	1.290*** (4.36)	1.298*** (4.25)	1.416*** (4.06)	1.363*** (3.94)
Natural Heritage	1.952*** (5.78)	1.920*** (5.52)	2.074*** (5.24)	1.994*** (5.12)
Cultural and Natural Heritage	2.678*** (6.93)	2.592*** (6.56)	2.877*** (6.25)	2.714*** (6.08)
Ecological Restoration	0.849*** (11.23)	1.013*** (10.49)	1.123*** (9.62)	1.216*** (9.86)
Tax	-0.0680*** (-8.97)	-0.0705*** (-9.02)	-0.0821*** (-8.16)	-0.0801*** (-8.70)
Water Quality X Private Sector		0.134*** (4.82)		0.144*** (3.46)
Ecological Restoration X Upper Basin		-0.331* (-2.37)		-0.366* (-2.27)
Water Quality X Negative Perception		0.0497* (2.55)		
SD				
Water Quality			0.137*** (5.85)	0.117*** (5.43)
Cultural Heritage			-0.00243 (-0.01)	0.0216 (0.04)
Natural Heritage			-0.114 (-0.09)	-0.131 (-0.12)
Cultural and Natural Heritage			0.00108 (0.00)	-0.0294 (-0.05)
Ecological Restoration			0.204 (0.77)	0.00698 (0.01)
Observations	2754	2679	2754	2679

*t* statistics in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$